Oct. 19, 1948. K. E. GOULD ET AL 2,451,484

CATHODE-RAY SIGNAL UTILIZING MEANS

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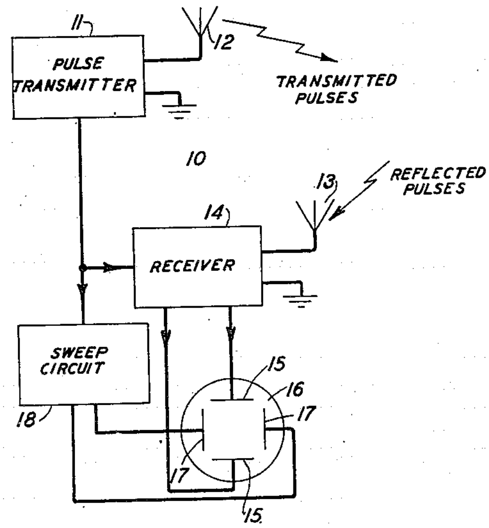

FIG. 1

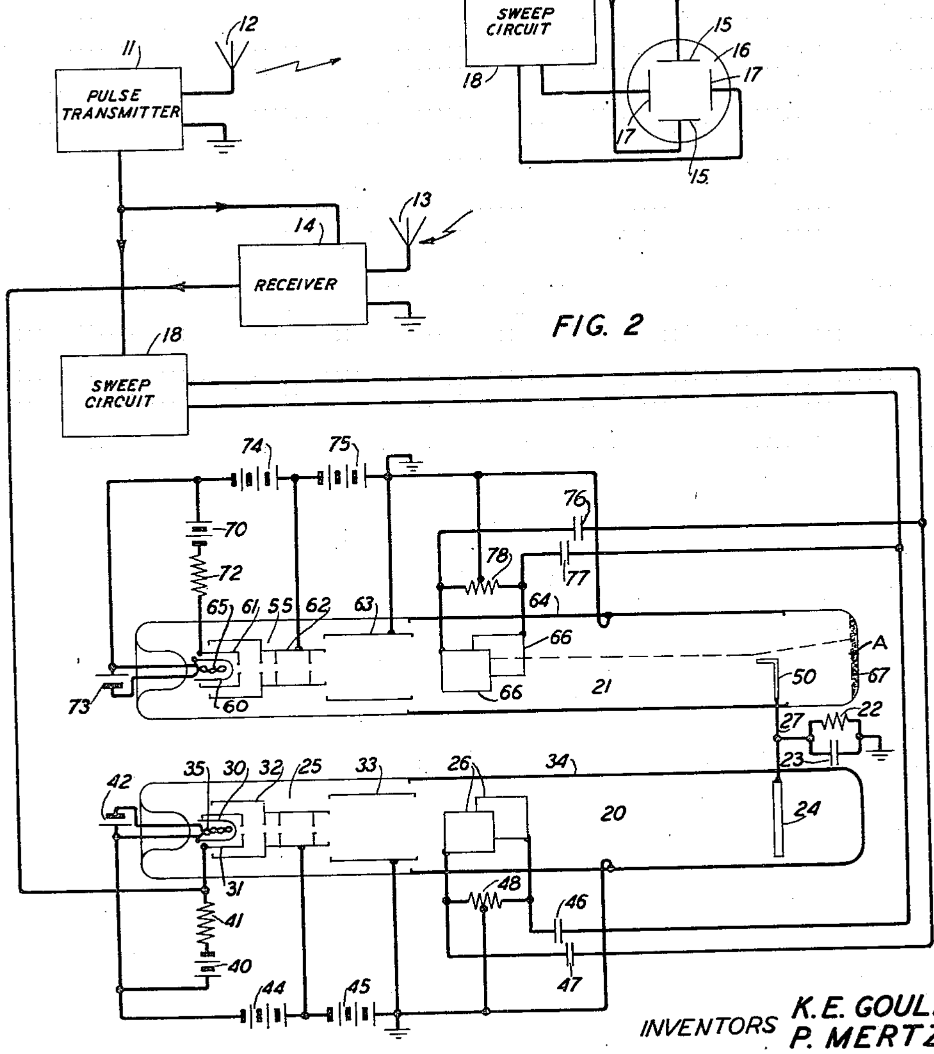

FIG. 2

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FIG. 3

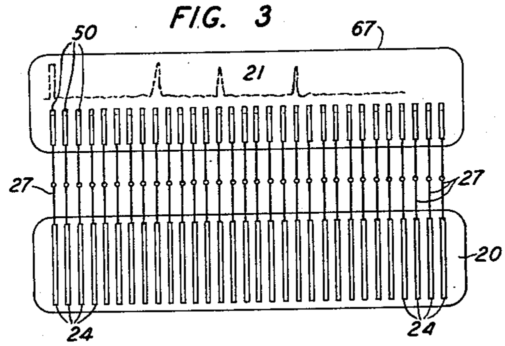


FIG. 6

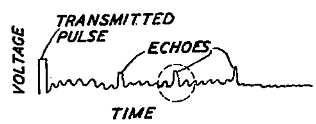


FIG. 7

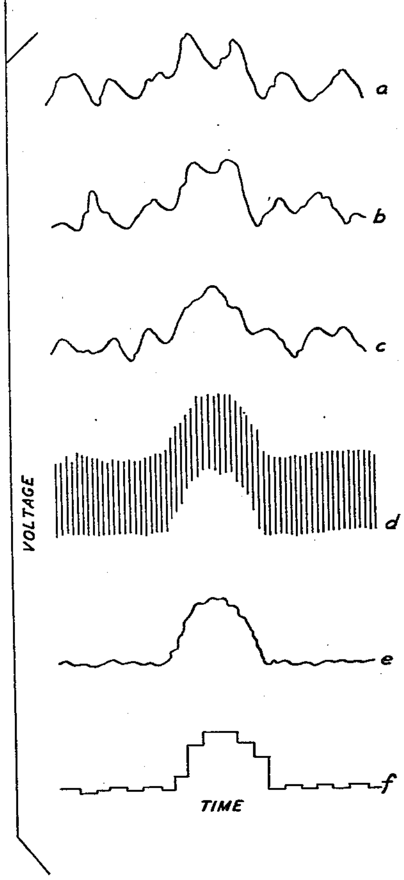


FIG. 4

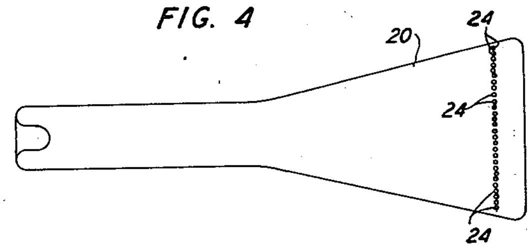
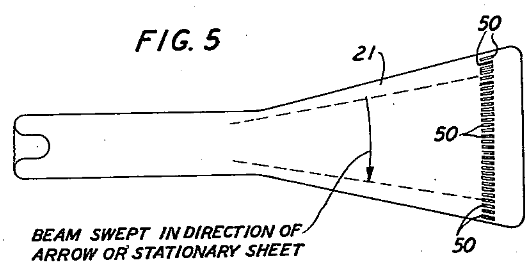


FIG. 5



BEAM SWEPT IN DIRECTION OF ARROW OR STATIONARY SHEET OF ELECTRONS.

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CATHODE-RAY SIGNAL UTILIZING MEANS

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Application October 5, 1943, Serial No. 505,028

21 Claims. (Cl. 315—9)

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This invention relates to cathode ray means for utilizing signals, and in an important specific aspect, to means for distinguishing between signals and noise in radio object-location systems and in other systems using similar signals.

In many radio object-location systems, frequently called "radar" systems, ultra-short carrier waves modulated with spaced pulses are directively emitted from a transmitting station and caused to strike objects within a particular region, causing echoes or reflections therefrom which are received by a receiving system at the transmitting point. After detection, various echo pulses produced by the reflections of a transmitted pulse are observed on the screen of a cathode ray oscilloscope along with a pulse corresponding in time to the transmitted pulse. The pulses are indicated by displacements of the beam perpendicular to the direction of scanning in the cathode ray oscilloscope. The various pulses are interspersed with noise and the noise distorts the successive presentation of the echo signals in an erratic way, and in addition causes spurious variations before and after each echo. Due to the fact that the echo pulses for each transmitted pulse are similarly disposed on the screen there is some effective cumulation of signals due both to the phosphor retentivity of the fluorescent screen and to the retentivity of the eye itself; the effect of these retentivities is to make successive presentations additive, the effect of the latest always being greatest and that of the earlier ones being diminished in order of their age. This additive effect of the signals makes them distinguishable from the random and non-additive (at least to as large an extent) effect of the noise. The effect of these cumulations is, however, not as satisfactory as desired. The present invention, in one of its aspects, relates to the improvement of the signal-to-noise ratio in the observed electrical variations so that the amplitude of the signal pulses can be more clearly differentiated from the noise peaks.

It is an object of the present invention to provide means for improving the signal-to-noise ratio in electric circuits and more particularly in systems adapted to receive pulses reflected from distant objects, which received pulses are accompanied by noise.

It is another object of this invention to provide novel cathode ray means for more clearly differentiating between repeated pulse signals and spurious variations, such as noise variations, which are of random distribution and character.

It is a further object to provide novel cathode

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ray means adapted to a variety of uses in the signal art.

In accordance with a specific embodiment of the invention, shown by way of example for illustrative purposes, successive trains of voltage variations at the receiver, each train extending over an interval corresponding to the time between transmitted pulses (or a fraction thereof) and comprising a number of echo pulses interspersed with spurious variations, (and, if it is not blanked out by means under control of a pulse from the transmitter, for example, a received pulse corresponding to the transmitted pulse) are used to modulate a focused beam of electrons. This beam is caused to strike in turn a number of target elements each of which is connected to an element shaped to deflect a second focused beam of electrons (having a fluorescent screen as a target) in a direction perpendicular to its scanning direction by an amount dependent upon the charge accumulated on the element by the first beam. This accumulation takes place because each element is connected through an integrating circuit, such as, for example, a parallel connected resistance element and capacity element, to ground (the potential of the final anode of the beam forming means). The time constant of this resistance-capacity circuit is made longer than the time interval between transmitted pulses (preferably, very much longer) so as to permit leakage of the charge at a desired low rate. As each of the echo pulses affects the same target element or elements cycle after cycle (for a number of cycles, at least) there is a steady cumulative effect until an equilibrium is reached for the particular voltage of the echo (at which point the increase of charge on the condenser of each cycle is exactly balanced by the decrease due to the leakage through the resistor) but as the noise peaks do not occupy the same position in each train there does not result a corresponding cumulative effect of noise peaks on particular target elements although there is, of course, some cumulation as noise is present throughout each train. Thus the echo pulses are accentuated with respect to the noise variations.

In a modified arrangement, the second beam is a stationary beam (that is, it does not sweep) which is as wide as the row of target elements. The various elemental portions of this beam are deflected by the row of deflecting elements. The amount of the deflection in each case is determined by the charge on the corresponding target element.

While the invention in its primary aspects is concerned with the improvement of the signal-to-noise ratio in radio object-location systems, it will be apparent that in other aspects the invention is not so limited as the apparatus of this invention may be utilized for other purposes as, for example, in an oscilloscope system for observing heartbeats, or in any other system transmitting pulses or waves of substantially even spacing accompanied by spurious current or voltage variations of a random distribution and character.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which:

Fig. 1 shows in greatly simplified form a radio object-locating system of the prior art;

Fig. 2 is a schematic diagram of a radio object-locating system in accordance with the invention;

Fig. 3 is an end view of the cathode ray tubes shown in the system of Fig. 2;

Fig. 4 is a simplified plan view of the lower tube in the arrangement of Fig. 2;

Fig. 5 is a simplified plan view of the upper tube in the arrangement of Fig. 2 and in an alternative arrangement making use of a stationary sheet of electrons instead of a moving beam; and

Figs. 6 and 7 are diagrammatic and graphical representations to aid in understanding the invention.

Referring more specifically to the drawings, Fig. 1 shows in greatly simplified form a radio object-locating system of the prior art while Fig. 2 is a schematic diagram of a radio object-location system shown by way of example to illustrate the principles of novelty of this invention. In the arrangement of Fig. 1, a pulse transmitter **11** produces pulses of any suitable periodicity such as, for example, four hundred per second and each of a length of from one (or a fraction thereof) to ten microseconds. These pulses are used to modulate a suitable ultra-high frequency carrier and are then applied to the transmitting antenna **12**. By way of example, transmitter **11** can comprise an oscillator for providing a sine wave and having a suitable periodicity which can conveniently be four hundred cycles per second. This oscillator energizes a pulse generator of any one of several suitable types well known to the art; for example, see United States Patent 2,117,752, issued May 17, 1938 to L. R. Wrathall, which provides an energy pulse at a particular point of each cycle of the input wave provided to it. The pulse from the pulse generator is then applied to a carrier generator and modulator of any suitable type. Modulated pulses are then applied to the transmitting antenna **12**. Waves reflected from one or more objects within the range of the transmitting antenna **12** are received by the receiving antenna **13**. The antennas **12** and **13** are of any suitable type; they can be, for example, of the polystyrene "polyrod" type disclosed in an application of G. E. Mueller, Serial No. 469,284, filed December 17, 1942 and which issued as Patent 2,425,336 on August 12, 1947. The reflected waves picked up by the receiving antenna **13** (and also the transmitted waves) are applied to a receiver **14** of any suitable form wherein they are amplified and detected and the resultant video signals are then applied to one set of deflecting plates **15**, **15** in the cathode ray oscilloscope **16**. The oscilloscope **16** can be of any well-known type. Applied to the other set of deflecting plates **17**, **17** in the oscilloscope **16** is a sweep wave of saw-

tooth wave form produced by a suitable sweep circuit represented by the box **18** in Fig. 1. As an example of a suitable sweep circuit see Patent 2,178,464, issued October 31, 1939 to M. W. Baldwin, Jr. Pulses from the pulse generator in the transmitter are used to initiate each of the sweep waves so that the beam in the cathode ray oscilloscope **16** starts each sweep cycle upon the occurrence of a transmitted pulse. If desired, by suitable delay means, the sweep wave can be initiated a predetermined time after the occurrence of each of these pulses. Moreover, a so-called "expanded sweep" wave can be utilized if it is desired to view only a portion of the video signal with this portion being spread out or amplified in the direction of sweeping. Variable delay means are ordinarily used with expanded sweeps. For an example of an expanded sweep generator and variable delay means, reference is made to Patent 2,244,513, issued to E. T. Burton on June 3, 1941.

In the arrangement of Fig. 1, there is viewed on the screen of the oscilloscope **16** a "type A scan," that is, a plot of signal intensity appearing as a deflection on the cathode ray oscilloscope versus time which represents range. Such a plot is shown generally in Fig. 6. The start of each sweep or scan is preferably synchronized, as pointed out above, with the outgoing or transmitted pulse. Returning echoes are then indicated by displacement of the beam perpendicular to the direction of scanning. In the "type A scan" there is some cumulation of the signal, both by the phosphor retentivity and by the eye response. A better understanding of the cumulation in the "type A scan" may be had by referring to Fig. 7 which shows (greatly amplified) various plots of signal voltage vs. time for a very small portion of the trace of Fig. 6 (such as the portion in the dashed-line circle). Figs. 7*a*, 7*b* and 7*c* represent in a schematic way successive traces of the region around a particular echo and the noise accompanying it. The noise distorts the successive presentations of the echo signal in an erratic way, and in addition, causes the formation of spurious signals or variations before and after the echo. The effect of the eye and phosphor cumulation is to superpose successive presentations, the latest always appearing most bright and the earlier signals appearing with diminished brightness in order of their age. The result is shown schematically in Fig. 7*d*. The trace of the echo signal shape is broadened out by the noise, but the center of gravity of the broader trace shows, more exactly than is the case with any one single scan, the systematic shape of the echo signal. The type of effect that is desired from the cumulation of the sort which takes place in the present invention is shown in Fig. 7*e*. Here at every abscissa an ordinate is plotted which represents the "running weighted average" of the corresponding ordinates in the traces being cumulated, the most recent signal being given the most weight and the others decreasing in weight in order of their age. The echo indication follows the same general outline as in Fig. 7*d* but the trace is narrower. The residual irregularities in the trace will vary slowly with time, in accordance with the time constant of the cumulating mechanism to be described below. It is clear that this trace gives a more favorable indication than that obtained in Fig. 7*d*, the improvement being greater as the number of traces being cumulated becomes larger.

In accordance with the present invention a trace, such as that shown in Fig. 7*f*, which is roughly like the "ideal" trace of Fig. 7*e*, is obtained from trains of signals which produce successive traces as shown in Figs. 7*a*, 7*b* and 7*c* by storing the signals corresponding to the ordinates for each abscissa separately, over a period corresponding to that for the number of scannings desired, and by having the storage mechanism deliver to the final trace a signal proportional to the "running weighted average" of this cumulation, that is, an average in which the more recent signals are given more weight than those preceding them. The trace of Fig. 7*f* differs from the "ideal" one shown in Fig. 7*e* because of the finite dimensions of the parts of the target elements in the apparatus now to be described.

A specific embodiment of apparatus to accomplish this purpose is shown in Fig. 2. In this arrangement, the transmitter **11**, the transmitting antenna **12**, the receiving antenna **13**, the receiver **14** and the sweep circuit **18** are respectively similar to the corresponding elements in Fig. 1. The oscilloscope **16** has been replaced, however, by two tubes **20** and **21** (which may be, if desired, replaced by a single tube having both guns, all target elements, and both sets of deflecting elements arranged therein). These two tubes have a multiplicity of connections **27** therebetween (see Fig. 3). Each connection **27** is connected through a parallel connected resistance member **22** and capacity member **23** to ground (the potential of the final anode in the tube **20**) as will be apparent from the description which follows.

The tube **20** comprises an evacuated container enclosing a multiplicity of target elements **24**, an electron gun **25** for generating, focusing and accelerating a beam of electrons of such velocity that a negative charge can be built up on each of the target elements **24** in turn, and a pair of electrostatic deflecting plates **26**, **26** for causing the beam of electrons to contact every elemental target element **24** in turn. The electron beam generated by the gun **25** is modulated by the output waves (the video signals) from the receiver **14** in a manner which will be described more completely below.

The electron gun **25** preferably comprises a cathode **30**, a control electrode or member **31**, a first anode member **32**, and a second and final anode member comprising a cylindrical member **33** and a coating **34** of conducting material on the inside wall of the envelope extending from the region of the cylinder **33** to the region of the target element **24**.

The control electrode **31** is placed at any suitable negative potential with respect to the potential of the cathode **30** by means of the source **40** and the resistor **41**, the positive terminal of the source being connected to the cathode **30**. The video signal from the receiver **14** is applied to the control electrode **31**. The cathode **30** is heated by a heater **35** which receives current from a source **42** connected thereacross. The first anode **32** and the final anode members **33**, **34** are placed at appropriate positive potentials with repect to the cathode **30** by means of the source **44** and the source **45**. The negative terminal of the source **44** is connected to the cathode **30** while the positive terminal thereof is connected to the negative terminal of the source **45**, the positive terminal of which is connected to ground and to the final anode members **33** and **34**. The potentials applied to the various electrode members and their location and shape are such that a beam of focussed electrons strikes the target elements **24**. These elements may, if desired, be treated with carbon so as to ensure that the ratio of primary electrons striking each target element to the number of secondary electrons leaving it is less than one so that a negative charge can be built up on each element in turn as the condenser **23** connected between the element and ground is charged. The resistor **22** allows the charge to leak off but the time constant of each circuit is longer than the time period between successive transmitted pulses from the transmitter **11**. The charge on each target element **24** is proportional to the "running weighted average" of the signals, over a number of the most recent cycles, which are used to modulate the beam when it is in position to strike the particular target element. It will be readily apparent that the action of the condenser **23** and resistor **22** tends to weight the most recent signal most and the others less and less in the order of their age.

The beam generated by the electron gun **25** is caused to be deflected upon each of the target elements **24** in turn by means of appropriate potentials applied to the deflecting plates **26**, **26** by the electrostatic sweep circuit **18**. The sweep circuit **18** is connected to the plates **26**, **26** by means of coupling condensers **46** and **47** while a resistance **48** of the value of many megohms is connected across the plates **26**, **26**. The mid-point of the resistance **48** is connected to ground so that the average of the potentials of the deflecting plates does not deviate more than slightly from the potential of the final anodes **33**, **34**. This relationship is maintained to avoid changes in the sensitivity of the deflecting system and the consequent distortion which would otherwise result. The sweep circuit **18** is synchronized by pulses from the transmitter **11** so that each sweep wave is actuated by a pulse from the transmitter or from some pulse at a constant time relationship thereto. If desired, a delay circuit (not shown), and which may be variable, may be included in the circuit between the pulse transmitter **11** and the sweep circuit **18**. This sweep circuit causes the beam in the tube **20** to contact in turn each of the target elements **24** (see Fig. 3) within the time interval corresponding to the period between two successive pulses from the transmitter **11**. As the intensity of the cathode ray beam during the sweep movement is varied by the video signal from the receiver **14**, which video signal comprises the received transmitted pulse from the transmitter (unless it has been blanked out), one or more echo pulses from a target or targets which have been struck by the pulses transmitted from the sending antenna **12** and spurious variations which are generally designated "noise," each of the target elements **24** receives electrons from the beam in varying amounts depending on the voltage of the video signal at the particular instant the beam is on the target element in question. These electrons, successively applied, for example, four hundred times per second, are utilized to charge up the condensers **23** one of which is connected between each target element **24** and ground (the potential of the final anode in the tube **20**). Each of the condensers **23** is shunted by a resistance **22**. The time constant of each of these resistance-capacity circuits is preferably made much longer than the period between repeated scannings of the corresponding target element **24** so that the potential of each element **24** (after a short initial period required to build up the charge on the condenser **23**) is proportional to the "running weighted average" of the successive video signals corresponding to the particular target element. If the particular target element 24 is in such position that it has applied thereto repeatedly beam currents representative of an echo signal, its "running weighted average" potential will be emphasized with respect to the "running weighted average" potential of a target element which is being repeatedly struck by the beam when it is being modulated by noise variations only as the peaks of noise do not appear in the same position in each cycle, as represented by Figs. 7*a*, 7*b* and 7*c* which are greatly enlarged views of the visual indication for the area adjacent an echo pulse for three successive scannings of this area. Single traces, such as shown in Figs. 7*a*, 7*b* and 7*c*, can be obtained on the screen of a cathode ray oscilloscope using phosphorescent material for the screen. The noise peaks tend to add up in random time so it is for this reason that the "running weighted average" potential of the target element struck by the beam when varying in intensity with the noise level assumes a value which is proportionally much less than for those struck by the beam when it is being modulated by echo signals. In other words, the noise peaks are flattened out with respect to the echo pulses when cumulation of this type takes place.

Connected to each target element 24 by the conductor 27 is a deflecting element 50, the deflecting elements 50 being arranged in a line in the tube 21. The tube 21 includes an electron gun 55, which is similar to the electron gun 25 in tube 20 and which comprises a cathode 60, a control element 61, a first anode member 62, a second anode member 63, 64 and a cathode heater 65, and a pair of deflecting plates 66, 66. The members 60 to 65, inclusive, correspond respectively to the corresponding members 30 to 35 and the plates 66 correspond to the plates 26 in the tube 20. Sources of direct potentials 74 and 75 corresponding to sources 44 and 45 are provided to supply proper anode potential for the anode members 62, 63 and 64, while source 70 and resistor 72 corresponding to the source 42 and resistor 41 in the circuit of the tube 20 place the control element 61 at a negative potential with respect to the cathode 60. Unlike the circuit of the tube 20, however, no modulating signals are applied to the control element 61 as the beam in the tube 21 is not caused to be varied in intensity. A suitable source 73 is supplied to provide current for the heater 65.

The focused beam in the tube 21 is adapted to be deflected in a path above the horizontal portions of the deflecting member 50 by means of the sweep wave applied between the deflecting plates 66, 66 from the sweep circuit 18, the beam in the tube 21 being synchronized with that in the tube 20. This synchronization is merely illustrative, however, and is not required. Entirely separate sweep circuits may be provided to deflect the beams in the two tubes, if desired. For example, the sweep circuit 18 may be used to deflect the beam in the tube 20 while a separate sweep circuit which may be self-oscillating can be used to deflect the beam in the tube 21. The frequency of the sweep circuit connected to the plates 66, 66 may be higher than that connected to the plates 26, 26 or it may be lower. It should not, however, be low enough to give flicker trouble or so low that the actual changes in signal permitted by the time constant of the circuit 22, 23 are not followed and this information lost. Coupling condensers 76 and 77 and resistor 78, respectively, fulfill functions similar to the corresponding members 46, 47 and 48 in tube 20.

The beam, in the absence of a deflecting signal applied to a deflecting element 50 by means of its connection to the corresponding target element 24, is adapted to just pass over but not touch the horizontal portion of the member 50. When a member 50 has a negative charge applied thereto because of the charge on the corresponding member 24, the electrons in the beam are repelled, as indicated by the dotted line in Fig. 2, and the beam strikes the fluorescent screen 67 at the end of the tube 21 at a point which is above the base line, represented in Fig. 2 by the point A, by an amount depending upon the intensity of the charge applied to the target member 24 by the beam in the tube 20. The continuous trace appearing on the fluorescent screen 67 is therefore of the type shown schematically in Fig. 3 which is an end view of the tubes 20 and 21 to show the rows of target elements 24 (of tube 20) and deflecting elements 50 (of tube 21). Simplified plan views of the tubes 20 and 21 omitting the electron guns and deflecting plates are shown in Figs. 4 and 5, respectively.

The operation of the arrangement shown in Fig. 2 is as follows: Pulses are sent out from the transmitting antenna 12 and received by the receiving antenna 13. Between transmitted pulses, echo signals, produced by reflections of the transmitted pulses from one or more targets, are received by the receiving antenna and these with the transmitted pulse and the accompanying noise produce a train of signals or electrical variations. These trains, after being removed from the carrier and amplified in the receiver 14, are applied to the control element 31 of the tube 20 to modulate the beam therein and to vary the intensity thereof in accordance with the variations in the video signal. These variations are represented by the ordinates in the train of signals shown in Fig. 6. As the target elements 24 are treated to discourage secondary emission, more electrons are collected from the beam than there are leaving each target element, causing its potential to swing in a negative direction by an amount depending upon the intensity of the beam which, in turn, is proportional to the intensity of the corresponding portion of the signal train. This swing in potential causes the condenser 23 corresponding to the element 24 to be charged. Some of the charge leaks off through the resistance 22 during the interval between successive scannings of the same elemental target member 24 but the time constant of this circuit is preferably made much longer than the time interval between transmitted pulses. That is, the leakage is low. As the echo pulses affect the same target element cycle after cycle (for a number of cycles at least) there is a steady cumulative effect until an equilibrium is reached (at which point the amount of charge added by the beam is balanced by that subtracted by the discharge through the resistor 22) but as the noise peaks do not, in general, occupy the same position in each train there does not result a corresponding cumulative effect of noise peaks on any single target element. The noise peaks tend to accumulate in a random manner rather than by direct cumulation as a noise peak may cause the charge of one condenser element 23 during one train of signal waves and the charge of another condenser element during a succeeding train of waves. Due to the direct connection between each target element 24 and the corresponding deflecting element 50 in the tube 21, each of the members 50 is at a negative potential (of varying value along the row of members) with respect to the final anode members 63, 64 in that tube. The beam of constant intensity in the tube 21 is caused to pass over each of the deflecting members 50 in turn and to be deflected upward (in the plane of Fig. 2) by an amount depending on the value of the potential of the member 50. This will produce a trace on the screen 67 of the tube 21 which, if an expanded sweep wave is used, will be like that shown in Fig. 7*f*. This trace, it will be readily understood, is a marked improvement over that shown in Fig. 7*d* and is generally equivalent to the "ideal" trace of Fig. 7*e*.

Preferably there should be as many deflecting members 50 to the inch as physical possibilities dictate. Where the device is used merely for searching purposes the invention can be applied directly to the complete sweep. Where accuracy in range indication is needed, the invention can be applied to an expanded sweep wave, which is, as pointed out above, a wave which produces a sweeping during only a portion of the time between successive transmitted pulses.

Instead of a small diameter focused beam in the tube 21, a sheet of electrons can be utilized and it will not be necessary to move this sheet. In such an arrangement the electron gun system 55 of the tube 21 is replaced by any well-known electron optical arrangement for producing a sheet rather than a beam of electrons and the deflecting plates 66, 66 are removed entirely. Such an arrangement is shown in Fig. 3 of an application of G. K. Teal, Serial No. 404,767, filed July 31, 1941, and which issued as Patent 2,337,578 on December 28, 1943. In this arrangement the various portions of the sheet are deflected upwardly to produce the type of trace on the screen 67 described above and which may be, if expanded sweep waves are used, like that shown in Fig. 7*f*. The alternative use of a stationary sheet is indicated in Fig. 5 of the drawings.

As a modification, each circuit 22, 23 may be replaced by any other form of integrating circuit to change the weighting curve in obtaining the "running weighted average."

In another modification, the tubes 20 and 21 can be combined to form a single tube and one of each of the members 24, 27 and 50 combined to form a single member.

Various other modifications may be made in the embodiment disclosed above without departing from the spirit of the invention, the scope of which is indicated in the appended claims. It will be noted that the invention in certain of its broader aspects may find a wide variety of uses; for example, the two electron beams which cooperate to produce an indication of the size or character of signals with which one of the beams is modulated may obviously be used in synthesizing images, the modulating signals being representative of the light-tone values of elemental areas of the subject an image of which is to be produced. The deflections of the second beam may readily be converted into intensity variations by means well known in the art, such, for example, as by the use of optical wedges receiving light from the respective illuminated portions of the fluorescent screen with optical means for collecting the light transmitted through the wedge or wedges and aligning it on a screen. The storage feature of the invention, moreover, has special utility where time spaced signals are regularly repeated and corresponding cumulative electric charges control amplitudes of deflections which are made visible as corresponding displacements from a base-line, the eye being adapted to distinguish between small differences in position better than between small differences in light intensity.

What is claimed is:

1. Means for differentiating between repeated pulse signals and spurious variations of a random distribution and character, comprising means for producing a beam of electrons modulated with said pulse signals and said spurious variations, an array of insulated electrical conductors, means for repeatedly sweeping said beam over said conductors in turn to charge them with electrons from said beam, said sweeping means comprising means for starting each sweep a short period before said beam is modulated in accordance with one of said pulses, said period being the same or nearly the same for each sweep, whereby the conductor or conductors which are impinged by said beam at the instants the modulations thereon correspond to said pulses receive a charge each sweep cycle while adjacent conductors receive charges corresponding to the spurious modulations only occasionally because of the random distribution of the spurious variations, and means under control of the charges on said conductors to enable a comparison of said charges to be made.

2. Means for differentiating between repeated pulse signals and spurious variations of a random distribution and character, comprising means for producing a beam of electrons modulated with said pulse signals and said spurious variations, an array of insulated electrical conductors, means for repeatedly sweeping said beam over said conductors in turn to charge them with electrons from said beam, said sweeping means comprising means for starting each sweep a short period before said beam is modulated in accordance with one of said pulses, said period being the same or nearly the same for each sweep, whereby the conductor or conductors which are impinged by said beam at the instants the modulations thereon correspond to said pulses receive a charge each sweep cycle while adjacent conductors receive charges corresponding to the spurious modulations only occasionally because of the random distribution of the spurious variations, means for generating a second beam of electrons, and means under control of the charges on said conductors to influence said second beam of electrons.

3. The combination of elements as in claim 2 in which said second beam is a wide stationary beam the width of which corresponds to the length of the array of insulated electrical conductors.

4. The combination of elements as in claim 2 in which said second beam of electrons comprises a beam having a relatively small cross-section, said second beam being adapted to be deflected over each of the insulated electrical conductors in turn without contacting any of them.

5. Means for differentiating between repeated pulse signals and spurious variations of a random distribution and character, comprising means for producing a beam of electrons modulated with said pulse signals and said spurious variations, an array of insulated electrical conductors, means for repeatedly sweeping said beam over said conductors in turn to charge them with electrons from said beam, said sweeping means comprising means for starting each sweep a short period before said beam is modulated in accordance with one of said pulses, said period being the same or nearly the same for each sweep, whereby the conductor or conductors which are impinged by said beam at the instants the modulations thereon cor-

respond to said pulses receive a charge each sweep cycle while adjacent conductors receive charges corresponding to the spurious modulations only occasionally because of the random distribution of the spurious variations, means for generating a second beam of electrons, means for controlling said second beam in response to said charges, and a fluorescent screen upon which the electrons of said second beam impinge.

6. In combination, means for forming a beam of electrons, means for modulating said beam with successive trains of electrical signals, means responsive to said modulation of said beam for building up a plurality of electrical charges over a period of time corresponding to the duration of a plurality of said trains, means for forming a second beam of electrons, means for sweeping said second beam in one direction, and means for utilizing said charges without varying their intensity to produce successive deflections of said second beam in directions transverse to said one direction.

7. In combination, means for forming a beam of electrons, means for modulating said beam with successive trains of electrical signals, means responsive to said modulation of said beam for building up a plurality of electrical charges over a period of time corresponding to the duration of a plurality of said trains, means for forming a sheet of electrons, and means for utilizing said charges to cause each of a plurality of portions of said sheet along a transverse portion thereof to be deflected substantially independently of the other portions.

8. In combination, means for forming a time modulated beam of electrons, means for forming a sheet of electrons, and means controlled by said beam for simultaneously controlling different elements of said sheet along a line transverse to said sheet in accordance with successive modulations of said beam respectively.

9. In combination, means for forming a beam of electrons, means for modulating said beam with signals, means for forming a sheet of electrons simultaneously with the formation of said beam, and means responsive to the modulated beam for causing the simultaneous deflection of certain portions at least of the sheet along a transverse region thereof.

10. In combination, means for forming a beam of electrons, means for modulating said beam with a signal train, means including an array of target elements which are successively contacted by said beam for setting up separate elemental charges thereon, means for forming a second beam of electrons, and means for deflecting said second beam in a direction parallel to the longitudinal axis of said array of elements and in a path which is displaced from all the elements in a direction at right angles to said direction of deflection so that said second beam passes said target elements in succession but does not touch any of them, whereby said second beam is caused to be deflected in a direction perpendicular to said axis by each charge in turn and by an amount proportional to the charge.

11. In combination, a condenser, cathode ray means for repeatedly applying charging impulses to said condenser, means for relatively slowly discharging said condenser at a rate which permits only a partial discharge thereof within the period of time between successive charging impulses, whereby a cumulative charge is formed, means for generating a cathode ray beam independent of said cathode ray means, and means for utilizing said cumulative charge to deflect said cathode ray beam.

12. In combination, means for setting up a succession of trains of electrical waves each train comprising a plurality of signal pulses interspersed with spurious variations of a random distribution and character, and electron discharge means for increasing the contrast between the amplitudes of said signals and interference peaks, said last-mentioned means including means for modulating a first beam of electrons with said trains of waves, means responsive to said first beam of electrons for causing the deflection of a second beam of electrons, and a fluorescent screen upon which said second beam impinges.

13. The combination with an array of electron deflecting elements within an evacuated space, of means for generating and simultaneously projecting electrons past each of said deflecting elements, electric storage means equal in number to said deflecting elements and respectively connected thereto, means for impressing signals on said storage elements, and means for utilizing the resulting deflection of the electrons passing said elements to produce effects indicative, at any given instant, of the respective charges in said storage means.

14. In combination, means for regularly repeating substantially the same train of signals, means for generating a beam of electrons modulated with said repeated signals, an array of conductive elements serving as a target for said beam, means for repeatedly sweeping said beam over said array at the repetition frequency of said signal train, means for generating a second beam of electrons and causing it to pass by said conductive elements in proximity thereto, separate electric storage means connected respectively with said conductive elements, separate leakage paths for said storage means respectively to permit charges to leak from said conductive elements at a rate to permit an accumulation of charges over a plurality of cycles of said signal train, and means for visually indicating the amounts of deflection of said second beam caused by the charges on said electrical conductors.

15. The combination of claim 14 in which said indicating means comprises means for producing visual indications the positions of which indicate the respective deflections.

16. The combination of claim 14 in which said means for producing a second beam causes this beam to be in the form of a sheet of electrons so wide at said array as to extend thereacross.

17. The combination with a stationary sheet of electrons, of an array of electron deflecting elements parallel to said sheet, in proximity thereto, and extending transversely thereof, means for distributing electric current to said elements in succession to charge them electrically and thereby cause portions of the sheet adjacent said elements to be deflected in accordance with the charges impressed on said elements, and a screen upon which the different deflected portions of said sheet impinges to produce visual indications of the amount of deflection.

18. The combination with means for producing a regularly repeated train of signal impulses which are similarly widely spaced apart in each train, of an array of cathode beam deflecting conducting elements, means for generating a beam of electrons and causing it to pass by each of said conducting elements in close proximity thereto, said array extending transverse to

said beam, separate electric storage means conductively associated with said elements respectively, means for distributing said signal impulses of each train to certain ones of said elements so that corresponding impulses of the different trains are impressed upon the same element or elements, separate leakage paths for said conductive elements respectively to permit charges to leak therefrom at a rate to permit an accumulation of charges for a plurality of signal trains, and means for producing visual indications the positions of which indicate the respective amounts of beam deflection caused by the charges on said storage means.

19. In combination, an array of condensers, cathode ray means for repeatedly applying charging impulses to said condensers, means for relatively slowly discharging said condensers at a rate to permit only a partial discharge thereof within the period of time between successive charging impulses, whereby a cumulative charge is formed on each condenser, means for generating an electron stream, means for utilizing said cumulative charges to deflect said electron stream, and means for giving said stream of electrons an additional component of motion in a direction perpendicular to said deflections.

20. The combination with a conductive electron-target structure which is insulated except for a leakage path of predetermined resistance value to permit an electric charge thereon to leak off, of means for causing electrons to impinge upon said target structure to impart a charge thereto, and means separate from said causing means to direct other electrons in such a manner that they pass, in the form of a stream, a portion of said structure and are deflected by

the charge imparted by the impinging electrons, the amount of deflection depending upon the size of the charge which in turn depends upon the rate of reception of the impinging electrons.

21. The combination with an array of similar conductive electron-target structures each of which is insulated except for a leakage path of predetermined resistance value to permit an electric charge thereon to leak off, of means for causing electrons to impinge upon said target structures in turn and other electrons, in the form of a stream, to pass a portion of each of said target structures in turn whereby the latter are deflected by the charges imparted by the impinging electrons and the amount of said deflection is at each instant dependent upon the size of the charge on the target structure which said stream is then passing.

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