Dec. 1, 1970 T. BATES 3,544,834

# OSCILLOSCOPE OPERATING CIRCUITS

Filed Feb. 3, 1969

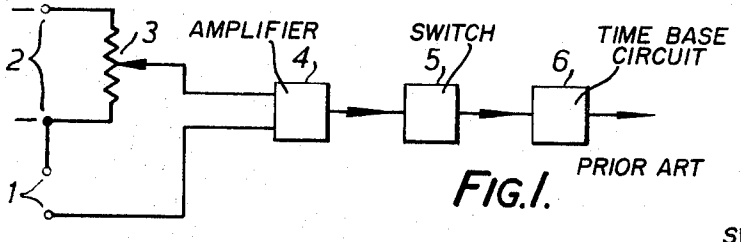



FIG. 1.

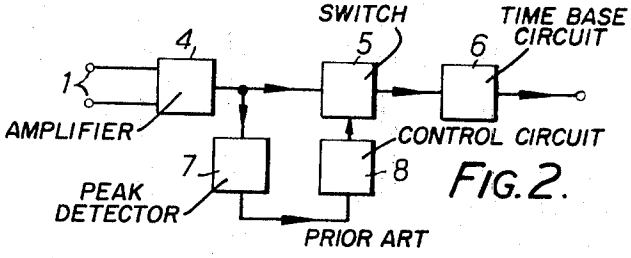



FIG. 2.

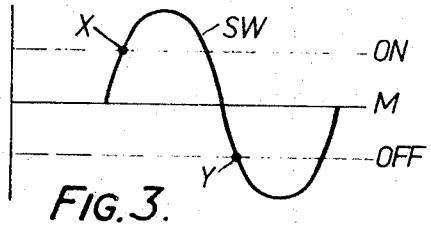



FIG. 3.

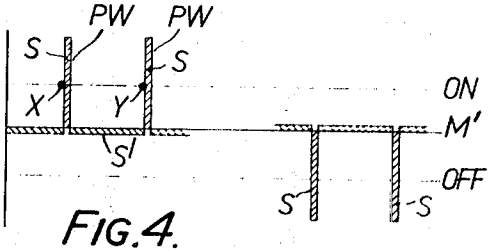



FIG. 4.

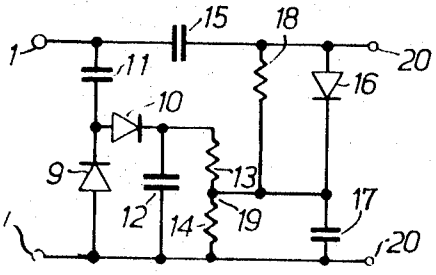



FIG. 5.

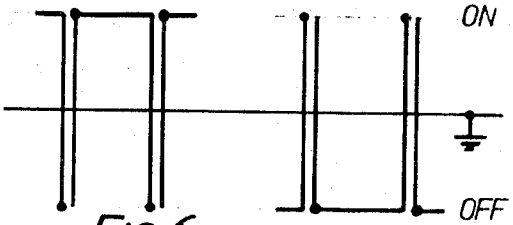



FIG. 6.

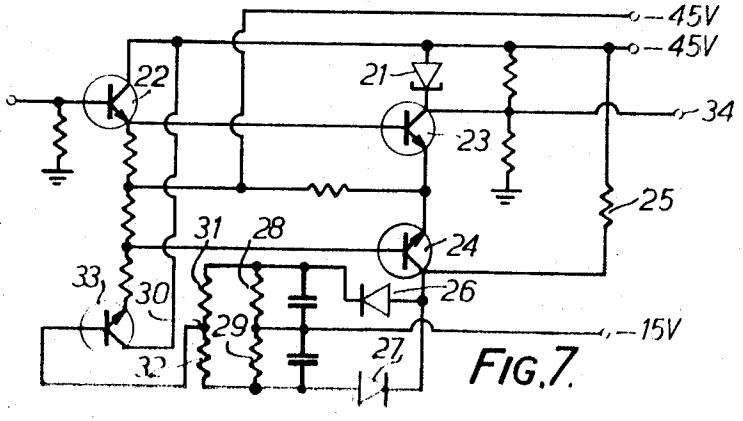



FIG. 7.

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# OSCILLOSCOPE OPERATING CIRCUITS

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U.S. Cl. 315—18 6 Claims

## ABSTRACT OF THE DISCLOSURE

In an oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input waveform which is to be displayed the input wave form is applied to a circuit which produces a similar waveform which is substantially symmetrical about a fixed potential. This similar waveform is used to trigger the time base by means of an electronic switch adapted to trigger the time base to commence a time base excursion in response to a predetermined amplitude of the waveform.

This invention relates to operating circuits for oscilloscopes and more particularly to time base generator controlling circuits for cathode ray tube oscilloscopes for use for such purposes as the display, measurement, and investigation of electrical wave forms.

The invention is illustrated in and explained in connection with the accompanying diagrammatic and explanatory graphical drawings.

It is common practice in present day cathode ray oscilloscope instruments to provide means whereby the operator may at will select either so-called manual operation or so-called auto-operation. In manual operation a time base generator—usually a linear saw-tooth wave form generator—is triggered into operation when an input wave form is to be displayed and manually adjustable means are provided for superimposing upon the input wave form a manually adjustable D.C. component the value of which determines the point in the input wave form at which the time base is triggered.

FIG. 1 of the drawings shows, in simplified form, a typical prior art manually operated oscilloscope operating circuit for providing an adjustable D.C. component which determines the point in an input wave form at which a time base is triggered.

FIG. 2 of the drawings is a block diagram of a typical prior art automatically operated oscilloscope operating circuit for providing a D.C. component which determines the point in an input wave form at which a time base is triggered.

FIG. 3 is a graphical representation of a sinusoidal input wave form which may be applied as an input to the circuit illustrated in FIG. 2.

FIG. 4 is a graphical representation of positive and negative narrow pulse wave forms which may be applied as inputs to the circuit illustrated in FIG. 2.

FIG. 5 is a schematic diagram of one illustrative embodiment of the present invention.

FIG. 6 is a graphical representation, similar to FIG. 4, of positive and negative narrow pulse wave forms which illustrate the improved results obtained in operation of the circuit shown in FIG. 5.

FIG. 7 is a schematic diagram of a second illustrative embodiment of the present invention.



Referring to FIG. 1 an input wave form to be displayed is applied at terminals **1** and on it is superimposed an adjustable D.C. potential derived from a source (not shown) which is connected at terminals **2**, the superimposed D.C. potential being adjusted by adjusting the position of the slider on a potentiometer **3** which acts as a level control. The input wave, with the adjusted D.C. potential superimposed, is amplified by an amplifier **4** the output from which is a wave of a peak-to-peak amplitude depending on the input wave amplitude at **1**, the actual peak amplitudes depending also on the value of the superimposed D.C. voltage. This output is used to operate a current or voltage responsive electronic switch **5** which, when the input thereto reaches a pre-determined value, triggers a time base circuit **6** constituted by a saw tooth voltage source which on being triggered, produces a time base excursion for the cathode ray tube (not shown) used to display the input waveform. It will be seen that, by suitably adjusting the slider of the potetniometer, the time base may be triggered into operation at any desired point in the input wave form.

FIG. 2 shows a typical known circuit which is brought into operation (by suitable switching means not shown) in place of the circuit shown in FIG. 1 when auto, rather than manual, operation is required. In FIG. 2 the level control potentiometer **3** of FIG. 1 is removed from the circuit an dthe input signal at **1** is applied directly to the amplifier **4**. The output from amplifier **4** is again applied to the switch **5**, which, for auto-operation, may be arranged to constitute an astable-bistable e.g. a pair of cross-connected transistors arranged in well known manner to run as a free running multi-vibrator or oscillator in the absence of an input signal but as a triggered oscillator when a wave form to be displayed appears at **1**. In the absence of a wave form input at **1** the oscillator **5** triggers the time base **6** at regular intervals so chosen that a time base trace appears continuously on the screen of the cathode ray tube (not shown). When, however, an input wave appears at **1** a corresponding wave appearing at a convenient stage in the amplifier **4**—in the case illustrated at the output thereof—is detected by a peak detector **7** the output from which is fed to a control circuit **8** which is arranged to trigger the bistable **5** into one state when the input to **8** reaches a pre-determined value, said bistable **5**, when triggered, causing the time base **6** to commence a time base excursion. A customary arrangement is one in which the bistable **5** is triggered to the state in which it triggers the time base into action when the input wave at **1** reaches a certain instantaneous amplitude when changing in one direction e.g. increasing, in (say) the positive half wave of an input wave form and is triggered back again (ready to be triggered again) when the input wave at **1** reaches the same instantaneous amplitude when changing in the same direction in (say) the negative half wave of the input wave form. The time base, once triggered to commence a time base excursion, completes that excursion. It is common practice to provide switching means (not shown) whereby the time base

may be arranged at will to be triggered either during positive half waves of the input or during negative half waves. Means (not shown) are also often provided for enabling the input wave instantaneous amplitude at which the time base is automatically triggered to be adjusted.

Stable and satisfactory auto-operation of the circuit shown in FIG. 2 requires that, once set up or adjusted to cause the time base to be triggered at a particular instantaneous amplitude of the input wave, it always causes such triggering to occur at that amplitude. It is also obviously desirable that stable automatic triggering shall be obtained on both positive and negative polarities. These requirements are satisfied if the input wave form is sinusoidal or approximately so, with successive half waves approximately similar, of similar peak amplitude values, and more or less symmetrical about earth. If, however, the input wave for has a large (or small) mark/space ratio—for example if the input wave form consists of short spaced pulses, (either positive or negative)—the arrangement does not opreate satisfactorily and is seriously lacking in stability. The reasons for this will be explained with reference to the graphical FIGS. 3 and 4.

FIG. 3 illustrates the operation when the input wave form at terminals **1** of FIG. 2 is sinusoidal. The amplifier **4** provides a sinusoidal output represented by the wave SW of FIG. 3, the amplifier **4** being so biased and operated that the wave SW makes equal excursions about the mean value (usually earth), represented by line M, of the amplifier output. If the broken lines marked "ON" and "OFF" represent respectively the voltage at which the switch **5** is triggered with the state in which it causes unit **6** to start a time base excursion and the voltage at which the switch **5** is triggered back (ready to be triggered again during the next positive half wave, not shown), then a time base excursion will commence at the time indicated by the dot X and will continue until completed. At the time represented by the dot Y the switch **5** will be returned to its original state and the next time base will commence at a time in the next positive half wave corresponding to that indicated by the dot X. The amplitudes—one positive and the other negative—at the points X and Y are equal and symmetrical with regard to the mean value M. The minimum strength of input wave which will produce triggering of the switch **5** is obviously one which will result in a wave SW having peak amplitudes equal to the voltages corresponding to the lines "ON" and "OFF" respectively, the voltage separation of which is, for obvious reasons, often referred to as the operating "hysteresis." If, as is the case in practice, the peak amplitudes of the wave SW are large in relation to the amplitudes at X and Y, satisfactory and stable operation is obtained. As will be apparent, stable operation is also obtained if the arrangement is switched over (by the normally provided polarity switch) as respects operating polarity i.e. if the "ON" voltage line is caused to be below the mean line M and the "OFF" voltage line is caused to be an equal amount above the line M.

Suppose, however, the input wave has a large (or small) mark/space ratio e.g. is a narrow pulsed wave form, either positive or negative, as indicated at PW in FIG. 4. The output from the amplifier **4** will be, as indicated, a wave form in which the shaded areas S and S′ will be equal. Positive pulses will start from a line which is a very little below the line of symmetry M′. Similarly negative pulses wil start from a line which is a very little above the line of symmetry M′. With the polarity switch in one position the switch **5** will be triggered on at the times represented by X′ and Y′ on the positive pulses but, as will be seen, the time base will be triggered only on the positive excursions and if the wave form is inverted (as also shown in FIG. 4) the switch **5** will not be triggered at all. The presence of a large amplitude input wave is apt to cause very erratic triggering and an unstable display. This defect could, of course, be overcome by arranging level control means, e.g. a potentiometer such as the potentiometer **3** in FIG. 1, to be still in circuit when auto operation is required and suitably adjusting the level control so as to give stable triggering in each polarity. Such a level control would, however, need to be re-adjusted every time a different input wave form was to be displayed and this is obviously objectionably and time wasting. So long as such level control adjustment is necessary at all the circuit cannot be said to be fully automatic. The present invention seeks to overcome this defect.



According to this invention an oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input wave form to be displayed comprises a circuit to which said wave form is applied, means controlled by said wave form for causing said circuit to produce, irrespective of the input wave form shape, equal and opposite intsantaneous output amplitudes in response to equal and opposite instantaneous input wave form amplitudes on either side of a mean value and an electronic switch adapted in one state to trigger said time base to commence a time base excursion in response to a pre-determined instantaneous output amplitude from said circuit.

According to a feature of this invention an oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input wave form to be displayed comprises means for deriving from said input wave form a voltage equal to one half the peak-to-peak amplitude of the input wave form, means for D.C. restoring the input wave to this voltage, and an electronic switch controlled by the D.C. restored voltage and responsive when said D.C. restored voltage reaches a pre-determined value, to adopt a state in which it triggers said time base to commence a time base excursion.

In one way of carrying out this feature of the invention the input wave form is applied to a peak-to-peak detector having a centre tapped load resistance the voltage from the centre tap on which is applied to a D.C. restoring circuit the output from which is employed as control voltage for the switch. In a preferred circuit of this nature the input wave form is applied across a condenser in series with a first diode; a second diode, oppositely sensed in relation to the first, is connected in series with a second condenser across the second diode; a centre tapped load resistance is connected across the second condenser; the input wave form is also applied through a third condenser across a circuit branch consisting of a third diode shunted by a resistance and in series with a fourth condenser said third diode being sensed in the same way as the second; the centre tap is conected to the junction point of the third diode with the fourth condenser; and control voltage for the switch is taken from across the third diode and the fourth condenser in series.

According to another feature of this invention an oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input wave form to be displayed comprises means for deriving from the input wave form a D.C. voltage dependent on the difference between the positive and negative peak voltages of said input wave form; means for superimposing said D.C. voltage on said input wave form; and means for utilising the resultant of superimposition to control an electronic switch responsive when said resultant reaches a pre-determined value to adopt a state in which it triggers said time base to commence a time base circuit.

In one way of carrying out this feature of the invention the input wave form is applied to a so-called long-tailed pair the differential output from which is applied to a pair of peak detectors having equal load resistances, D.C. voltage from a centre tap between the load resistances being superimposed upon the input wave form.

FIG. 5 is a diagram showing, so far as is necessary to an understanding thereof, a preferred arrangement in accordance with the first mentioned feature of this invention

and FIG. 6 is a graphical figure, of the same nature as FIG. 4, showing the results obtainable in operation of the circuit of FIG. 5. As will be seen later FIG. 6 also illustrates the results obtainable in operation of another circuit shown in FIG. 7.

Referring to FIG. 5 an input wave form to be displayed is applied at terminals **1** to a peak-to-peak detector comprising diodes **9** and **10** which are oppositely sensed. The diode **9** is in series with the condenser **11** across the terminals **1**. The diode **10** is in series with a condenser **12** which is across two equal series resistances, **13** and **14**. The elements **10** and **12** in series are connected across the diode **9**. The input wave is also applied through a condenser **15** across a diode **16**, sensed to the same way as the diode **10**, in series with a condenser **17**. A resistance **18** is connected across the diode **16** and the centre tap **19** between the resistances **13** and **14** is connected to the junction point of the elements **16** and **17**. Output is taken from the terminals **20** to the eletcronic switch (normally as astable-bistable) triggering the time base. So as not to complicate the drawing the switch and time base are not shown in FIG. 5. They correspond however to the switch and time base **5** and **6** of FIG. 1 and are connected in the same way as therein shown except, of course, that the circuitry of FIG. 5 replaces the single amplifier **4** of FIG. 1 or, preferably, follows an amplifier in the position of amplifier **4** of FIG. 1.

Diodes **9** and **10** act as a peak-to-peak detector and, since resistances **13** and **14** are equal, the voltage at the centre tap **19** will always be half the peak-to-peak voltage of the input wave form, irrespective of its shape. The action of the diode **16** is to restore the input wave to the voltage at **19** so that the result is a signal with positive and negative excursions which are always substantially symmetrical to a fixed potential—normally earth. The improved results achieved will be apparent from FIG. 6 in which the "ON" and "OFF" voltages for the electronic switch are represented by broken lines, the line of substantial symmetry is represented as earth, and triggering points are repersented, as in FIG. 4 by dots. As will now be appreciated, stable fully automatic operation on both positive and negative excursions is obtainable, irrespective of input wave shape, and without any need to make manual adjustments of level to suit different inputs.

FIG. 7 shows a preferred circuit embodying the second feature of the invention. In FIG. 7 it is assumed that the electronic bistable switch is a tunnel diode **21**. This is a current device rather than a voltage device and the circuit of FIG. 7 is therefore shown as adapted to suit this type of device. The voltage values indicated in FIG 7 are practical but are by way of example only.

Referring to FIG. 7 the input wave form to be displayed is applied through an emitter follower transistor **22** to a circuit including as the active elements the transistors **23** and **24**. The tunnel diode switch element **21** is driven directly as shown by transistor **23**. A voltage proportional to the output current from the transistor **24** appears across a resistance **25** and is applied to a pair of peak detector diodes **26, 27** the load resistances **28, 29** of which are equal and returned to a point of fixed voltage (in the example illustrated —15 volts) of value equal to the mean of the two voltages required, to turn the bistable switch (diode **21**) "on" and "off" respectively. Accordingly the two detectors **26** and **27** operate to rectify positive and negative excursions respectively. If the rectified voltages from the two detectors **26, 27** differ, there will be produced, at the junction point **30** of two equal resistances **31, 32** connected as shown, a voltage proportional to the difference and this is superimposed, via a further emitter follower transistor **33** upon the input wave form which, in FIG. 7, can be regarded as the output from the transistor **22**. The output terminal of the whole arrangement is referenced **34**.

Any difference between the detected outputs from the rectifiers **26** and **27** is thus fed back to, and superimposed on, the effective input, the sense of feed back being, of course, such as to maintain the difference at substantially zero. Thus positive and negative peaks are always kept equal automatically and stable fully automatic operation on excursions of either polarity is obtained irrespective of waveform shape. An incidental advantage of the arrangement of FIG. 7 is that the D.C. conditions are maintained constant in the absence of input signals, thus minimising drift.

FIG. 6, showing results achieved, applies equally to FIGS. 5 and 7. For simplicity it is drawn for the case in which the peak amplitude of the input wave form is what may be termed the "threshold" amplitude i.e. it is only just enough to procure triggering which accordingly occurs, (in the case illustrated by FIG. 6) at the peaks of the wave form. With input wave forms of substantially larger amplitudes triggering occurs well below the peaks and the larger the peak amplitudes in relation to the "ON" and "OFF" voltages the nearer does the operation of the circuit approach to the theoretical ideal (from the point of view of stability) which is that at which triggering occurs at the centre of the waveform.

I claim:

**1.** An oscilloscope operating circuit arrangement of the kind wherein a time base means is automatically triggered into operation under the control of an input wave form to be displayed, said arrangement comprising means for deriving from said input wave form a voltage equal to substantially half the peak-to-peak voltage amplitude of said input wave form, means for combining said input wave form with said substantially half of the peak-to-peak voltage amplitude, and an electronic switch means controlled by said means for combining for triggering said time base means.

**2.** An oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input wave form to be displayed, said arrangement comprising means for deriving from said input wave form a voltage equal to substantially one half the peak-to-peak amplitude of the input wave form, means for D.C. restoring the input wave to this voltage, and an electronic switch controlled by the D.C. restored input wave and responsive when said D.C. restored input wave reaches a predetermined value, to adopt a state in which it triggers said time base to commence a time base excursion.

**3.** An arrangement as claimed in claim **2** wherein the input wave form is applied to a peak-to-peak detector having a centre tapped load resistance the voltage from the centre tap on which is appiled to a D.C. restoring circuit the output from which is employed as control voltage for the switch.

**4.** An arrangement as claimed in claim **2** wherein the input wave form is applied across a condenser in series with a first diode; a second diode, oppositely poled in relation to the first diode, is connected in series with a second condenser across the first diode; a centre tapped load resistance is connected across the second condenser; the input wave form is also applied through a third condenser across a circuit branch consisting of a third diode shunted by a resistance and in series with a fourth condenser, said third diode being poled in the same way as the second diode; the centre tap is connected to the junction point of the third diode with the fourth condenser; and control voltage for the switch is taken from across the third diode and the fourth condenser in series.

**5.** An oscilloscope operating circuit arrangement of the kind wherein a time base is automatically triggered into operation under the control of an input wave form to be displayed, said arrangement comprising means for deriving from the input wave form a D.C. voltage dependent on the difference between the positive and negative peak voltages of said input wave form; means for superimposing said D.C. voltage on said input wave form; and means for utilising a modified wave form which is the resultant

of superimposition to control an electronic switch means responsive when said modified wave form reaches a predetermined value to adopt a state in which it triggers said time base to commence a time base excursion.

6. An arrangement as claimed in claim 5 wherein the input wave form is applied to a pair of transistors, an output from which is applied to a pair of peak detectors having equal load resistances, and said D.C. voltage is effectively derived from a centre tap between the equal load resistances and is superimposed upon the input wave form.



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U.S. Cl. X.R.

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