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2,967,969

DIRECT VIEW STORAGE TUBE WITH CONTROLLED ERASURE

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3 Sheets-Sheet 1

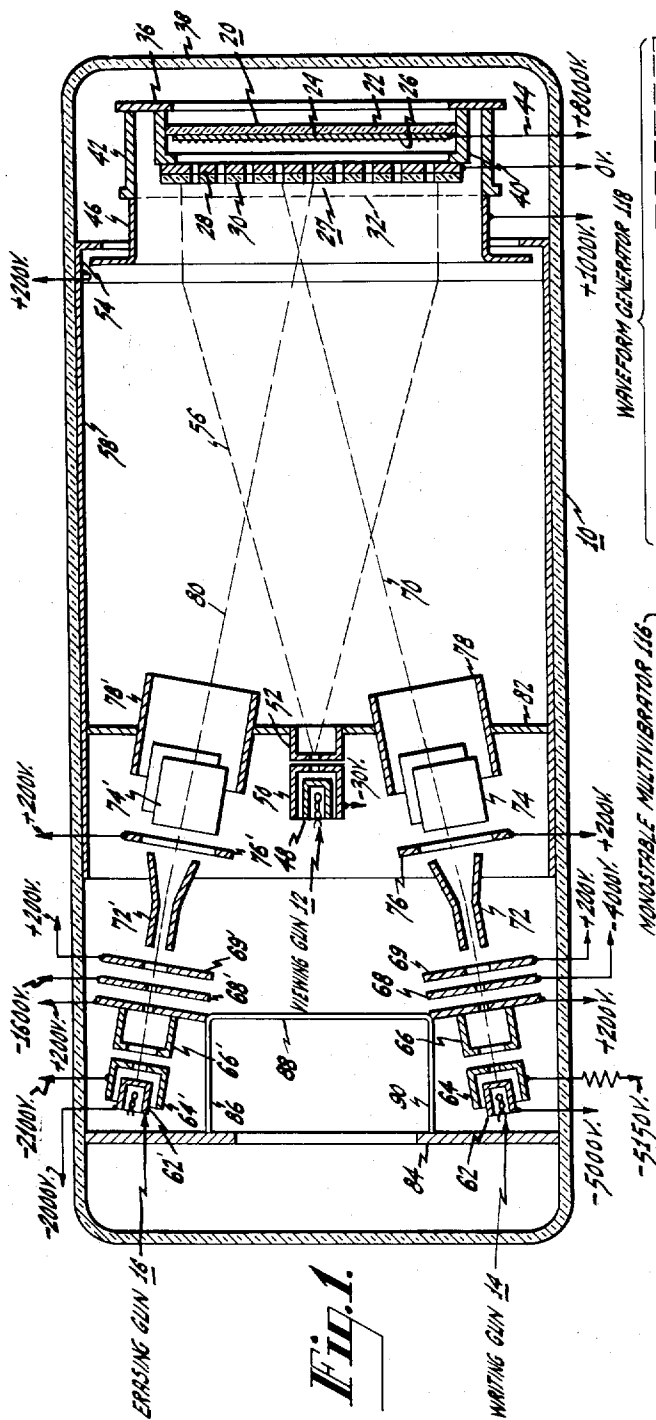
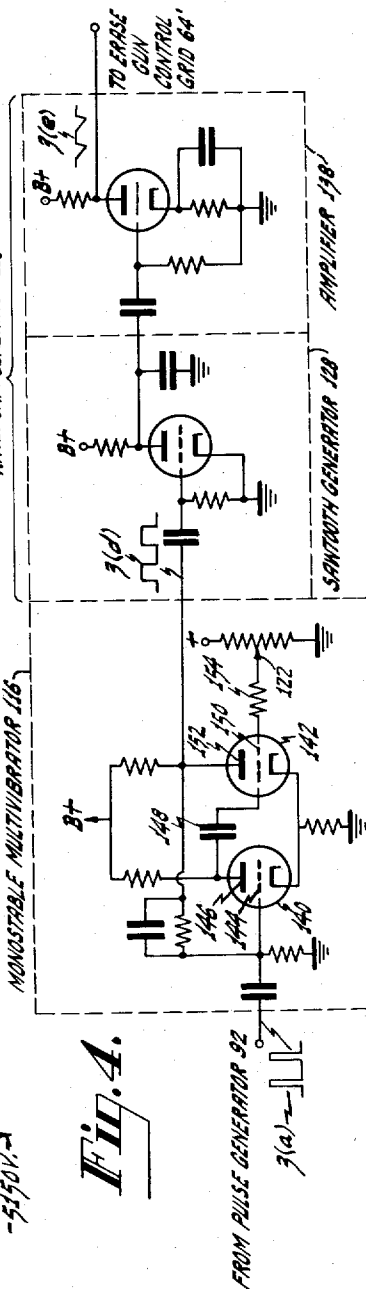


Fig. 4.



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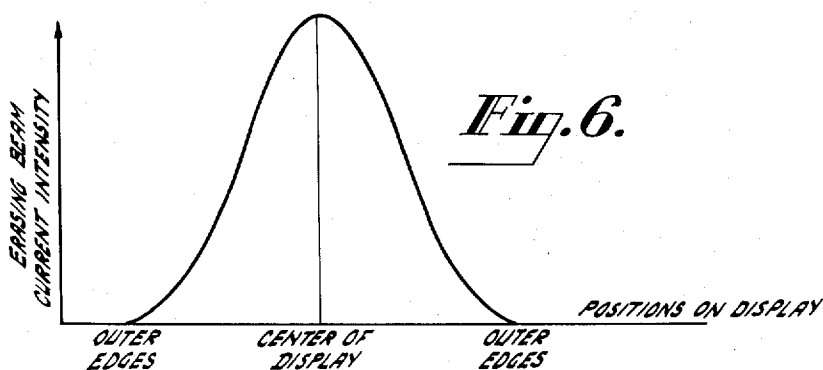
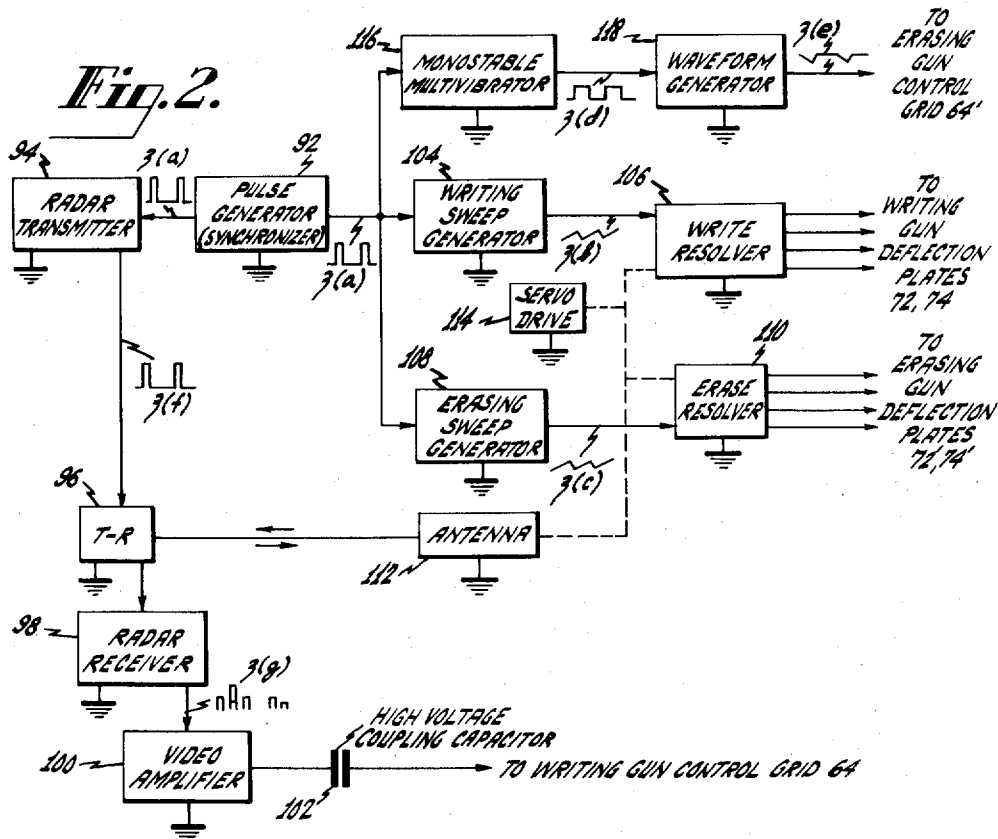
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DIRECT VIEW STORAGE TUBE WITH CONTROLLED ERASURE

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3 Sheets-Sheet 2



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DIRECT VIEW STORAGE TUBE WITH CONTROLLED ERASURE

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3 Sheets-Sheet 3

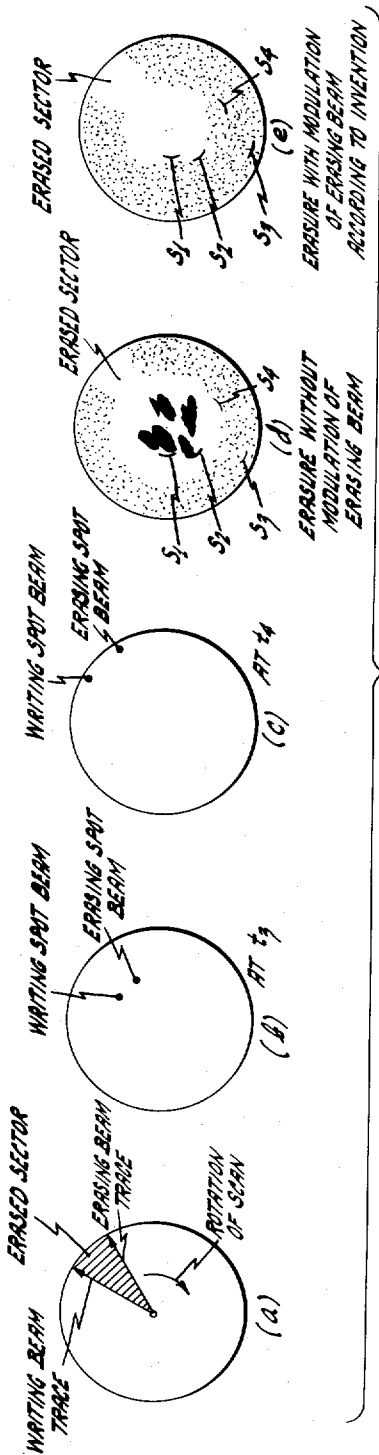


Fig. 3

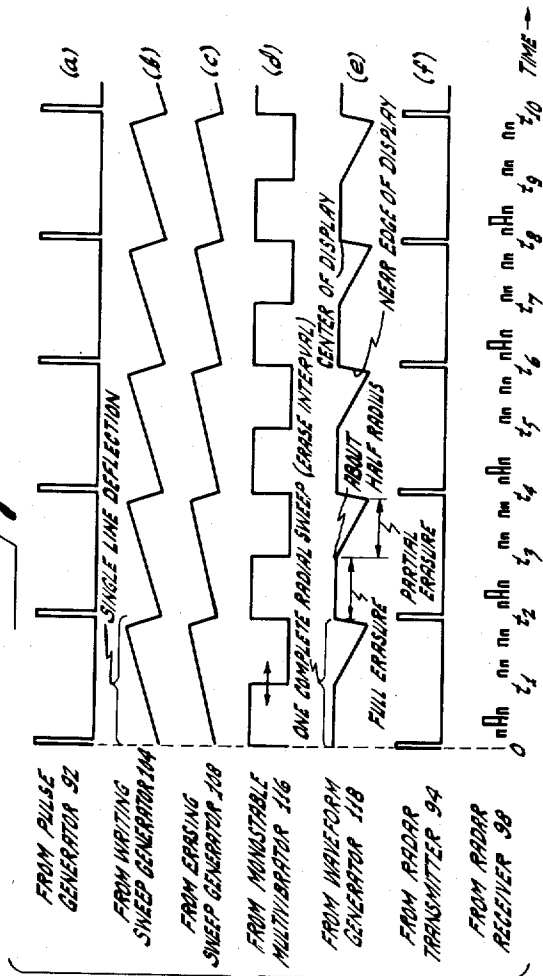


Fig. 3

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DIRECT VIEW STORAGE TUBE WITH CONTROLLED ERASURE

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6 Claims. (Cl. 315—8.5)

This invention relates generally to electrical storage tubes and signal display systems and to improved methods and means for utilizing a direct view type of electrical storage tube for storing and displaying signal intelligence.

The direct view storage tube as presently known is used in connection with radar systems, ground-to-air private line communication systems, and for related purposes. The storage tube combines both the features of signal storage and signal display thus eliminating the requirements for one or more electrical storage tubes in combination with a separate display tube. Furthermore, the direct view storage tube provides an excellent high brightness radar display which can be viewed in normal daylight, making it ideally suited to airborne display applications. In addition to high brightness, the direct view storage tube has long term storage properties and controllable decay characteristics.

A typical direct view storage includes a writing gun assembly, a viewing gun assembly, an erasing gun assembly, and a target assembly including a storage grid and a fluorescent screen. The writing gun assembly produces a well defined and focused electron beam having exceptionally small effective area at the storage grid. Signal intelligence modulates the focused electron beam during deflection, and a charge pattern, corresponding to the signal input, is written on the insulating surface of the storage grid.

The viewing gun assembly produces a low-velocity electron stream which continuously floods a major portion of the area of the storage grid. The storage grid modulates and thereby serves to control the transmission of the flooding viewing beam so that stored information on the storage grid is displayed on the screen. Electrons which pass through the storage grid are accelerated toward the fluorescent screen where they reproduce the stored charge pattern in the form of a bright display.

The erasing gun assembly provides an electron beam which may be focused and deflected to erase a single line of the storage grid at a time. By operating the cathode of this gun at a potential somewhat more negative than the potential of the viewing gun cathode, and scanning the erasing beam across the storage grid, the stored information is erased and a uniform potential is established over the surface of the storage grid in preparation for another writing. Deflection waveforms applied to the erase gun may be so derived that they cause the erasing spot beam to lead the writing spot beam and thus erase "old" portions of the charge pattern just prior to the time that new information is to be written.

Heretofore in the direct view storage tube, the signal intelligence displayed near the center of a radar P.P.I. display often has appeared indistinct as a result of intense signal strength, ground clutter, and overlap of successive radial scans. And, the intensity of signal intelligence displayed near the periphery of a radar P.P.I. display is comparatively weak, and maintained for a comparatively short period of time.

An object of the present invention is to provide im-

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proved methods and means for storing and displaying signal intelligence.

Another object of the invention is to provide improved methods and means for utilizing a direct view storage tube.

Another object is to provide improved methods and means for erasing data stored and displayed by the direct view storage tube.

A further object is to provide an improved signal display system providing signal integration, noise discrimination, and ground clutter elimination.

The foregoing and other objects and advantages are achieved, according to a preferred embodiment of the invention, by applying an appropriate waveform to the erasing gun assembly during each radial deflection of the erasing beam. The application of the waveform causes the intensity of the sharply focused erasing beam to vary while the erasing beam progresses from the center to the outer edge of the P.P.I. display. The desired waveform when applied, according to the invention, causes the negative bias on the control grid to remain constant when erasing at the center of the display, and then, as the erasing spot beam sweeps outward to the edge, progressively causes the bias on the grid to go more negative resulting in a decrease in erasing beam intensity. The control grid bias is initially set at a threshold value which provides an erasing spot beam with an intensity that affords substantially complete erasure of ground clutter signals. In this manner, erasure in a direct view storage tube is caused to vary with range so that ground clutter at close range is suppressed, normal operation is provided at intermediate range, and signal integration is provided at long range.

In another mode of operation according to the instant invention, the erasing electron beam is defocused resulting in a broad erasing beam with maximum erasing current density at the center of the storage member and lesser erasing current density towards the edges of the display.

The invention will be described in greater detail with reference to the accompanying drawings in which:

Figure 1 is a schematic diagram showing the structural arrangement of a typical direct view storage tube employing three electron guns;

Figure 2 is a block diagram of a P.P.I. radar system in which one embodiment of the invention is incorporated; Figure 3 is a series of wave diagrams useful in understanding the operation of the system shown in Figures 1 and 2;

Figure 4 is a circuit diagram which shows in detail certain portions of the diagram of Figure 2;

Figure 5 illustrates writing and erasing in a P.P.I. system according to the invention; and

Figure 6 is a graph showing the typical current density distribution for a defocused broad erasing beam.

Like reference characters are applied to like elements throughout the drawings.

Storage tube structure

Referring to the drawing, Fig. 1 shows a direct view type storage tube having an evacuated substantially cylindrical envelope 10, for example, a glass, bulb. Positioned within the envelope 10 and lying along its longitudinal axis is an electron gun 12. Gun 12 is positioned in a central portion of the tube and hereinafter will be referred to as the "viewing" gun. At one end of envelope 10 and on opposite sides of the tube axis are two other electron guns 14 and 16. Guns 14 and 16 will be referred to as the "writing" and "erasing" guns, respectively, and are inclined toward the axis at some desired angle (for example, 10°).

A viewing screen assembly 20 including a glass support

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sheet 22 having a thin conductive film disposed on the surface thereof facing the electron guns is mounted at the opposite end of the envelope 10. The film 24 may be formed, for example, of a metal or metallic compound such as tin oxide. On top of the conductive film 24 is a screen 26 formed from a phosphor material which fluoresces under electron bombardment.

A storage target assembly 27 is spaced from the surface of the fluorescent screen 26 and in the direction towards the electron guns 12, 14, and 16. Assembly 27 includes a fine metal conductive mesh screen, 28, called the backing electrode, which is spaced several millimeters from the fluorescent screen 26. A storage grid 30 is formed, by evaporation or some other convenient means, on the surface of the backing electrode 28 and comprises a dielectric insulating material such as a film of silica or magnesium fluoride of the order of several microns in thickness. At a distance of the order of several millimeters from the backing electrode 28 (in the direction towards the electron guns) is a second fine mesh metal screen 32. Screen 32 may be a woven or electroformed stainless steel, copper, or nickel mesh of the order of 100 to 500 mesh per inch. The backing electrode 28 and the mesh dielectric storage grid 30 also may have a fineness of the order of 100 to 500 mesh per inch.

Assembly 20 is mounted on a ring 36 or a series of spacers of insulating material within envelope 10 and adjacent the tube faceplate 38. Fixed to the ring 36 is an annular metal support ring 40 which supports between its ends the glass support sheet 22 and across its extremities the backing electrode 28. Also mounted on the insulating ring 36 is a second annular metal support ring 42 across the open ends of which is mounted the metal mesh screen 32. The conductive tin oxide film 24 is insulated from the support ring 42 by the glass sheet 22 and is connected by a lead 44 to a source of positive potential outside the envelope 10. Mesh screen 32 also is connected to a source of positive potential via an annular metal ring 46. The backing electrode 28 ordinarily is set to a potential of the order of a few volts negative with respect to ground to twenty to thirty volts positive with respect to ground. In the present example it will be assumed that the backing electrode 28 is set to a potential of zero volts with respect to ground.

The viewing gun 12 comprises a cathode electrode 48, a control electrode 50, and an accelerating electrode 52 mounted successively along the axis of the tube toward the faceplate 38. During the tube operation these electrodes are maintained at appropriate voltages (indicated on the drawing) to form the electron emission from the cathode 48 into a wide beam or spray 56 of electrons. The inner surface of the envelope 10 has applied thereto a conductive coating 58 which is maintained at the same positive potential as the accelerating electrode 52 by means of an annular metal ring 54 with springs (not shown) which provide contact thereto. Since the wall coating, contact ring 54, and the ring 46 are at different potentials a collimating electron lens is provided which aligns the electrons of the spray beam 56 in a direction axially with respect to the target assemblies.

The structure of the writing electron gun 14 comprises a cathode electrode 62, a control electrode 64, a first accelerating electrode 66, a focusing electrode 68, and a second accelerating electrode 69. The foregoing electrodes and wall coating 58, which serves as a third accelerating electrode, form the electrons of gun 14 into a sharply defined and focused beam 70. Separate pairs of deflection plates 72 and 74 are provided for electrostatically deflecting beam 70 in a desired manner. In order that the writing beam 70 be deflected in a field free region of the tube an apertured disk-like electrode 76 is disposed intermediate the pairs of deflection plates 72 and 74 and a conductive cylinder 78 is positioned adjacent the deflection plates 74. These electrodes 76 and 78 and accelerating electrode 69 are then maintained at the

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same positive potential to provide the field free region.

The structure of the erasing electron gun 16 and the deflection and shielding electrodes associated therewith is similar to the structure associated with the writing gun 14. Accordingly, like structure is designated with prime notations. However, the erasing beam produced by this structure is indicated by the reference numeral 80.

The structures for guns 12, 14, and 16 are given mechanical support by apertured metal support members 82 and 84, and by support members 86, 88, and 90. Support member 82 also affords electrical contact between wall coating 58, shield members 78 and 78', and the viewing gun accelerating electrode 52.

Tube operation

To prepare the storage target for storing a charge pattern on the storage grid 30, it is necessary to erase old stored data by establishing a uniform potential thereover. With the viewing gun 12 turned on, the electrons of the spray beam are accelerated with energies up to 1000 volts through the metal mesh screen 32. Since "no-signal" portions of the backing-electrode 28 are at zero volts with respect to ground (the same potential as the viewing gun cathode) the spray of electrons passing through screen 32 is drawn through the interstices of the storage target assembly 27 by the positive field of the fluorescent screen 26 to bombard the screen 26 and cause luminescence.

On the portions of the storage grid 30 where signal intelligence previously has been written and stored, the grid 30 is charged negatively with respect to ground. This is true because the writing beam 70 strikes the storage grid 30 above the second crossover point on the secondary emission ratio curve for the insulator storage grid 30. Above the second crossover point the secondary emission ratio is less than unity. At those points where negative charges are stored on the storage grid 30 the charges neutralize the effects of the fluorescent screen's positive field. The low velocity electrons of the spray beam 56, in those charged areas, do not see the positive field and are reflected to the mesh screen 32 where they are collected. The display provided on the fluorescent screen 26 is dark writing on a light background.

Erasure of stored data is afforded by scanning the storage grid with the erasing beam 80. Since the erasing beam is operated between the first and second crossover points of the insulator secondary emission ratio curve, the storage grid 30 is driven positively with respect to ground at those points where the beam 80 strikes. Electrons from the spray beam 56 then land on the storage grid 30 at these points and bring its potential to zero volts (viewing gun cathode potential). By scanning the erasing beam 80 over the entire surface of the storage grid 30 old data is completely erased and a uniform potential is established over the storage grid surface so that new data may be written.

If desirable the above described writing and erasing technique may be modified to provide light writing on a dark background. In such a situation the storage grid 30 is set to a potential which is negative with respect to viewing gun cathode potential. The writing gun is then operated between the first and second crossover points and the erasing gun operated either below the first or above the second crossover point.

P.P.I. radar display system

Referring to Figure 2, and the series of wave diagrams of Figure 3, a pulse generator 92 generates pulse (Figure 3-a) which synchronously trigger a writing sweep generator 104, an erasing sweep generator 108, a radar transmitter 94, and a monostable multivibrator 116. The writing sweep generator 104 produces a sawtooth wave (Figure 3-b) in response to each pulse. The sawtooth waves are then applied to a sine-cosine resolver 106, the

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outputs of which are coupled to the electrostatic deflection plates 72 and 74 of the writing gun. A linear time-base sweep thus is produced which deflects the cathode ray writing beam 70 from the center of the display tube to the edge in a direction corresponding to the instantaneous direction of the antenna 112. The range sweep is rotated about the face of the display tube in synchronism with the azimuthal scanning of the antenna 112 by means of a servo drive 114.

The erasing sweep generator 108 also produces a sawtooth wave (Figure 3-c) in response to each pulse from the pulse generator 92. These sawtooth waves are applied to a sine-cosine resolver 110 and the outputs of the resolver 110 in turn are applied to the electrostatic deflection plates 72' and 74' of the erasing gun. The cathode ray erasing beam 80 is caused to move from the center of the display to the edge synchronously with the sweep of the writing beam 70. However, the erasing beam 80 leads the writing beam 70 in rotation around the P.P.I. display by several lines. This is accomplished by shifting the angular position of the stator of the erase resolver 110 with respect to the stator of the write resolver 106 to produce a small fixed angular displacement of the erase sweep with respect to the write sweep on the face of the direct view storage tube. The writing beam thus trails the erasing beam allowing stored information to be erased just prior to writing new information on the P.P.I. radar display. The displacement of the stator of the erase resolver 110 with respect to the stator of the write resolver 106 may be controlled by a micrometer mount on the stator of the erase resolver 110.

Simultaneous with the triggering of sweep generators 104 and 108, the pulse generator 92 triggers a radar transmitter 94 which generates high intensity pulse signals. These high intensity pulses are coupled via a T-R device 96 to a rotating directional antenna 112. After transmission of the pulse energy the antenna 112 receives reflected echoes or re-transmitted pulses which pass to the radar receiver 98 through the T-R device 96. The echo signals are amplified by a video amplifier 100, and the video amplifier output is passed through a high voltage coupling capacitor 102 to the writing gun control grid 64 to modulate the writing beam 70.

Simultaneous with the keying of sweep generators 104 and 108, and the keying of the radar transmitter 94, pulse generator 92 triggers a monostable multivibrator 116. The output of multivibrator 116 (Figure 3-d) alternately switches a waveform generator 118 on and off. The leading positive-going edge of the multivibrator output cuts the generator 118 off, as shown for example, in Figure 3-e at t_2 . The trailing negative-going edge activates the waveform generator 118 to produce a negative-going sawtooth wave, as shown during the interval t_3-t_4 . The resultant composite waveform (Figure 3-e) derived from generator 118 is then applied to the erasing gun control grid 64'. While the erasing spot beam 80 sweeps outward, the control grid bias remains constant for an initial period and thereafter is decreased for the remainder of the outward sweep. The decrease in control grid bias reduces the erasing beam intensity, thus effecting a partial erasure of the long range signals indicated near the periphery of the P.P.I. display. The partial erasure permits integration of the weak long range signals.

Also, full erasure of ground clutter signals during the deflection of the erasing beam over the approximate first half of the radial sweep is accomplished by setting the intensity of the erasing spot beam 80 at a "threshold" value. Operating the erasing beam at "threshold" causes an excess positive charge to be deposited on the storage grid 30. The writing beam 70 is then required to remove the excess positive charge to bring the storage grid 30 to a condition where viewing electrons can pass to the fluorescent screen 26. Only those echo signals that add to the ground clutter signals, or are of greater intensity than the ground clutter signals so as to exceed the "threshold,"

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will appear on the indicator during approximately the first half of the radial sweep.

Figure 4 shows a diagram of a typical circuit which produces the composite waveform of Figure 3-e. The circuit includes a cathode-coupled monostable multivibrator 116 which operates in a conventional manner to produce the rectangular wave-form of Figure 3-d. The monostable multivibrator 116 includes an electron tube 140 which is normally cut off, and an electron tube 142 which is normally conducting when the multivibrator is in its quiescent state.

Positive pulses (Fig. 3-a) from pulse generator 92 are applied at the normally cut-off grid 144 of tube 140 at $t_2, t_4, t_6, \dots$, the amplitude of these pulses being large enough to overcome the cutoff bias. The applied pulses cause tube 140 to conduct, during intervals $t_2-t_3, t_4-t_5, \dots$, and the anode 146 of tube 140 thus is driven more negative. Since the anode 146 of tube 140 and the grid 150 of tube 142 are coupled through a capacitor 148, the grid 150 goes negative driving the tube 142 towards cutoff. While tube 140 is conducting, capacitor 148 charges through the grid current of tube 142. When the capacitor 148 discharges through resistor 154, tube 142 starts to conduct and the circuit is again operating in its quiescent state. The resultant output from the plate 152 of tube 142 is a rectangular waveform (Fig. 3-d) with a pulse width determined by the values of the capacitor coupling 148, the high resistance of resistor 154, and the variable resistor 122.

The trailing edge of the rectangular wave (Fig. 3-d) produced by the monostable multivibrator 116 triggers a conventional sawtooth wave generator 128 which generates a positive-going sawtooth waveform during the intervals $t_1-t_2, t_3-t_4, \dots$. The output from the sawtooth generator 128 is amplified and inverted in the amplifier 138 to produce the composite waveform (Fig. 3-e).

Adjustment of the pulse width control 122 of the multivibrator 116 will vary the time of triggering of the sawtooth generator 128 during the erase interval. Thus a progressively varying erasing intensity can be commenced at any point along the radial sweep. Any appropriate waveform may be applied to the erasing gun control grid 64' to produce a desired erasing effect. For example, a negative-going sawtooth wave may be applied to the grid 64' during the entire period of each erase interval, or complete radial sweep, to produce a progressively decreasing erasing intensity.

Referring to Figure 5, the relationship between the writing and erasing beams are shown. In Figure 5-a, the erasing beam trace leads the writing beam trace by several degrees in clockwise rotation around the radar indicator. Figures 5-b and 5-c show the positions of the writing and erasing spot beams at intervals t_3 and t_4 respectively. Figure 5-d shows received signal S_1, S_2, S_3 and S_4 and the clutter smear at the center on the P.P.I. indicator when erasing intensity is constant across the entire face. Figure 5-e illustrates the effect of erasure with modulation of the erasing beam according to the invention.

The invention is not limited to the arrangement as described in the preferred embodiment above. Generally, any signal storage tube which erases written intelligence progressively in sections, segments, or lines may employ the instant invention to vary the erasing intensity over the entire storage area. Therefore in addition to P.P.I. operation, the present invention is applicable to any radar or television system wherein a storage tube, such as the direct view storage tube, is employed.

The use of a separate write resolver 106 and a separate erase resolver 110 is described above. In lieu thereof, one resolver and a phasing network may be utilized to produce the angular displacement of the erasing beam from the writing beam.

Another method of operation for providing a varying intensity of erasure as a function of the radial distance

across the storage grid 30 surface is achieved without deflection of the erasing beam merely by defocusing the erasing spot beam 80. The erasing beam 80 is defocused into a broad area beam (similar to the flood or spray beam 56) by operating the erasing gun 16 at appropriate potentials, and is caused to diverge by utilizing electrostatic lenses within the storage tube. By proper design and positioning of the erasing gun structure 16 in the direct view storage tube, the broad erasing beam impinges on the storage grid 30 so that the electron density is greater at the center than at the edge of the grid 30 as shown in the distribution curve of Figure 6. The continuous application of the broad erasing beam with varying intensity results in greater erasure at the center of the display, and less erasure towards the edges.

The instant invention thus affords the advantages of ground clutter suppression and long range signal integration thus providing a uniform picture in a radar P.P.I. display. The invention also is applicable to other systems, and various changes and modifications may be made in the embodiments described above in which the features of the invention are incorporated.

What is claimed is:

1. A signal storage tube system comprising an electrical storage tube containing a charge storage member, and a viewing screen, means providing a writing electron beam, means providing an erasing electron beam, means for deflecting said beams across said storage member with said writing beam trailing said erasing beam by a predetermined amount, connection means for a source of signals for modulating said writing beam with signal intelligence during deflection thereof to store said intelligence on said charge storage member, means providing a viewing beam to flood said storage member and reproduce said stored intelligence on said viewing screen, means for activating said erasing beam to erase said stored intelligence on said storage member line by line, and means for varying the intensity of said erasing beam during the erasure of each line of said stored intelligence.

2. In a plan position type display for a radar system, a direct view storage tube of the type including a storage member, a viewing screen adjacent one side of the storage member, means producing a viewing beam for flooding the other side of said storage member, means providing a writing beam to scan said storage member, means to modulate said writing beam to produce a charge pattern on said storage member during said scanning of said storage member, means providing a focused erasing beam which leads said writing beam in scan rotation about said storage member, means to activate said erasing beam to erase said charge pattern line by line on said storage screen, and means to vary the intensity of said erasing beam during the erasure of each line of said charge pattern.

3. In a plan position type display for a radar system, a direct view storage tube of the type including a storage member, a viewing screen adjacent one side of the storage member, means producing a viewing beam for flooding the other side of said storage member, means providing a writing beam to scan said storage member, means to modulate said writing beam to produce a charge pattern on said storage member during said scanning of said storage member, means including a control grid for providing a focused erasing beam which leads said writing beam in scan rotation about said storage member, means

to activate said erasing beam to erase said charge pattern line by line on said storage screen, and means for applying a varying voltage to said control grid to change the intensity of said erasing beam during erasure of each of said lines of said charge pattern.

4. A signal storage tube system comprising an electrical storage tube having an electron permeable charge storage member, a viewing screen spaced from one side of said storage member, and spaced from the other side of said charge storage member, means providing a sharply defined and focused writing electron beam, means for deflecting said sharply defined and focused electron beam across said storage member, means for modulating said electron beam with signal intelligence during deflection thereof to write an electrical charge pattern on said storage member, means providing a viewing flood beam across said storage member so that said written charge pattern on said storage member modulates the flow of electrons of said viewing flood beam passing through said electron permeable member, said viewing beam electrons thereafter impinging on said viewing screen and producing a visual display corresponding to said charge pattern, means providing a focused erasing electron beam, means to deflect said erasing electron beam across said storage member to provide erasure of successive portions of said charge pattern, and means for varying the intensity of said erasing beam over different parts of each portion during the deflection across said portion.

5. In a plan position type display system, a signal storage tube system comprising an electrical storage tube having an electron permeable charge storage member, a viewing screen spaced from one side of said storage member, and spaced from the other side of said charge storage member, means providing a sharply defined and focused writing electron beam, means for sweeping said sharply defined and focused electron beam radially across said storage member, means for modulating said electron beam with signal intelligence during the radial sweep thereof to write an electrical charge pattern on said storage member, means providing a viewing flood beam across said storage member so that said written charge pattern on said storage member modulates the flow of electrons of said viewing flood beam passing through said electron permeable member, said viewing beam electrons thereafter impinging on said viewing screen and producing a visual display corresponding to said charge pattern, means providing a focused erasing electron beam, means to sweep said erasing electron beam radially across said storage member, means to displace said erasing beam with respect to the writing beam, and means for varying the intensity of said erasing beam during the radial sweep thereof.

6. The invention according to claim 5 wherein said last means comprises means for making the intensity of the erasing beam greater during the first part of said radial sweep than it is during the latter part of said radial sweep.

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