March 4, 1958 R. R. PITTMAN ET AL 2,825,886

CATHODE RAY TUBE VIEWING DEVICE

Filed June 7, 1956 8 Sheets-Sheet 1

FIG. 1.

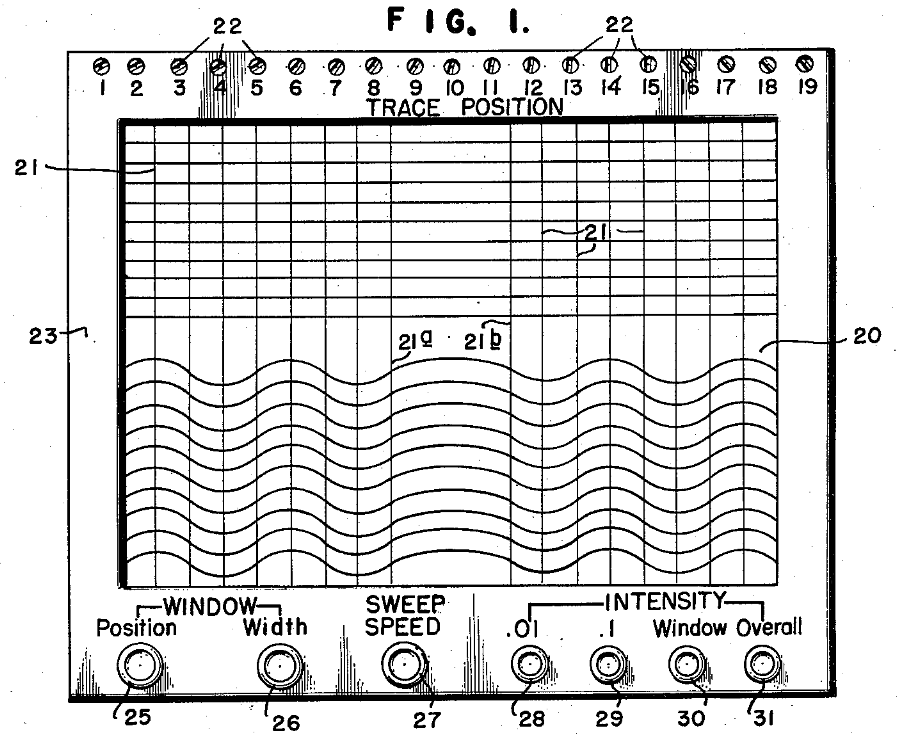
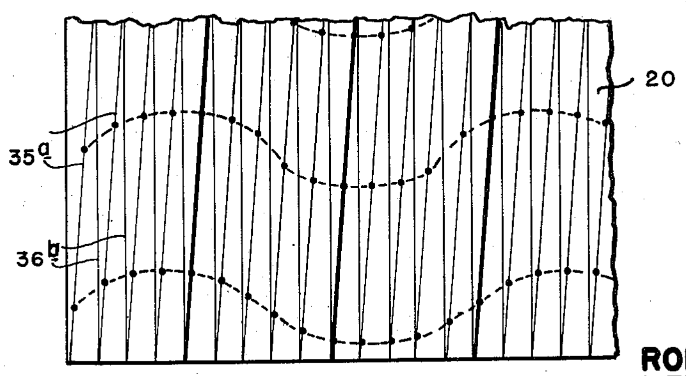


FIG. 2



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CATHODE RAY TUBE VIEWING DEVICE

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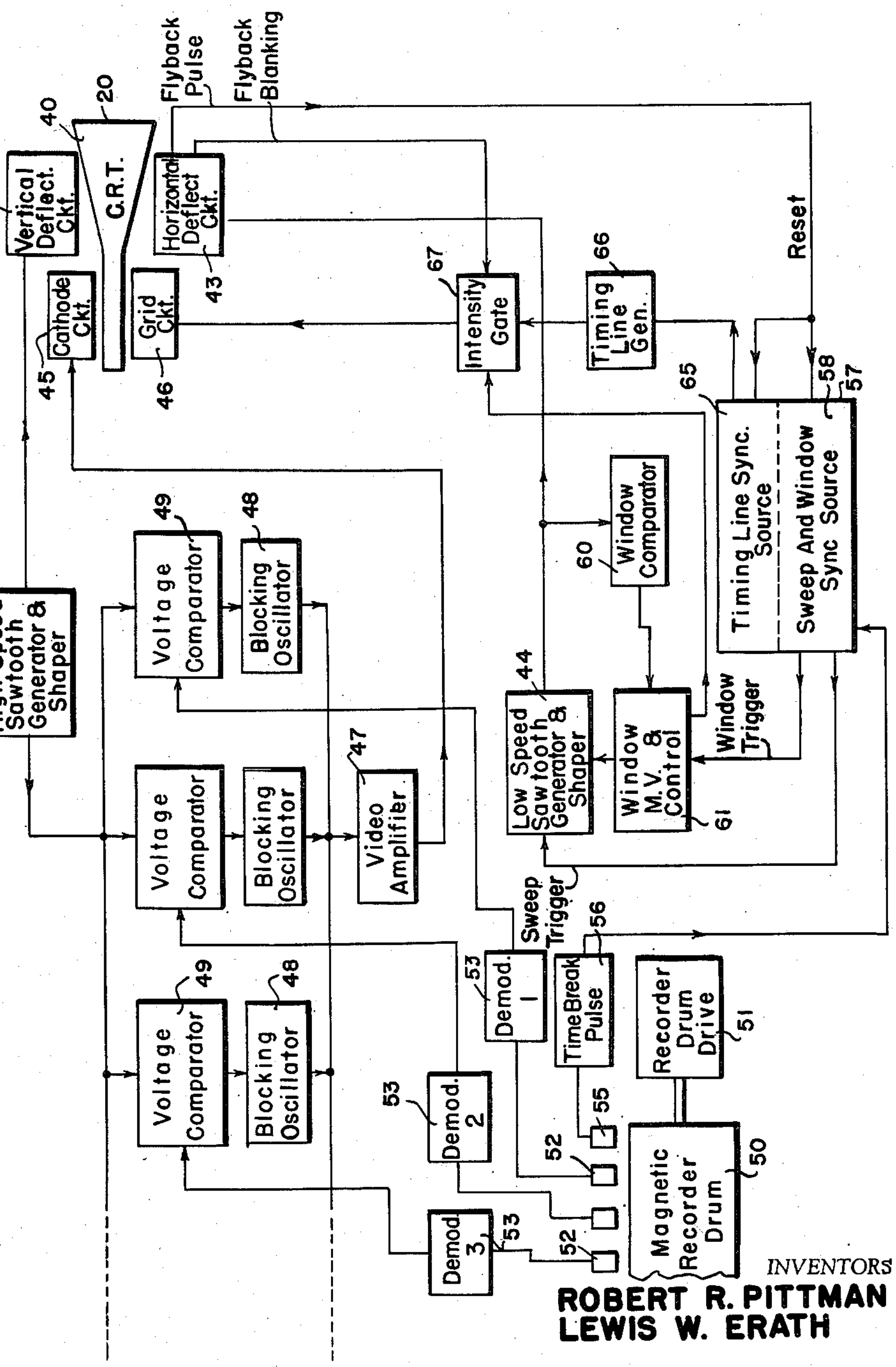

FIG. 3.

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CATHODE RAY TUBE VIEWING DEVICE

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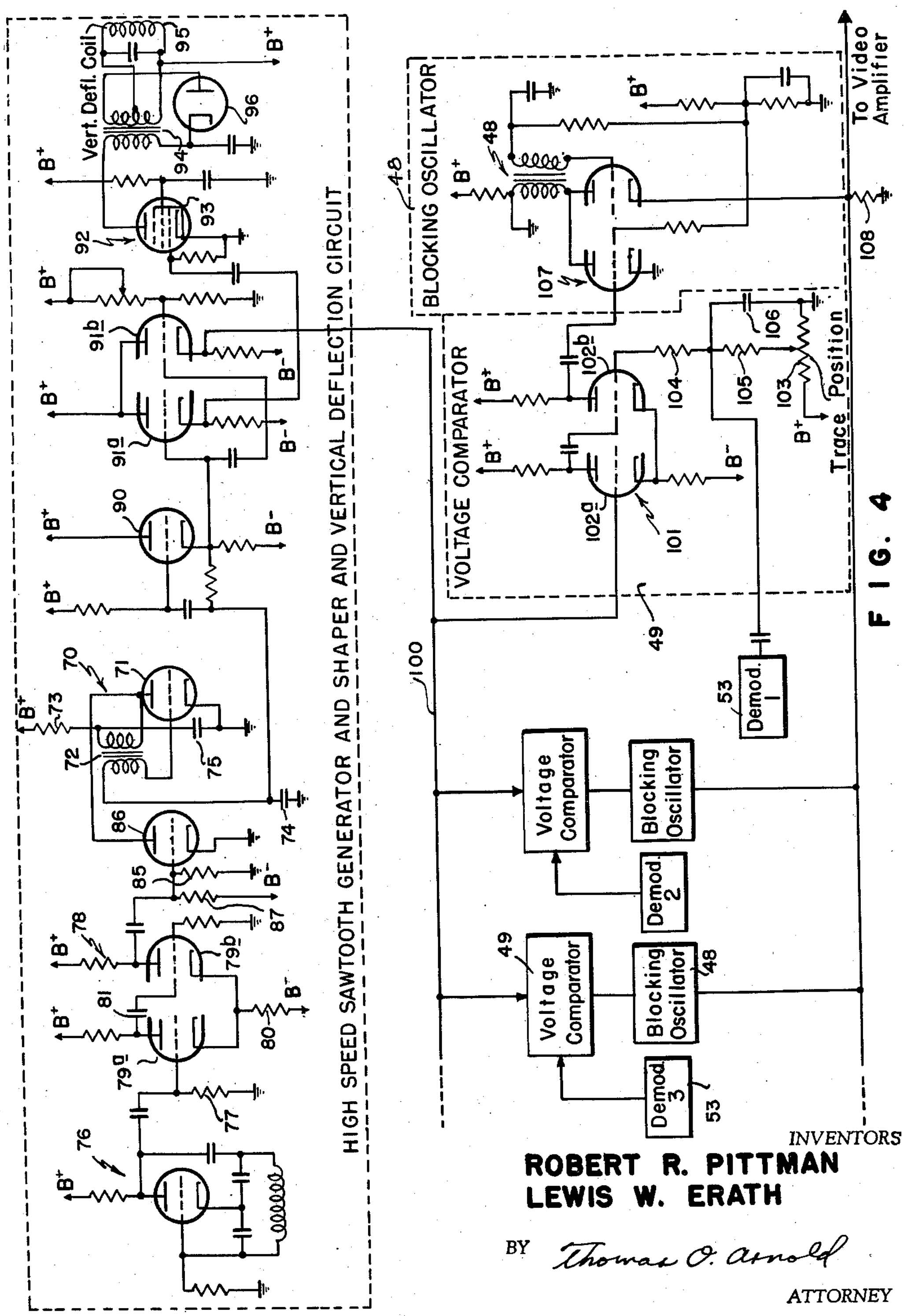

FIG. 4

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CATHODE RAY TUBE VIEWING DEVICE

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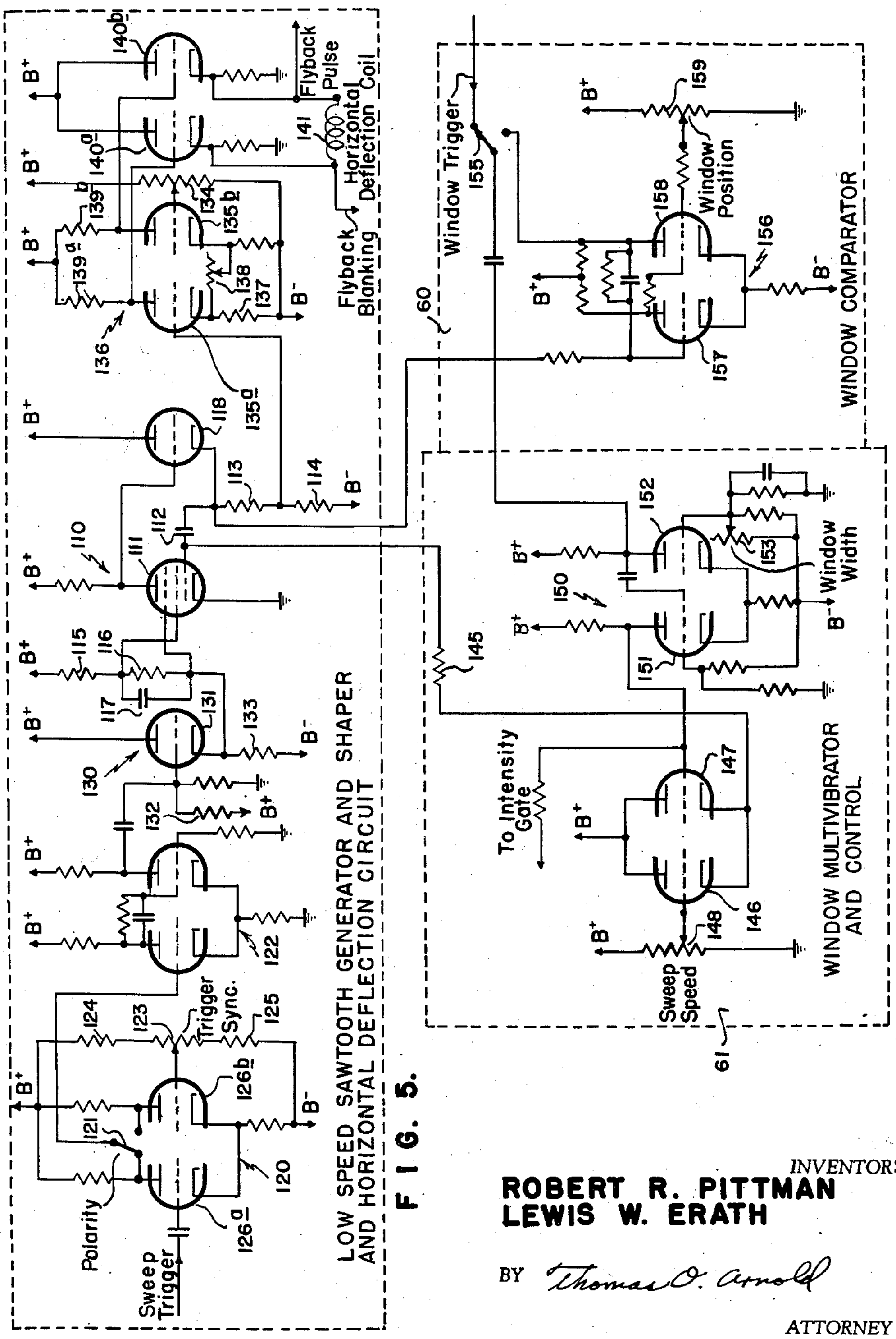

FIG. 5.

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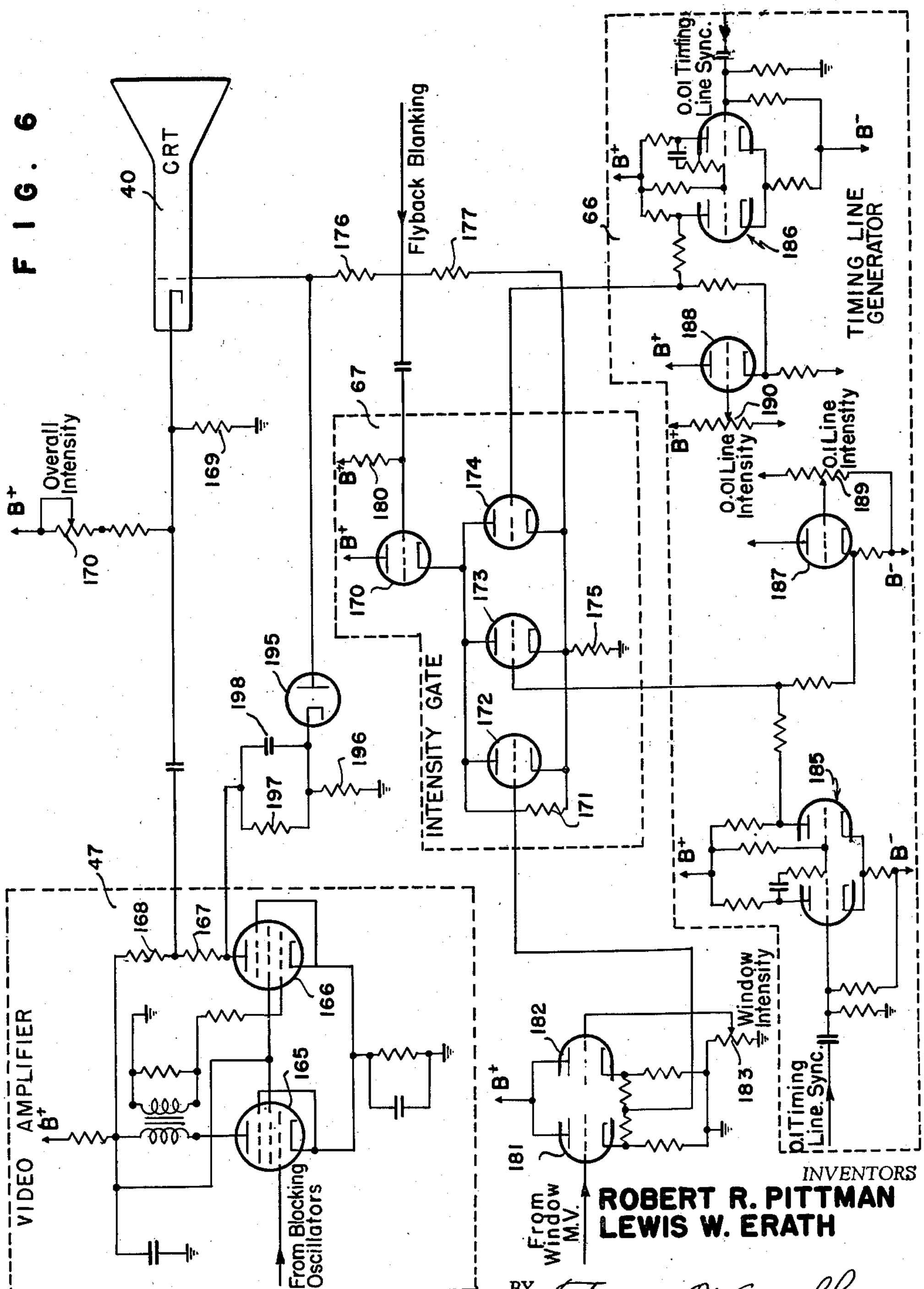
FIG. 6



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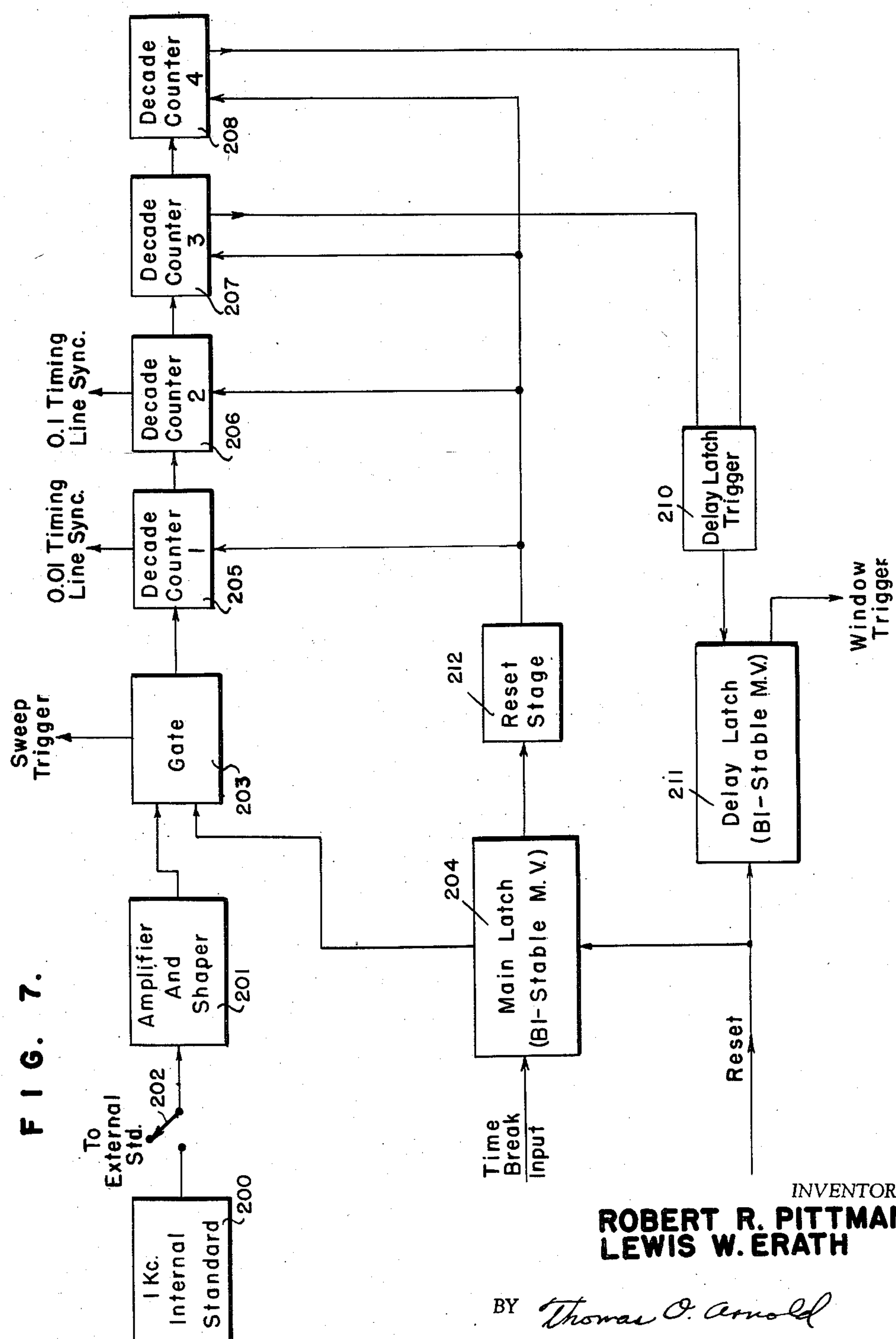

FIG. 7.

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CATHODE RAY TUBE VIEWING DEVICE

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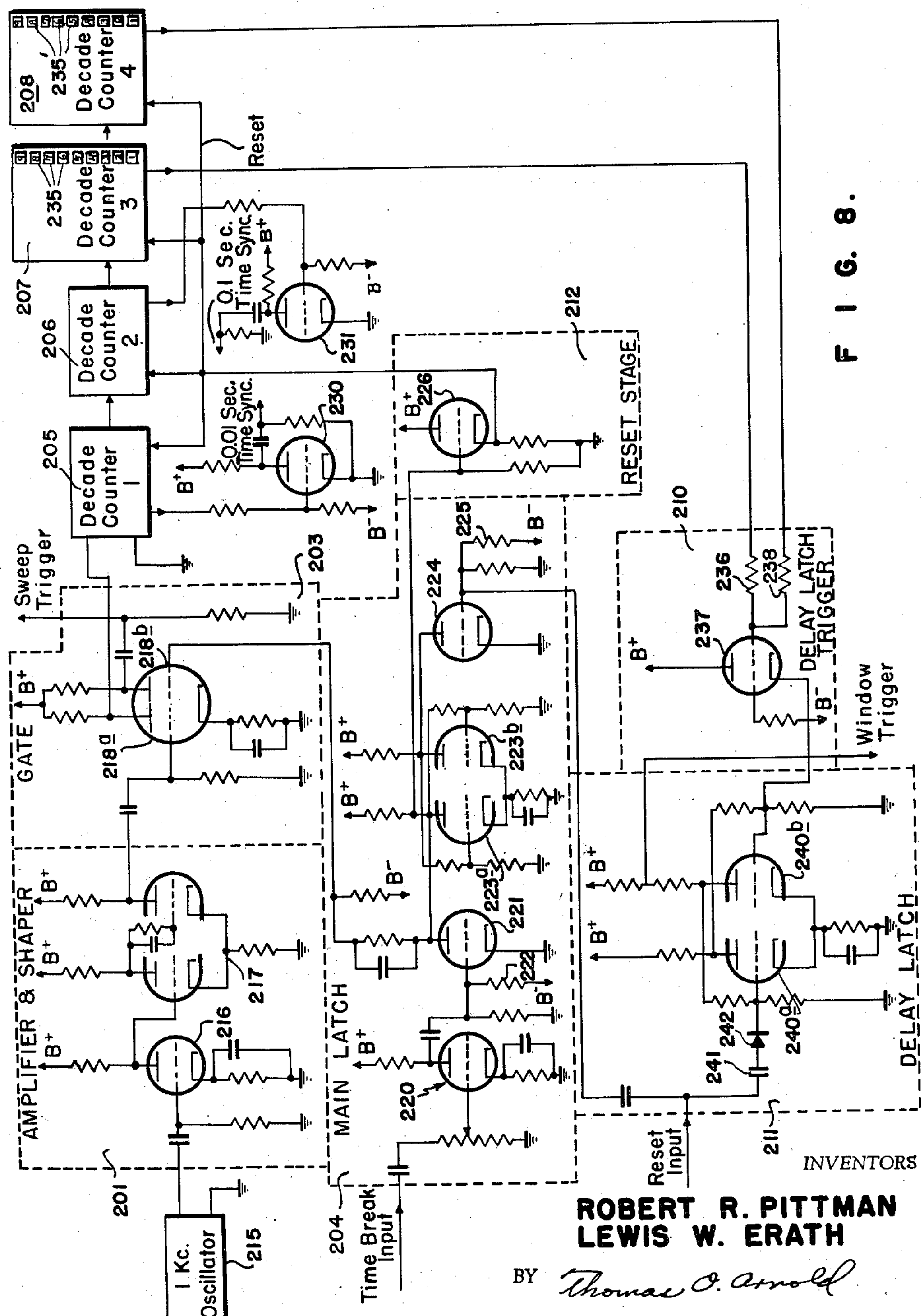

FIG. 8.

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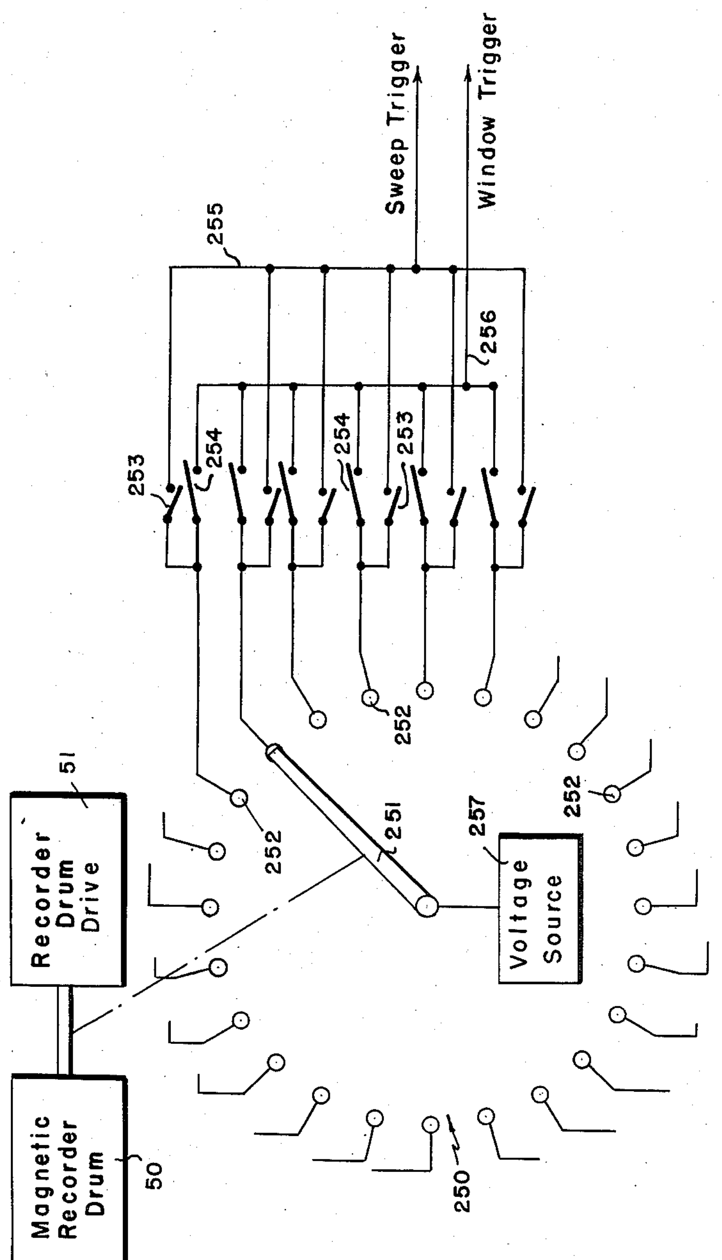
FIG. 9.



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United States Patent Office

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2,825,886

CATHODE RAY TUBE VIEWING DEVICE

Robert R. Pittman and Louis W. Erath, Harris County, Tex., assignors to Southwestern Industrial Electronics Company, Harris County, Tex., a corporation of Delaware

Application June 7, 1956, Serial No. 590,041

24 Claims. (Cl. 340—15)

This invention relates to apparatus for exhibiting simultaneously a plurality of signals, and, more particularly, to a cathode ray tube viewing device operable to exhibit a plurality of voltage signals simultaneously on its fluorescent target.

Many branches of science have need for a device which will display a plurality of signals visually in simultaneous manner, so that correlation between the various signals can be observed. For instance, petroleum seismology, aerodynamics and medicine all employ vibration-type signals for analysis purposes, and such signals are converted into electrical voltages by transducers and recorded in suitable manner as an aid to such analysis.

This invention is particularly applicable to pertoleum seismology and will be described in that connection, but it will be evident after the apparatus of the invention has been described that it could be used in the other sciences mentioned, as well as for other applications. As a matter of fact, the apparatus to be described is usable in connection with display visually of a plurality of time base signals obtained from any source.

Petroluem seismology involves the generation of ground vibrations by detonation of one or more shots beneath the surface of the earth or dropping a weight on the earth, and detection of the vibrations at a plurality of geophones spaced from the source of the vibrations. A large amount of the energy that reaches the geophones is in the category of noise, while a relatively small amount represents information. In order to increase the "signal to noise" level of the geophone outputs, it has become conventional to perform several different operations on the geophone output voltages, including compositing, filtering, etc. One of the objects of the apparatus of the present invention is to furnish an apparatus which will present the geophone signals in visual form so that the waveforms can be examined while these various operations are performed on the signals.

The apparatus of the present invention is particularly adapted for use with magnetic recordings of geophone signals made in the field and then taken back to the laboratory for analysis and clarification. Filtering and phase angle correction of the signals may be performed in the laboratory, and the present apparatus can be used to give a visible indication to determine when optimum filtering or phase shift is obtained.

In display of signals such as geophone output voltages, it is particularly desirable to furnish some indication of relative time along with the signals. The apparatus of the present invention includes circuitry for displaying timing lines on the cathode ray tube face along with the signals. The apparatus also includes means for expanding the representation of a selected portion of the signals, so that portion may be more readily examined.

The apparatus of the present invention, generally speaking, includes a cathode ray tube including the usual beam sweeping elements and an intensity control means. Means are provided for sweeping the beam at high speed along one dimension of the target and at low speed along an-

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other dimension substantially perpendicular to said one dimension. The beam is normally turned off by the intensity control means, but it is turned on by circuits including comparators which compare the signal voltages and suitable bias voltages therefor with the high speed sweep, and pulse generators which generate a train of voltage pulses for the intensity control means in response to the comparator outputs. The beam spot is thereby caused to generate a plurality of traces corresponding to the signal voltages spaced apart along said one dimension. The apparatus also includes means for displaying the timing lines along with the signal voltages, means for speeding up the slow speed sweep for a portion of the sweep to expand a portion of the representation, means for synchronizing the slow speed sweep with an appropriate event, such as the time break signal, and means for selecting the position of the faster speed sweep portion of the representation (called the "window") accurately.

The apparatus of the present invention will now be more fully described in conjunction with preferred embodiments thereof, as shown in the accompanying drawings.

In the drawings:

Fig. 1 is a somewhat diagrammatical elevational view of the front of a cathode ray tube viewing device constructed in accordance with this invention;

Fig. 2 is a diagrammatical representation of the method of sweeping the beam of the cathode ray tube along the target and the method of indicating the signal voltages on the target;

Fig. 3 is a block diagram of the apparatus and circuits of the cathode ray tube viewing device of the invention;

Fig. 4 is a schematic diagram of a portion of the apparatus of Fig. 3 including the high speed sawtooth generator and the associated voltage comparators and blocking oscillators;

Fig. 5 is a schematic diagram of the low speed sawtooth generator and associated circuits of Fig. 3;

Fig. 6 is a schematic diagram of the intensity controlling circuits of the cathode ray tube of Fig. 3;

Fig. 7 is a more complete block diagram of the timing line sync source and the sweep and window sync source of Fig. 3;

Fig. 8 is a schematic diagram of the apparatus to Fig. 7; and

Fig. 9 is a diagrammatic representation of an alternate method for furnishing a sweep and a window trigger voltage for the apparatus of Fig. 3.

The apparatus of the present invention is particularly designed to show a plurality of geophone output signal voltages on the target or face of a cathode ray tube. For such use, the geophone voltages are preferably played back from a magnetic recording tape wound on a recorder drum and the geophone voltages displayed on the cathode ray tube target in vertically spaced positions, with the horizontal dimension of the representation indicating time, and the vertical dimension indicating amplitude of the geophone voltages at every instant.

It is conventional in petroleum seismology to detect vibration waves caused by detonation of a shot beneath the surface of the earth or by dropping a weight onto the earth at a plurality of points spaced from the source of vibrations through transducers called geophones. The geophones may be positioned in any appropriate fashion, but it is conventional to record the outputs of the geophones for a time period of the order of five seconds after the vibrations are generated. If a shot is the source of the vibrations, the time period is measured from the so-called "time break" indicating the moment the shot is fired, and the time break is recorded along with the geophone outputs.

In order to represent the geophone output voltages so obtained with the apparatus of the present invention, the record of those voltages is played back by rotating the record number on a drum past appropriate playback heads in continuous fashion such that the five second record period is repeated over and over.

The geophone voltages are then displayed on the face of target **20** of a cathode ray tube, such as shown in Fig. 1. In that figure, beginning from the bottom of the face of the tube, the first nine traces are shown as varying in amplitude in somewhat similar manner to geophone voltages, though the showings are extremely idealized for convenience in representation. The next ten geophone traces are shown as straight horizontal lines, indicating that no geophone voltages are supplied to these channels of the viewing device.

In order to represent time on the face of the cathode ray tube in such fashion as to make it convenient to determine the relative time of any voltage change, timing lines **21** are generated and placed on the face of the tube in a manner to be described. Further, in order that a portion of the geophone output voltages may be examined more closely, that portion is expanded on the surface of the tube by increasing the speed of the sweep for a portion of the extent thereof, such as shown between timing lines **21*a*** and **21*b*** in Fig. 1.

The apparatus for expanding this portion of the sweep, called the "window" will be described hereinafter.

The positions of the traces on the face of the cathode ray tube are controlled through potentiometers having screws **22** exposed along the upper surface of the cabinet **23** which supports the face of the cathode ray tube.

The position of the window between timing lines **21*a*** and **21*b*** is controlled by a control knob **25**, while the width of the window along the horizontal dimension of the tube face is controlled by a knob **26**. The speed of the sweep of the cathode ray tube beam along the horizontal dimension is controlled by a knob **27**.

Several controls for the intensity of the cathode ray tube beam are provided, including knobs **28** and **29** for controlling the intensity of the timing lines **21** which represent every one-hundredth of a second and every tenth of a second, respectively. The intensity of the portion of the sweep within the window is controlled through knob **30**, while the intensity of the overall representation is controlled by knob **31**.

Referring now to Fig. 2, this figure represents in diagrammatic form the method of generating a raster on the face of the cathode ray tube and intensity modulating the beam to represent the voltages on the tube face. In order to accomplish the sweep shown diagrammatically in Fig. 2, the beam is deflected vertically through a very high speed sweep voltage having a period of the order of 200 microseconds, while the beam is swept along the horizontal dimension by a voltage having a period of the order of about five seconds. At the beginning of one complete sweep, the beam spot would be at the lower left-hand corner of the tube face **20** and would proceed therefrom upwardly along a nearly vertical line **35*a***. When the spot reaches the upper end of the tube, it is returned very rapidly to the lower end along a substantially vertical path **36*a***. The beam spot repeats this vertical sweep action a very large number of times during a horizontal sweep cycle to describe the sweep paths shown diagrammatically in Fig. 2.

The cathode ray tube is provided with an intensity control which normally keeps the beam turned off so that the spot is not seen on the surface of the tube. However, the beam is turned on through the intensity control in accordance with a comparison between the various signal voltages and the vertical sweep, by pulses of voltage reaching the intensity control from a plurality of comparator stages, to be described. When a signal voltage is applied to the trace channels, the beam is caused to be turned on at points indicated by the dots in Fig. 2, so describing the voltages supplied the trace channels. It will be understood that the representation of Fig. 2 has been expanded considerably so as to show the sweep action of the beam. The sweep is actually very much faster than indicated in Fig. 2, with the result that the vertical sweep is very nearly perpendicular to the horizontal dimension of the tube face and the dots on the face of the tube are spaced apart by such small distances that they appear to form continuous lines.

When no signal voltages are supplied to the trace channels, the beam is turned on in such fashion as to generate substantially horizontal lines for these channels.

General circuit description

Referring now to Fig. 3, a complete apparatus for furnishing the representations shown in Figs. 1 and 2 is shown therein in block diagram form. In that figure, the cathode ray tube **40** is provided with a vertical deflection circuit **41** which is supplied with sweeping energy from a high speed sawtooth generator and shaper **42**. A horizontal deflection circuit **43** is supplied with sweeping energy from a low speed sawtooth generator and shaper **44**.

The intensity controlling means for the cathode ray tube beam includes a cathode circuit **45** and a grid circuit **46**. Cathode circuit **45** is supplied with voltage pulses to turn the beam on from a video amplifier **47** which receives its input from a plurality of channels. Each of the channels providing an input to the video amplifier **47** includes a blocking oscillator **48** and a voltage comparator **49**. One of the inputs to each of the voltage comparators **49** is a voltage from the high speed sawtooth generator **42**, while the geophone output signals provide the other inputs to the voltage comparators.

The geophone signals are fed into the system through playback of the record tape on which they are recorded on a magnetic recorder drum **50** driven by an appropriate recorder drum drive **51**. The drum moves the record tape past a plurality of playback heads **52**, one for each of the geophone channels recorded. The outputs of the playback heads **52** are supplied to demodulators **53** if, as is conventional, the geophone output voltages have been frequency modulated before recording on the record tape. Each of the demodulators **53** is connected to the appropriate voltage comparator **49** to supply the geophone output voltage to the comparator for comparison with the high speed sawtooth.

This comparison action results in the video amplifier providing a train of voltage pulses to the cathode circuit **45** which turns the beam on each time it receives a pulse of voltage.

The initiation of the low speed sweep is controlled by an appropriate synchronizing pulse such as that which can be obtained by recording a time break pulse on the record tape with the geophone signals and playing back the time break pulse at the beginning of the playback cycle. It is conventional to record the time break pulse on a channel separate from the geophone output voltages, though it could as well be recorded along with the output voltages. As indicated above, the time break indicates the moment of initial generation of the vibrations detected by the geophones. If the time break is recorded on a separate channel, a playback head **55** is provided to detect this recording and furnish it to a source of synchronizing voltage indicated generally at **56** in Fig. 3 and termed "time break pulse." The output of the block **56** is supplied to the control circuit **57** of Fig. 3 and, more particularly, to the sweep and window sync source **58** of the control circuit. This sync source provides a sweep trigger voltage to the low speed sawtooth generator **44** to initiate the horizontal beam sweep.

The window on the face of the cathode ray tube may be controlled in one of two ways. The first is by comparing the low speed sawtooth voltage with a controllable bias voltage in a window comparator **60** and providing the resultant output of the comparator to a window multivibrator and control circuit **61**. The circuit **61** is used to control the low speed sawtooth circuit **44** during a portion of the horizontal sweep to increase the sweep speed.

An alternative method for controlling the window is by providing a window trigger voltage from the sync source **58** to the window multivibrator.

In order to furnish timing lines **21**, such as shown in Fig. 1, along with the geophone representations, the control circuit **57** includes a timing line sync source **65** which provides synchronizing voltage for a timing line generator **66**. Generator **66** provides an input voltage for an intensity gate circuit **67** which controls grid circuit **46**. Each time that a timing line voltage is generated, intensity gate **67** provides a pulse of voltage to the grid circuit **46** to turn the beam on during the vertical sweep corresponding to the time of the timing line voltage.

In addition, the intensity gate is provided with voltage from the window multivibrator **61** to increase the intensity of the beam during the window time period, since the higher sweep speed during this period would normally result in an apparent decrease in beam intensity.

In order to turn the beam off at the end of the trace and until the beam spot returns to the lower left-hand corner of the tube face, horizontal deflection circuit **43** provides a flyback blanking voltage to intensity gate **67**.

In order that the various synchronizing sources in the control circuit **57** may be reset at the end of one complete beam sweep, a flyback pulse from the horizontal deflection circuit is provided as a reset to each of the time line sync source **65** and the sweep and window sync source **58**.

Vertical sawtooth generator

Referring now to Fig. 4, the circuitry of the high speed sawtooth generator and the associated blocking oscillators will be more completely described. The high speed sawtooth is generated by a blocking oscillator **70** including a triode tube **71** having its cathode grounded and its plate connected through the primary of an iron core transformer **72** and a resistor **73** to a source of positive voltage indicated only as B+. The grid of the triode is connected through the secondary of the feedback transformer **72** and a capacitor **74** to ground. The primary of the transformer and the B+ source are shunted by a capacitor **75**.

The well-known action of the blocking oscillator **70** results in the provision to capacitor **74** of a rectangular pulse of voltage at intervals determined by the parameters of the circuit. These parameters are so selected for the apparatus of Fig. 4 that a high frequency train of pulses is supplied by the output of the blocking oscillator. The time period of such pulses may be of the order of 200 microseconds for an appropriate design. Capacitor **74** converts these pulses into sawtooth pulses of the same frequency.

The blocking oscillator may be synchronized by pulses provided from a circuit including a Colpitts oscillator indicated generally at **76** which provides a sine wave output across a resistor **77**. The sine wave voltage across the resistor is shaped into pulses by a shaper circuit **78** including a pair of triodes **79a** and **79b** having their cathodes connected together and connected through a resistor **80** to a source of negative voltage indicated as B− in Fig. 4. The grid-cathode circuit of triode **79a** is supplied with the sine wave voltage across resistor **77** and couples its output through a capacitor **81** to the grid of triode section **79b**. The output of the shaper circuit **78** is developed across a resistor **85** which is connected to the grid-cathode circuit of a trigger triode **86**. The grid of tube **86** is biased so that the tube is normally cut off by the combination of a resistor **87** and a source of negative voltage indicated as B−, connected to the grid of the tube. Trigger tube **86** provides a train of pulses of voltage of high speed sawtooth frequency to the plate of the blocking oscillator tube **71** to synchronize the blocking oscillator.

The high speed sawtooth voltage developed across capacitor **74** is coupled through a cathode follower stage **90** to a pair of coupling cathode followers **91a** and **91b**. The cathode follower **90** is designed to maintain the charging current for the sawtooth capacitor **74** as constant as possible. Coupler stage **91a** is cathode coupled to a vertical driver stage **92** which includes a pentode **93**. The output of the pentode **93** is developed across the primary of a transformer **94**. A portion of the secondary voltage of transformer **94** is used to drive the vertical deflection coil **95**. A damping circuit for the vertical deflection coil is also provided by a circuit including diode **96**.

The sawtooth voltage from coupler section **91b** is cathode coupled by a bus **100** which is connected to one input of each of voltage comparators **49**. More specifically, in each of the comparator circuits, bus **100** is connected to a multivibrator **101**, by connecting the bus to the grid of triode section **102a** of the multivibrator. The grid of triode section **102b** of the multivibrator is connected to a voltage divider formed by a trace position control potentiometer **103** (controlled by screws **22** of Fig. 1) connected across a source of positive voltage indicated as B+, by a series combination of resistors **104** and **105**. Resistor **105** is shunted by a capacitor **106**. The geophone output voltage corresponding to the first geophone channel is developed across capacitor **106** and therefore combined with a bias voltage of magnitude determined by the position of the trace position potentiometer **103**. The combination of the bias voltage and the geophone signal voltage is a composite voltage, which is compared with the high speed sawtooth voltage by comparator **101**.

As indicated in Fig. 4, each of voltage comparators **49** is provided with a geophone input from a different demodulator. For each of these comparators, the trace position potentiometer is adjusted differently, so that a different bias voltage is added to the geophone signal voltage for the different trace channels.

Multivibrator **101** will flip from its normal condition whenever the instantaneous vertical sawtooth voltage is approximately equal to the composite voltage formed by the geophone output voltage and the bias voltage. When this flipping action takes place, a pulse of voltage will be supplied from the plate circuit of triode section **102b** to a trigger tube **107**. The output of the trigger tube controls a blocking oscillator **48** which is of conventional design. The output of the blocking oscillator **48** of this first channel is combined with the outputs of all the other blocking oscillators **48** and developed across a resistor **108** connected in the cathode circuits of all of the blocking oscillators. Thus, each time that one of the composite voltages formed by the combination of the bias voltages and the geophone signal voltages is approximately equal to the instantaneous high speed sawtooth voltage, a pulse of voltage is developed across resistor **108**. The train of these pulses of voltage is supplied to the video amplifier.

Horizontal sawtooth generator

Referring now to Fig. 5, the low speed sawtooth generator for sweeping the beam along the horizontal tube dimension will now be described. In order to make the low speed sawtooth as linear as possible, a phantastron sawtooth generator circuit **110** is employed. This circuit includes a pentode tube **111** having its cathode grounded and its control grid connected through the combination of a capacitor **112** and series resistors **113** and **114** to a source of negative voltage indicated as B−. The screen grid of the pentode is connected through a resistor **115** to a source of positive voltage indicated as B+ and is also connected through the shunt combination of a resistor 116 and a capacitor 117 to the suppressor grid of the pentode. In order to increase the speed of recovery of the phantastron action, the plate of the pentode is connected to the control grid of a triode 118 which has its cathode connected to the junction between capacitor 112 and resistor 113 and its plate connected to B+.

The phantastron circuit so far described is conventional in design and yields a sawtooth wave of voltage in its plate circuit which is initiated by a positive-going synchronizing pulse applied to its suppressor grid, the sawtooth voltage being developed across resistors 113 and 114.

As indicated above, the initiation of the horizontal sweep is controlled by a sweep trigger voltage developed in the sweep and window sync source 58 through the time break pulse provided from head 55. This sweep trigger voltage is connected to a polarity selection circuit 120 of Fig. 5 having a switch 121 for selecting the sweep trigger of appropriate polarity to drive a Schmitt trigger circuit 122. The sweep trigger voltage is compared with a voltage developed by a trigger sync potentiometer 123 connected in a series circuit between B+ and B− through resistors 124 and 125. The slider of the potentiometer is connected to the grid of triode section 126*b* of the polarity selection circuit, while the sweep trigger is connected to the grid of triode section 126*a*.

The Schmitt trigger circuit is of conventional design and supplies its output as a positive pulse to the grid of a cathode follower 130 including a triode 131. Triode 131 is normally biased to cut off through a resistor 132 connected to B− and to the grid of the triode. A positive pulse from the Schmitt trigger circuit cuts triode 131 on, and the resultant pulse of voltage developed across the cathode resistor 133 is supplied to the suppressor grid of the phantastron pentode 111 to trigger the sweep voltage.

The sawtooth voltage developed across resistor 114 is supplied to the grid of triode section 135*a* of a circuit 136 designed to convert the single-ended sawtooth voltage to a push-pull voltage for driving the horizontal deflection coil. Triode section 135*a* has its cathode connected through a resistor 137 to B− and is connected through a potentiometer 138, whose position controls the length of the horizontal sweep, to the cathode of triode section 135*b*. The grid of section 135*b* is connected to the slider of a potentiometer 134 whose position controls the position of the horizontal sweep and which is connected between B+ and B−. The plates of the two triode sections are connected through resistors 139*a* and 139*b*, respectively, to B+. The plate of section 135*a* is connected to the grid of a triode driver section 140*a*, while the plate of triode section 135*b* is connected to the grid of driver triode section 140*b*. The push-pull output from the driver including sections 140*a* and 140*b* is cathode coupled to the horizontal deflection coil 141. Flyback blanking and flyback pulses are also developed across this coil and used to control the cathode ray tube grid circuit 46 to turn the beam off during flyback and to supply a reset voltage for the control circuit 57, respectively.

The speed of the horizontal sawtooth sweep is controlled by the control portion of the window multivibrator and control 61, the control circuit including a resistor 145 and a pair of parallel-connected triodes 146 and 147 having their plates connected to B+. The side of resistor 145 remote from the cathodes of the triodes is connected to the junction between the control grid of phantastron pentode 111 and capacitor 112. As will be obvious, the charging current for the capacitor passes through one or both of the triodes, so that the plate current of the triodes determines the magnitude of the charging current, and hence the slope of the sawtooth voltage. Triode 146 is normally conducting to an extent adjustable by control of a sweep speed potentiometer 148 having its slider (controlled by knob 27 of Fig. 1) connected to the grid of the triode 146, the potentiometer being connected between B+ and ground. Triode 147 is normally biased to cut off, but it may be cut on to increase the capacitor charging current through a multivibrator 150 including triodes 151 and 152. Multivibrator 150 is of conventional design having triode section 151 normally conducting and adapted to be flipped by a negative pulse applied to the grid of the triode 151, to supply a positive pulse of voltage at the output of triode 151. The width of the positive pulse so supplied is controlled by a window width potentiometer 153 (controlled by knob 26 of Fig. 1) which is connected in the grid circuit of triode 152.

The trigger pulse for multivibrator 150 to control the time when the window of the sweep is initiated may be supplied from an external source, or may be generated within window comparator 60. A switch 155 selects the external window trigger or the local window comparator circuit. The window comparator circuit includes a multivibrator 156 which is of conventional design and has the grid of its triode section 157 supplied with the horizontal sawtooth voltage from across resistors 113 and 114. The grid of triode section 158 is provided with a controllable bias voltage through a potentiometer 159 (controlled by knob 25 of Fig. 1) which controls the position of the window in the horizontal sweep. When switch 155 is in its lower position connecting the window comparator to the window multivibrator 150, triode section 158 is normally conducting and the multivibrator 156 flips to a condition such that triode section 157 is conducting when the horizontal sweep voltage on the grid of triode 157 is low enough to permit triode 157 to conduct.

Beam intensity control circuits

Referring now to Fig. 6, the intensity controlling circuits of the cathode ray tube and the circuits which provide voltages therefor will now be described. As indicated in conjunction with Fig. 4, the train of pulses from across resistor 108 is supplied to a video amplifier 47. Amplifier 47 includes a pair of pentodes 165 and 166, with the pulse train from the blocking oscillators being supplied to the control grid of the first pentode, and the plate thereof being transformer-coupled to the control grid of the second pentode. The plate of the second pentode is connected through a pair of resistors 167 and 168 to B+. The junction between these resistors is capacity-coupled to the cathode of the cathode ray tube 40 and the amplified pulses from the video amplifier are developed across resistor 169, connected between the cathode and ground. A circuit including potentiometer 170 (controlled by knob 31 of Fig. 1) connected between the cathode of the cathode ray tube and B+ determines the over-all intensity of the cathode ray beam.

As indicated in conjunction with Fig. 3, the grid circuit 46 of the cathode ray tube is supplied with voltage from an intensity gate 67. This intensity gate includes a cascode circuit including the series combination of a triode 170 with the shunt combination of a resistor 171 and three triodes 172–174, and a cathode resistor 175. The control grid of the cathode ray tube is connected through a pair of resistors 176 and 177 to the junction between the cathodes of triodes 172—174 and resistor 175, so that a voltage determined by the current flowing through the four triodes is developed between the control grid and cathode of the cathode ray tube.

The plate current of triode 170 is controlled in part by a resistor 180 connected between the grid thereof and B+, so that the tube is normally conducting, but the grid is supplied with a flyback blanking pulse at the end of every horizontal sweep to cut off the tube and thereby cut off the cathode ray beam.

The grid of triode 172 has its voltage controlled from a circuit including a pair of triodes **181** and **182** which form a differential amplifier. The grid of triode **181** is connected to the grid of triode **147** of the window multivibrator and control circuit, to receive a pulse of voltage each time the window is generated. The triode **182** has a controllable bias adjustable through a potentiometer **183** (controlled by knob **30** of Fig. 1) connected in the grid to cathode circuit of the triode.

The plate current through each of triodes **173** and **174** of the intensity gate circuit is controlled through timing line generator **66**. This generator is intended to place timing lines on the face of the cathode ray tube for every one-tenth and one-hundredth of a second of the horizontal sweep. To accomplish this function, a pair of multivibrators **185** and **186** is used, one being controlled by the one-tenth second timing line sync voltage, and the other being controlled by the one-hundredth of a second timing line sync voltage. The first multivibrator controls the bias of triode **173** while the second controls the bias of triode **174**. The static bias of the grid circuits of each of these tubes is controlled through triode circuits **187** and **188**, respectively, each having potentiometers in their grid circuits to control the normal conduction level of triodes **173** and **174**. Potentiometer **189** (controlled by knob **29** of Fig. 1) in the grid circuit of triode **187** controls the intensity of the tenth of a second timing lines, while potentiometer **190** (controlled by knob **28** of Fig. 1) in the grid circuit of triode **188** controls the intensity of the one-hundredth of a second timing lines.

The control circuit of Fig. 6 also includes a so-called "anti-blossoming" circuit to prevent the beam from being unduly intensified when a timing line is being placed on the face of the cathode ray tube and a pulse from the blocking oscillators simultaneously tends to turn the beam on. When these two conditions occur simultaneously, the tendency would be for the beam to be intensified to such an extent that some of the information on the face of the cathode ray tube would be obscured. In order to prevent this, the grid of the cathode ray tube is connected to ground through a diode **195** and a resistor **196** connected in series, while the plate of pentode **166** is connected to ground through the series combination of a resistor **197** shunted by capacitor **198** and resistor **196**. The action of this circuit is such as to decrease the amplitude of the pulse supplied by pentode **166** to the cathode of the cathode ray tube when a timing line is being generated.

Synchronizing and control circuits

Referring now to Fig. 7, the control circuit **57** of Fig. 3 will be described in more detail. The control circuit includes a source of internal standard frequency **200** which may be, for instance, 1 kc. The output of the standard **200** is supplied to an amplifier and shaper **201** when a switch **202** is in the appropriate position. The switch **202** may also be used to supply the amplifier with an externally-generated standard frequency. The output of the amplifier is connected to a gate **203** and is passed by the gate only when the gate is turned on by a pulse supplied from a main latch circuit **204**. As indicated, the main latch circuit includes a bi-stable multivibrator which is flipped to condition such as to open the gate by the time break input.

When gate **203** is opened it supplies a sweep trigger voltage to the low speed sawtooth generator of Fig. 3. After the gate is opened, and until it is closed again, the gate transmit pulses from the amplifier and shaper **201** to a series of decade counters **205** through **208**. Decade counters **205** and **206** are connected in series and each has the function of providing an output pulse for every tenth pulse supplied to its input. The counters are of conventional design and are readily available on the market, so that they will not be more particularly described. Counter **205** divides the one kc. internal standard by ten and supplies one-hundredth of a second pulses to multivibrator **186** of the timing line generator, while counter **206** divides the output of counter **205** by ten and supplies one-tenth of a second pulses to multivibrator **185** of the timing line generator.

The third and fourth decade counters have the characteristic of supplying an output pulse for every *n* input pulses, with *n* being manually selectable. The result is that counters **207** and **208** provide pulses for a number of tenths of a second and for a number of seconds after the time break, respectively, to the delay latch trigger circuit **210**. The output of the delay latch trigger circuit is supplied to the delay latch **211** which, as indicated, is a bi-stable multivibrator, and the delay latch, when in open position, supplies a window trigger pulse to the window multivibrator **150**. As indicated in Fig. 7, the main latch and the delay latch are reset to their proper positions at the end of every sweep by a reset voltage, and the main latch, when reset, supplies a reset pulse to reset stage **212**. Reset stage **212** supplies controlling voltages to decade counters **205**—**208** to reset the counters to zero at the end of every horizontal sweep.

Referring now to Fig. 8, the control circuit of Fig. 7 will be described in more detail. The one kc. internal standard is supplied by an oscillator **215** which provides a sine wave voltage to amplifier and shaper circuit **201**. This circuit consists of a triode amplifier **216** and a Schmitt trigger circuit **217** which shapes the input sine wave into a series of pulses of voltage of frequency corresponding to that of the oscillator **215**. The output of the trigger circuit **217** is supplied to gate **203** through capacity coupling to one triode section **218***a* of the gate. The other triode section **218***b* of the gate is normally conducting, so that section **218***a* is normally turned off, but section **218***b* is turned off by a voltage supplied from the main latch **204**.

Main latch **204** includes an amplifier section including a triode **220**, and a trigger triode **221**. Trigger triode **221** is biased to cut off by a circuit including a resistor **222** connected between the grid of the triode and a negative voltage B—. When the time break signal is supplied to the main latch, it is amplified in triode **220** and applied in positive sense to the trigger triode **221** to cause plate current to flow therein and furnish a negative pulse of voltage at the output of the trigger. This negative pulse is applied to the grid of triode section **218***b* of gate **203** to open the gate, so that pulses from the amplifier and shaper **201** pass through the gate to the decade counters. The trigger time break pulse from trigger **221** also flips a multivibrator circuit including triode sections **223***a* and **223***b*, the trigger output being supplied to the plate of section **223***a*. After the arrival of the trigger pulse, triode section **223***a* is conducting, while section **223***b* is cut off. The main latch is also controlled by a reset trigger circuit including triode **224**, the reset trigger tube also being normally cut off through a circuit including a resistor **225** connected between its grid and B—. The grid of triode **224** receives the reset input furnished by the flyback pulse of the horizontal deflection coil, and, when this positive-going pulse is supplied to the reset trigger, a negative pulse is applied from the trigger to cut off triode section **223***a* of the gate and cut on triode section **223***b*. The positive pulse of voltage from triode section **223***a* caused by the reset trigger operation is then coupled to reset stage **212**, including a triode cathode-coupled amplifier **226**.

The reset action accomplished with the output of triode **226** will be described hereinafter.

When gate **203** has been opened by arrival of the time break trigger pulse, the shaped pulses from the oscillator **215** drive decade counter **205**. As described in conjunction with Fig. 7, counter **205** has the property of dividing the number of pulses supplied its input and supplying at its output one pulse for every ten pulses at its input. One output of the decade counter **205** is supplied to the input of like decade counter 206, while the other output is provided to a shaper circuit including a triode 230. The shaper circuit supplies one-hundredth of a second timing line sync pulses to the timing generator 66 of Fig. 6.

Decade counter 206 also provides two outputs, with one pulse for every ten pulses provided its input, and one output of the decade counter drives a shaper circuit, including triode 231. The output of the shaper circuit provides one tenth of a second timing line sync pulses to the timing line generator.

The other output of decade counter 206 drives decade counter 207 which, like counter 208, is of somewhat different design than counters 205 and 206. Counter 207 has one output which represents a division of the input of the counter by ten, while the other output of the counter provides one pulse for every *n* pulses at its input. The number *n* is selected by push-buttons such as shown at 235 on the block of the decade counter. Thus, with the one kc. oscillator 215 and the two decade counters ahead of it in the chain, the second output of decade counter 207 provides a pulse a number of tenths of a second after the time break determined by the pushbutton 235 depressed. This pulse is provided to a delay latch trigger circuit 210 through a resistor 236 connected to the grid of a triode 237.

Decade counter 208 is identical with counter 207 and provides an output pulse delayed a number of seconds after the time break determined by which of pushbuttons 235′ is depressed. This pulse is supplied to the delay latch trigger circuit through a resistor 238 likewise connected to the grid of triode 237.

The delay latch trigger circuit controls a bi-stable multivibrator of delay latch 211 including triode sections 240*a* and 240*b*. When the trigger is operated by pulses supplied from both the decade counters 207 and 208, triode section 240*b* is turned on to supply a negative pulse in its plate circuit as a window trigger voltage for the window multivibrator 61 of Fig. 5. Despite any action of the counters 207 and 208, no window trigger will be supplied until the delay latch is reset. The reset input is connected to the delay latch through the combination of a capacitor 241 and a rectifier 242 connected to the grid of triode section 240*a*. When the horizontal deflection coil supplies its flyback pulse as this reset input to triode section 240*a* of the delay latch, section 240*a* is turned on and section 240*b* is turned off to prepare the latch for its next operation to provide a window trigger.

Reset stage 212 provides its output across the cathode resistor of triode 226 to the reset input of the decade counters 205—208, to reset all of the counters to zero at the end of a horizontal sweep.

Operation

In operation of the apparatus described above, the recorder drive 51 of Fig. 3 is operated to start the magnetic recorder drum 50 rotating. Head 55 picks up the time break pulse, which operates the main latch circuit and opens gate 203. The time break pulse is simultaneously applied as a sweep trigger pulse to the low speed sawtooth generator to begin the horizontal sweep. The vertical sweep of the cathode ray tube beam also begins through operation of the usual power switch (not shown) so that the beam begins its trace back and forth across the vertical dimension of the cathode ray tube target, while being deflected slowly along the horizontal dimension of the target. The vertical sawtooth voltage is compared in the circuits of Fig. 4 with the composite voltages formed by the bias voltages selected by potentiometers 103 and the signal voltages obtained from magnetic heads 52 of the recorder. As each composite voltage approximately coincides with the vertical sweep voltage, the appropriate blocking oscillator 48 provides a pulse of voltage to the video amplifier 47, and that pulse is supplied to the cathode of the cathode ray tube to turn the beam on instantaneously. This last-detailed action repeats automatically during each vertical sweep of the cathode ray beam, with the positions of the visible spot in each trace being determined by the instantaneous magnitudes of the signal voltages at the relative times with respect to the time break.

Every one hundredth of a second and every tenth of a second after the time break, decade counters 205 and 206 provide pulses to multivibrators 185 and 186, which in turn provide pulses to the grid of the cathode ray tube to turn the beam on for a period of time appropriately coinciding with the length of one vertical sweep of the beam. Thereby, one-tenth of a second and one hundredth of a second timing lines are generated on the face of the cathode ray tube.

After an interval of time from the time break determined by the setting of the pushbuttons of counters 207 and 208, or by the setting of the window position potentiometer 159, depending upon which position switch 155 is in, the multivibrator 150 of Fig. 5 generates a positive pulse which turns on triode 147 to increase the voltage across cathode resistor 145 and thereby increase the speed of charge of the phantastron capacitor 112. The slope of the horizontal sawtooth is thereby increased, to increase the speed of the horizontal sweep for a portion of the horizontal sweep time determined by the setting of the window width potentiometer 153. This window expands the corresponding portions of the geophone voltages on the face of the cathode ray tube.

After the multivibrator 150 returns to its normal condition to cut off triode 147, the horizontal sawtooth returns to its normal slope and completes the horizontal trace of the cathode ray beam. When the horizontal trace is completed, the horizontal deflection coil 141 supplies a flyback blanking pulse to the intensity gate 67 to turn off the beam, and the same coil supplies a flyback pulse to the control circuit of Fig. 8 to reset the delay latch, reset the main latch, return gate 203 to its closed condition, and reset the decade counters. When the magnetic recorder drum again reaches a position in which the recorded time break pulse is opposite pick up head 55, the above-described sequence of operations is repeated.

For the normal five second recording tape of the geophone outputs, the horizontal sweep time may be selected to be of the order of three to five seconds, while the vertical sweep time may be of the order of 200 microseconds. The fluorescent material of the target of the cathode ray tube is preferably selected to be of the high persistence type that will show the information presented thereon for a period of the order of the horizontal sweep time.

Modified synchronizer

It is not necessary that the horizontal sweep be initiated by the time break pulse, or that the window be synchronized by output pulses from decade counters. The apparatus of Fig. 9 is designed to accomplish both of these functions. That apparatus includes a commutator generally indicated at 250 which has a rotatable contact member 251 driven by the magnetic recorder drum drive 51. A plurality of arcuately-spaced stationary contacts 252 are positioned in the path of the rotatable contact member and are each connected to one side of each of a pair of switches 253 and 254. The other sides of switches 253 are connected together to a common circuit 255 which may be connected to the sweep trigger circuit, such as shown in Fig. 5.

The other sides of switches 254 are connected together to a common circuit 256 which may be connected to the window trigger circuit, such as the multivibrator 150 of Fig. 5.

The rotatable contact member 251 is connected to any appropriate source of voltage 257.

The operation of the apparatus of Fig. 9 is as follows. When recorder drum drive **51** is operated to begin rotation of the recorder drum, the rotatable contact member **251** rotates in synchronism with the drum. The operator may depress any one of each of switches **253** and **254**, thereby selecting when the horizontal sweep is initiated, and when the window of that sweep is initiated. When the rotatable contact member touches the stationary contact corresponding to the closed switch **253** or **254**, a pulse of voltage is supplied to the trigger circuit **255** or **256** to initiate the appropriate operation.

The apparatus of the present invention has been described in conjunction with preferred embodiments thereof. It will be obvious that many minor changes could be made in this apparatus without departing from the scope of the invention. Therefore, the invention is not to be considered limited to the apparatus specifically described herein, but only by the scope of the appended claims.

We claim:

1. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage, said second sawtooth being linear and normally of a pre-determined slope, and means for changing the slope of the second sawtooth along a portion of its extent to change the speed of sweep of the beam along a portion of said other dimension.

2. The apparatus of claim 1 in which said means for generating the second sawtooth includes a capacitor and a charging circuit therefore, and in which said slope-changing means includes means for changing the impedance of said charging circuit.

3. The apparatus of claim 2 in which said charging circuit includes a pair of parallel-connected discharge tubes each having a control electrode, one of said tubes being normally cut off and the other tube conducting the capacitor charge current, and said impedance-changing means includes means for supplying a pulse of voltage to the control electrode circuit of said one tube to cause it to conduct.

4. The apparatus of claim 3 in which said supplying means includes a monostable multivibrator, and means for triggering said multivibrator to supply said pulse of voltage.

5. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, said last-named means including a capacitor and a charging circuit normally operable to charge the capacitor at a predetermined rate to produce a linear sawtooth of predetermined slope but operable in response to a controlling voltage to charge the capacitor at a faster rate to increase the slope and thus the speed of sweep of the beam along a portion of said other dimension, means operable to supply said controlling voltage to said charging circuit for a portion of the charging operation, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, and means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage.

6. The apparatus of claim 5 including means for initiating the operation of said means for generating said second sawtooth wave, and in which said means operable to supply said controlling voltage is controllable to supply said controlling voltage a desired time interval after generation of the second sawtooth wave is initiated.

7. The apparatus of claim 6 including means for generating a train of equally time-spaced pulses of voltage, and means for controlling said last-named means to supply an output pulse of voltage a controllable interval of time after generation of the second sawtooth wave is initiated, said output pulse of voltage being operable to control said means operable to supply said controlling voltage.

8. The apparatus of claim 5 including means responsive to increase in the rate of charge of said capacitor operable to increase the voltage supplied to said intensity-controlling means whenever a pulse of voltage is supplied thereto to compensate for the apparent decrease in beam intensity caused by the higher sweep speed.

9. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, means for initiating the operation of said last-named means to start sweep of the beam along said other dimension of the target, means for generating a train of equally time-spaced pulses of voltage, counting means operable to supply an output pulse of voltage in response to arrival of a predetermined number of pulses from said train generating means, said counting means and said train generating means being effectively disconnected normally but connected together when the beam sweep along said other dimension of the target is initiated, said means for generating a second sawtooth including a capacitor and a charging circuit therefor, said charging circuit being normally operable to charge said capacitor at a predetermined rate to sweep said beam along said other dimension at a predetermined speed but being operable in response to arrival of a con-

trolling voltage to charge the capacitor at a faster rate to increase the speed of sweep, and means connected to said counting means operable to supply said controlling voltage to said charging circuit in response to generation of said output pulse of voltage.

10. The apparatus of claim 9 in which said means for generating a second sawtooth includes a phantastron having said capacitor connected therein, said charging circuit including at least one resistor, a source of voltage and a pair of parallel-connected discharge tubes, each of said tubes having a grid-cathode circuit, one of said tubes being normally conducting to carry the normal charging current of the capacitor and the other tube being normally cut off, said means for supplying said controlling voltage being connected to the grid-cathode circuit of said other tube to cause it to conduct for a portion of the sweep to allow the capacitor to charge at a faster rate.

11. The apparatus of claim 10 including a main latch circuit, a gate circuit, a delay latch circuit, and a reset circuit supplied with a flyback pulse from the second deflecting means operable in response thereto to furnish a reset pulse, said gate being connected between said counting means and said train generating means and operative in response to initiation of said sweep along said other dimension to permit the train of pulses to reach the counting means when the gate is in its normal condition, said main latch circuit being operable to switch said gate circuit to an abnormal condition immediately after said sweep is initiated, said means connected to said counting means including said delay latch circuit, said delay latch circuit being operable when in its normal condition to permit said output pulse of voltage to cause said controlling voltage to be connected to the grid-cathode circuit of said other discharge tube, said delay latch circuit being switched to an abnormal condition immediately after said output pulse of voltage reaches it, and said reset circuit being connected to said main latch and said delay latch and operable to reset them to their normal conditions when said flyback pulse is received.

12. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage, means for generating a train of equally time-spaced pulses of voltages spaced apart a time interval much smaller than the sweep time along said other dimension, and means for supplying said train of pulses to said intensity-controlling means to turn the beam on and provide time indications on the target.

13. The apparatus of claim 12 in which said one dimension is horizontal and said other dimension vertical, said first sawtooth occupies so much less time than said second sawtooth that the beam sweeps up and down in the vertical direction many times during one sweep in the horizontal direction, so that the vertical sweep is substantialy perpendicular to the horizontal dimension of the target, and said supplying means turns the beam on for substantially one complete vertical trace each time a pulse of voltage reaches it.

14. The apparatus of claim 12 including means connected to said comparing means and said supplying means operative when a pulse from each reaches the intensity-controlling means simultaneously to prevent the beam intensity from being as great as the sum of the pulses would otherwise direct.

15. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, means for supplying a synchronizing voltage, means for initiating operation of said means for generating a second sawtooth in response to arrival of said synchronizing voltage, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage, said second sawtooth being normally of a predetermined slope to sweep the beam at a predetermined speed along said other dimension of the target, a source of a train of pulses of voltage equally-spaced in time, first counting means operable to supply one pulse for every *n* pulses reaching it, second counting means operable to supply one pulse for every *n* pulses reaching it and controllable to vary the value of *n*, a gate circuit connected between said source and said first and second counting means opened by arrival of said synchronizing voltage, means connected between said first counting means and said intensity controlling means operable to turn said beam on every time said first counting means supplies a pulse, means connected to said second counting means operable in response to arrival of a pulse therefrom to increase the slope of said second sawtooth to increase the speed of sweep of the beam along said other dimension for a portion of a sweep, means for increasing the intensity of the beam above the normal amount directed by a pulse from the comparing means when the sweep speed along said other dimension is increased, and means responsive to simultaneous arrival of a pulse from said comparing means and a pulse from said first counting means at said intensity-controlling means operable to prevent the beam intensity from being as great as the sum of the pulses would otherwise direct.

16. In a cathode ray tube viewing device for exhibiting a plurality of geophone output signals simultaneously on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth voltage of high frequency and supplying it to said first deflecting means to sweep the beam rapidly along said one dimension, means for generating a second sawtooth voltage of low frequency and supplying it to said second deflecting means to sweep the beam slowly along said other dimension, said sweep speeds being of such relative values that the beam sweeps along said one dimen-

sion many times during one sweep along said other dimension, means for increasing the slope of said second sawtooth voltage to increase the speed of sweep along said other dimension of the target for a portion of said sweep, means for initiating the second sweep voltage and for controlling the time the speed thereof is increased, means for adding a different bias voltage to each of said signals to produce a plurality of composite voltages, and means for comparing the composite voltages individually with the first sawtooth voltage operable to produce a pulse of voltage every time the magnitude of a composite voltage substantially coincides with the magnitude of the first sawtooth voltage, said comparing means being connected to said intensity-controlling means to turn the beam on each time the comparing means provides a pulse of voltage.

17. The apparatus of claim 16 in which said geophone signals are recorded and played back from a rotatable drum, said initiating and controlling means includes a commutator comprising a rotatable contact member rotating with the drum and a plurality of arcuately-spaced stationary contacts positioned in the path of movement of the contact member, a source of voltage connected to the rotatable contact member, said fixed contacts being each connected to a switch and the other sides of the switches being connected together.

18. The apparatus of claim 16 in which a time break signal is supplied along with the geophone output signals and said initiating and controlling means includes a control circuit supplied with said time break signal and supplying an output sweep trigger voltage to said means for generating a second sawtooth voltage to initiate the second sawtooth and also supplying a window trigger voltage delayed with respect to the sweep trigger voltage to said means for increasing the slope of the second sawtooth voltage.

19. In a cathode ray tube viewing device for exhibiting a plurality of signal voltages on a fluorescent target and including means for generating a beam of electrons and directing it at the target, means for controlling the intensity of the beam to turn it on and off and first and second means for deflecting the beam along one dimension and another dimension substantially perpendicular to said one dimension of the target, respectively, means for generating a first sawtooth wave of high frequency and applying it to said first deflecting means, means for generating a second sawtooth wave of low frequency and applying it to said second deflecting means, means for adding a different bias voltage to each of said signal voltages to produce a plurality of composite voltages, means for comparing the composite voltages individually with the first sawtooth operable to produce pulses of voltage at different points along the first sawtooth determined by the bias voltages and by the magnitudes of the signal voltages, said last-named means being connected to said intensity-controlling means to turn the beam on each time said last-named means provides a pulse of voltage.

20. The apparatus of claim 19 in which said comparing means includes a plurality of monostable multivibrators each having said first sawtooth connected to one input circuit and one of said composite voltages connected to its other input circuit, a plurality of blocking oscillators each connected to one of said multivibrators and operable to develop a pulse of voltage when its multivibrator flips to its unstable condition, and means supplying the pulses from all of said blocking oscillators to said intensity-controlling means to turn the beam on each time a multivibrator flips to its unstable condition and causes its associated blocking oscillator to develop a pulse of voltage.

21. The apparatus of claim 20 in which said pulse supplying means includes a resistor common to the cathode circuits of all the blocking oscillators, and means for amplifying the voltage across said resistor.

22. The apparatus of claim 19 in which said means for generating the second sawtooth includes a capacitor and a charging circuit therefor, and in which said charging circuit includes a discharge tube and means for varying current flow through the discharge tube to change the speed of the second sawtooth.

23. The apparatus of claim 19 in which said second means for deflecting the beam includes first, second, third and fourth vacuum tubes each having at least a cathode, anode and control grid, means coupling said means for generating a second sawtooth between grid and cathode of the first tube, means biasing the second tube to a desired operating level, means directly connecting the anode of the first tube to the grid of the third tube and the anode of the second tube to the grid of the fourth tube, resistors in the cathode circuits of each of said third and fourth tubes, and a deflection coil connected between the cathodes of the third and fourth tubes.

24. The apparatus of claim 23 including a variable resistance connected between the cathodes of the first and second tubes adjustable to vary the length of the sweep along said other dimension, and means for varying the bias on said second tube to vary the position of said sweep.

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