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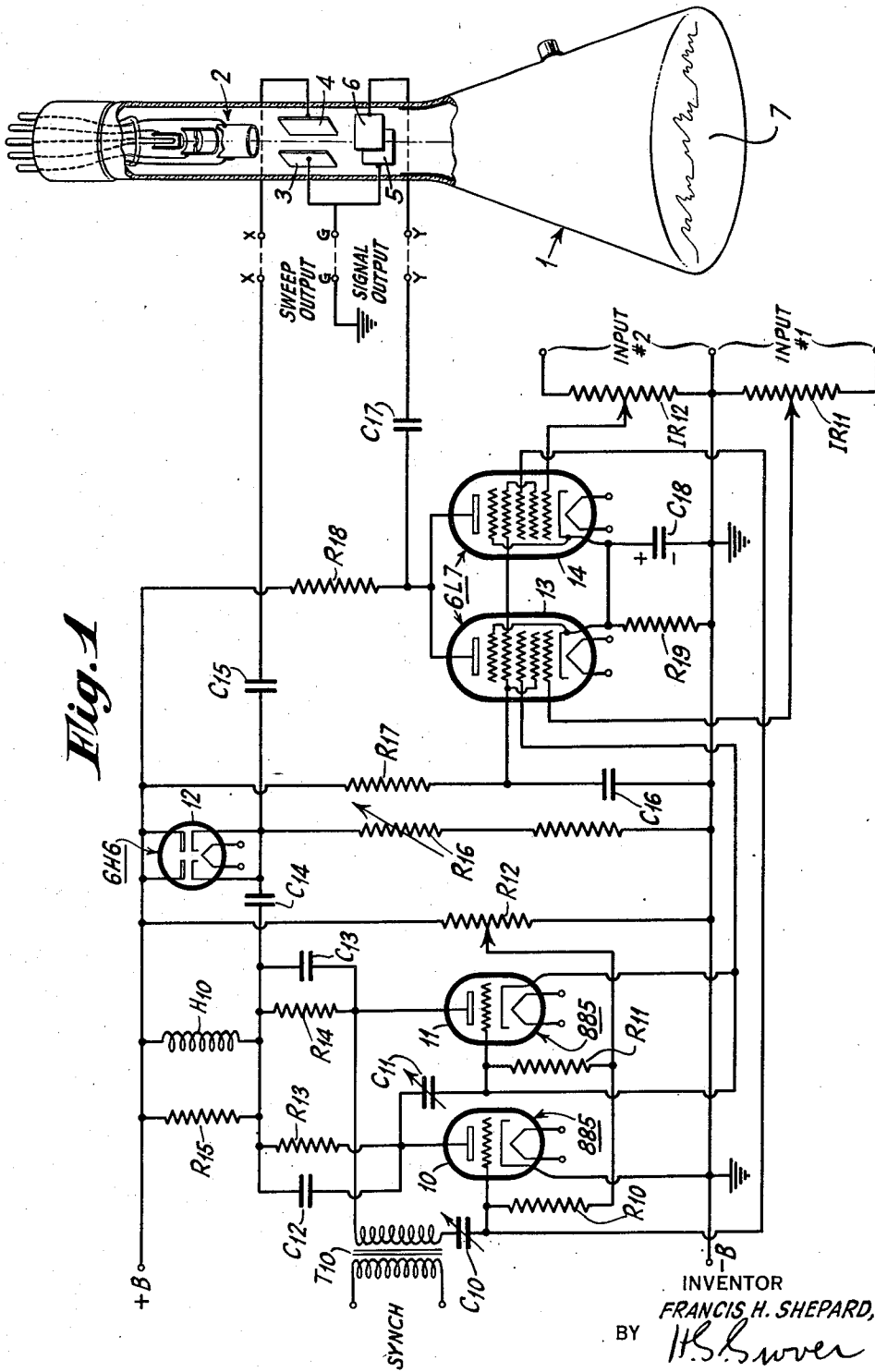
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2,221,115

MULTIPLE TRACE OSCILLOGRAPH SYSTEM

Filed June 30, 1937

5 Sheets-Sheet 1



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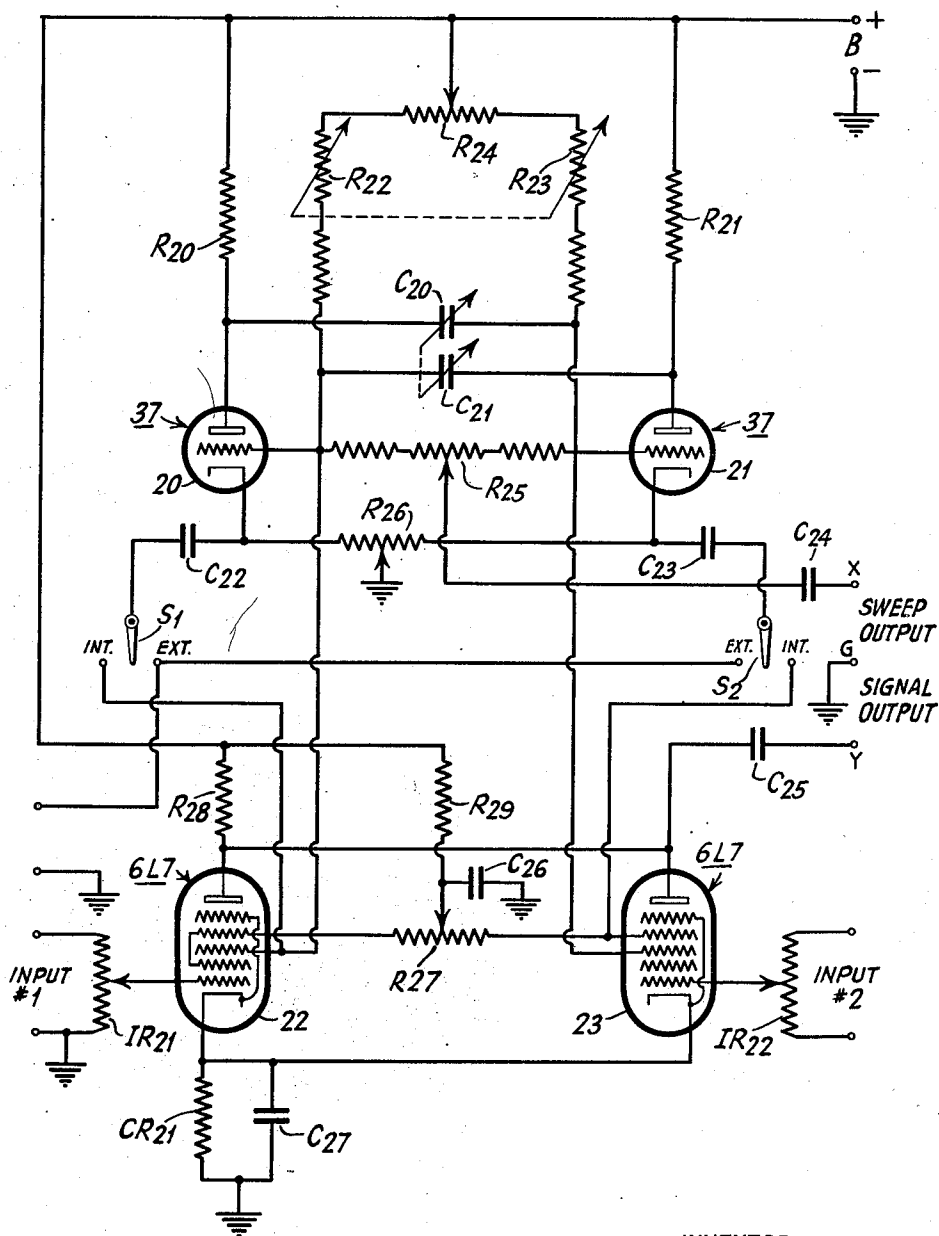
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MULTIPLE TRACE OSCILLOGRAPH SYSTEM

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5 Sheets-Sheet 2

Fig. 2



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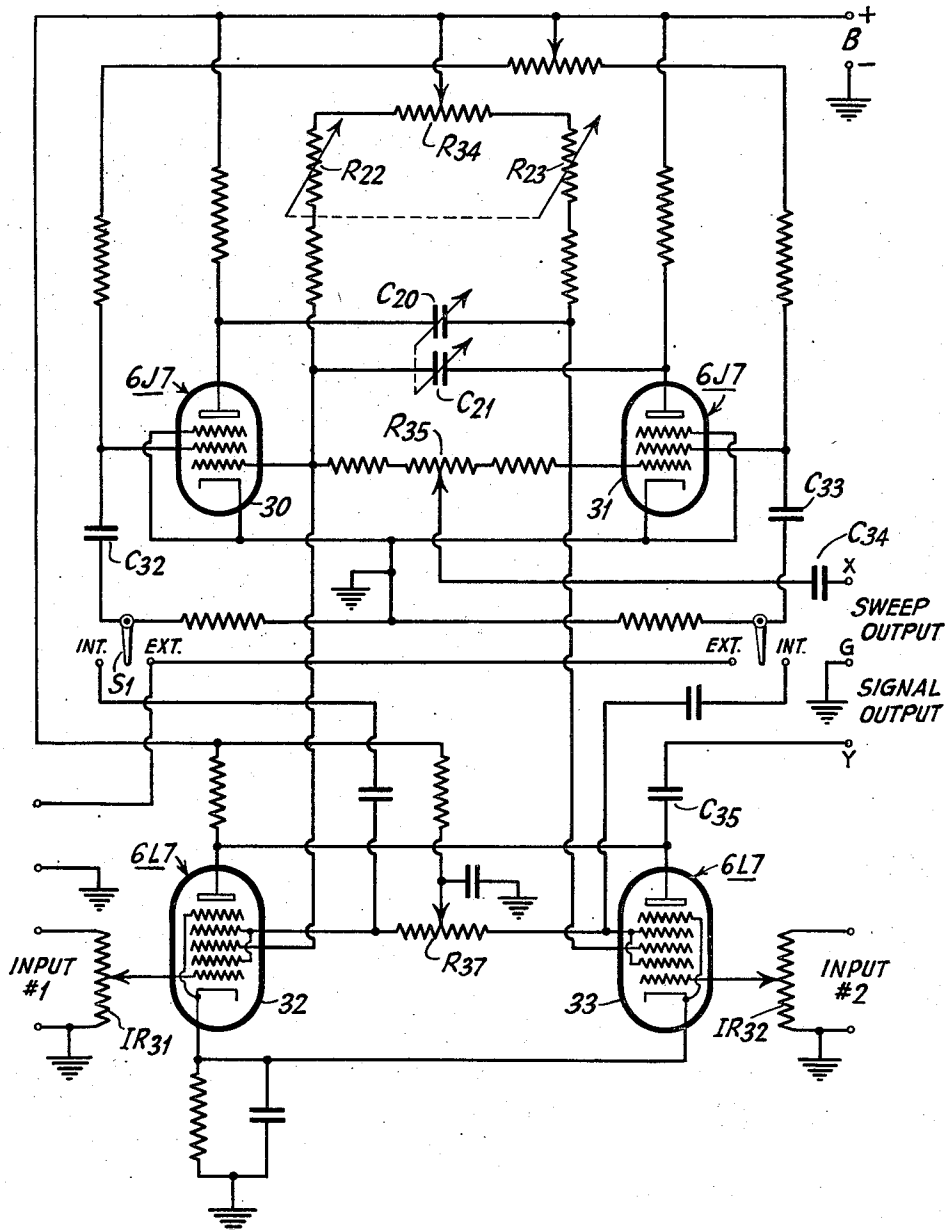
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MULTIPLE TRACE OSCILLOGRAPH SYSTEM

Filed June 30, 1937

5 Sheets-Sheet 3

Fig. 3



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2,221,115

MULTIPLE TRACE OSCILLOGRAPH SYSTEM

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5 Sheets-Sheet 4

Fig. 4

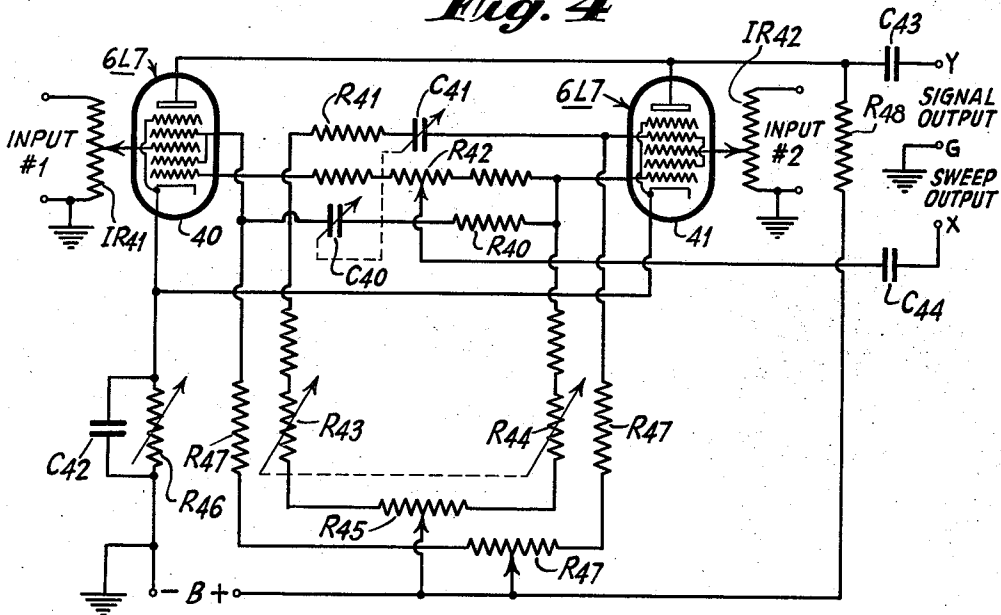
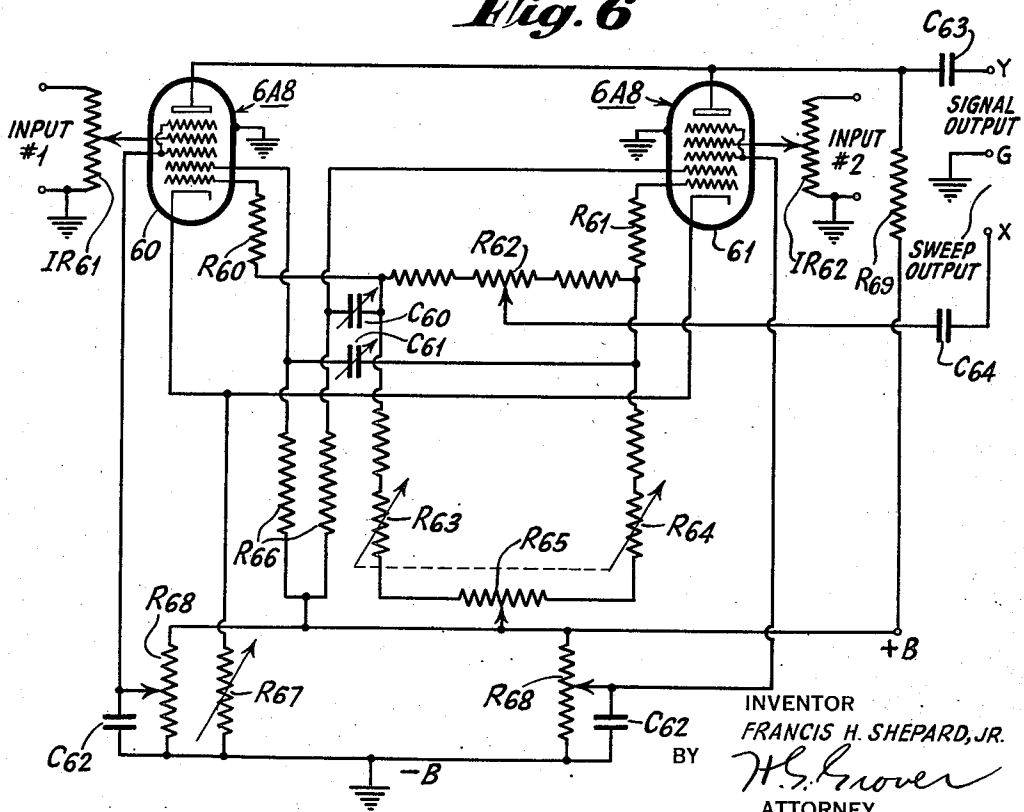


Fig. 6



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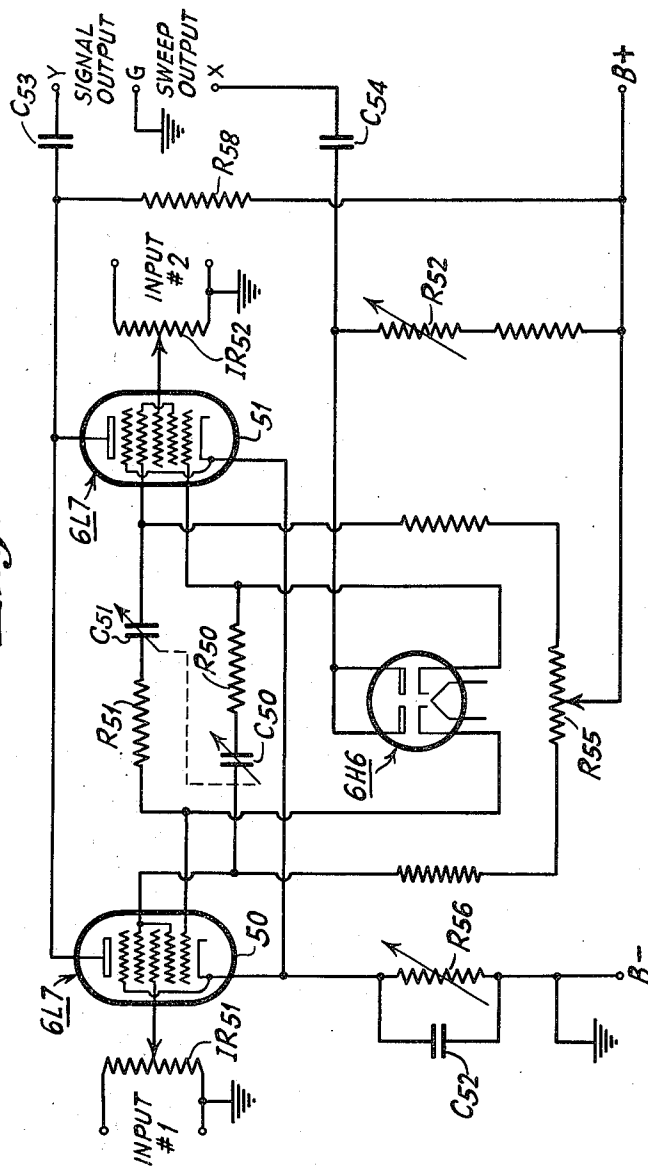
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MULTIPLE TRACE OSCILLOGRAPH SYSTEM

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5 Sheets-Sheet 5

Fig. 5



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UNITED STATES PATENT OFFICE

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MULTIPLE TRACE OSCILLOGRAPH SYSTEM

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Application June 30, 1937, Serial No. 151,160

18 Claims. (Cl. 171-95)

The present invention relates to a circuit for use primarily with cathode ray oscillographs in which a plurality of variables or transients may be observed simultaneously. This observation is obtainable by the provision of means for supplying signals from the plurality of sources in any selected order to an observation oscillograph. When these signals are so applied in the chosen sequence, they become visible upon the screen or target of the cathode ray tube in rapid succession.

The effect of simultaneous signal application is obtainable by virtue of the rapidity of switching and the time lag of light decay from the luminescent target, as well as the period of persistence of vision, it being understood, of course, that the switching rate is so selected as to be repeated at a frequency at least equal to the period of persistence of vision.

It is the purpose of this invention to produce a circuit which, when used with a cathode ray tube oscillograph will permit observation of a plurality of varying signals or transients simultaneously.

A further object of the invention is to produce a switching circuit which is capable of alternately switching from one signal source to another at a rate of from 10 or less to 10,000 or more times per second.

A further object of the present invention is to produce a circuit which is capable of amplifying uniformly and without distortion signal voltages which may vary in frequency from 10,000 to 30,000 or more cycles per second.

A still further purpose of my invention is to produce a system in which the switching may be synchronized and so interlocked as to operate with the frequency of either of the input signals.

A further purpose of my invention is to produce a system wherein the switching circuit may be operated in synchronization with an external and entirely independent source of impulses and/or where desired, in accordance with the frequency of a power supply source when A. C. operation is selected.

A still further purpose of my invention is to produce a system wherein the saw-tooth sweep or deflecting voltage for the cathode ray tube is supplied and wherein this voltage will always be in exact synchronization and in proper phase relation with the switch and also in which the amplitude of the sweep will remain constant over the entire frequency range of the system.

Other purposes and uses of the device will be-

come more apparent and immediately suggest themselves to those skilled in the art to which this invention relates from the following description of the circuits used, particularly when considered with the drawings, in which:

Fig. 1 represents one form of my invention for use in connection with a cathode ray tube oscillograph, and,

Figures 2 through 6 show various modified or alternative forms of my invention which may be used to accomplish broadly the same results.

In Figure 1, five discharge tubes serving as switching and/or control devices, are used to accomplish the purpose of this invention. The switching voltage is generated by a pair of gas triodes 10 and 11. These triodes, because of the manner in which they are inter-connected, function in a manner similar to that of a relaxation oscillation generator. The grid of tube 10 is connected to the anode of tube 11 by way of condenser C10 and similarly the control electrode of tube 11 is connected to the anode of tube 10 by way of condenser C11. To the anodes of each of the tubes 10 and 11 is connected resistances R13 and R14, respectively, in parallel with which are condensers C12 and C13 respectively. The source of positive potential is connected to these resistances and condensers by way of the resistance R15 and the radio-frequency choke coil H10. The frequency of the switching voltages and sweep impulses as supplied by these tubes is a function of the size of the condensers C10 and C11 and the size of these condensers may be altered simultaneously in order to vary the frequency of the output. An adjustment of resistance R16 also controls the frequency as will later become apparent. The control grids in each of the tubes are connected through resistances R10 and R11 to the variable resistance R12, which latter resistance acts as a potentiometer connected across the anode current supply whereby the grid bias of each of the tubes 10 and 11 may be varied.

The frequency oscillation of the tubes 10 and 11 may also be controlled or synchronized by an external source through the transformer T10.

The actual sweep voltage is obtained with the aid of an additional tube 12 which may be in the form of a twin diode. With each switching operation of the tubes 10 and 11 a voltage variation is caused to exist across the choke H10. The twin diode is connected in parallel with this choke with a condenser C14 which is inserted in the cathode connection. The impulses as applied to the choke are therefore impressed upon

the condenser C14 to successively charge the same, this condenser being intermittently discharged at a relatively constant rate through the resistance R16 and the voltages derived therefrom are impressed upon the horizontal beam deflecting means of the cathode ray tube by way of the coupling condenser C15 and the terminal X.

A conventional cathode ray tube is shown at 1, the tube having a ray developing means or electron gun 2. Plates 3, 4, 5 and 6 are shown for electrostatically deflecting the beam after it has been developed, the plates 3 and 4 operating to produce horizontal deflection of the beam when proper voltages are applied thereto and the plates 5 and 6 operating to produce vertical deflection of the beam. A fluorescent screen 7 is provided whereby movements of the electron beam may be observed. It is to be understood that the particular tube shown is only by way of example since, obviously, other forms of cathode ray tubes may be used and the electrostatic deflecting means may be replaced by electromagnetic means or a combination of electrostatic and electromagnetic deflecting means.

A pair of tubes 13 and 14 are also used and these tubes may be in the form of pentagrids in which the suppressor or #5 grid is connected internally to the cathode of the tube. It will be noticed that the grids of the tubes 10 and 11 are connected to the oscillator or #3 grids of the tubes 14 and 13, respectively, in order that the latter tubes may be alternately biased beyond cut-off in synchronism with the operation of the tubes 10 and 11. The two sources of signal input are impressed across the resistances IR11 and IR12, to which, by an adjustable contact, the #1 grids of the tubes 13 and 14, respectively, are connected. The anodes in each of the two tubes are tied together and are connected to the positive source of potential by way of resistance R18. Likewise the two screen grids of the tubes are connected to the positive source of potential by way of resistance R17. The values of these resistances R17 and R18 are so chosen that appropriate voltages will be applied to the screen grids and the anodes of each of the tubes 13 and 14. The signal output of these tubes is applied to the vertical beam deflecting means of the cathode ray tube by way of the condenser C17 and the terminal X.

It will therefore be apparent that as tubes 10 and 11 alternately become conductive to supply the sweep voltage, the two tubes 13 and 14 are likewise alternately made conductive or non-conductive in synchronism therewith, so that the signal input voltage variations are alternately made visible on the screen of the cathode ray tube oscillograph at a frequency determined by the frequency of operation of the tubes 10 and 11. The amplitude of the sweep, that is, the horizontal component of the image on the cathode ray tube, may be controlled by varying the condenser C14 and the resistance R16 while the amplitude of the signal, that is, the vertical component of the image on the cathode ray tube oscillograph screen, may be varied by adjusting the resistances IR11 and IR12.

Figure 2 shows a modified form of my invention wherein only four tubes are used. The tubes 20 and 21 are triodes and operate to supply the switch voltage and the sweep voltage. Their alternate operation is similar to the operation of tubes 10 and 11 of Figure 1, and the frequency of their operation may be controlled by varying

the size of condensers C20 and C21, together with a variation in the size of the resistances R22 and R23. The grids of the tubes 20 and 21 are interconnected by the resistance R25 over which an adjustable contact is movable. Connected to this contact is a condenser C24 through which the sweep voltage is applied to the cathode ray tube.

The tubes 22 and 23 operate as amplifiers for the input signals and are biased to cut off alternately in synchronism with the operation of tubes 20 and 21 since the #3 grid of the tubes 22 and 23 are connected respectively to the grids of tubes 20 and 21. The signal input voltage from the two sources is applied to the #1 grid of the tubes 22 and 23 in a manner similar to that shown and described in connection with the circuit shown in Figure 1.

The screen grids of the tubes 22 and 23 are connected together by resistance R27 and the positive source of potential is connected to an adjustable point along this resistance by way of the resistance R29.

The system shown may be caused to oscillate in synchronism with an external synchronizing voltage and in which case the switches S1 and S2 are placed in the position marked "Ext." on the drawings, in which case the external synchronizing impulses are supplied to the cathodes of the tubes 20 and 21.

For internal synchronizing, the switches S1 and S2 are placed in the alternate position marked "Int." on the drawings. When such a connection is made, the screen grids of the tubes 22 and 23 are connected to the cathodes of the tubes 20 and 21 by way of condensers C22 and C23, respectively.

This system has the advantage over the system shown in Figure 1 that the duration or percent of time that each function is amplified may be controlled by adjusting the potentiometer R24. By such adjustment, the length of time that one of the tubes 20 or 21 is conductive as compared to the length of time that the other tube is conductive, may be changed with the effect that the horizontal component of the two signal sources as they appear on the screen of the oscillograph may be differentially controlled.

Furthermore, in this system, the amplitude of the sweeps for the two functions can be differentially adjusted by varying the contact along the resistance R25. By such adjustment, the length of the horizontal component of the images as they appear on the oscillograph may be varied differentially.

A further advantage of this system is that the level of the zero lines of the two functions can be differentially adjusted by moving the contact along the resistance R27. This has the effect of differentially varying the voltage of the screen grid of the tubes 22 and 23 whereby the two signals, as they appear on the oscillograph, can be made to appear about the same axis or about two axes one above the other. This is a desirable characteristic, particularly when two or more switch units are combined to observe several functions simultaneously since the various functions may be isolated by vertical displacement.

Figure 3 shows another form of my invention. This system is in many ways the same as the system shown in Figure 2 with the difference that the tubes 30 and 31 are triple grid tubes, the suppressor grid being connected externally to the cathode of each tube. The use of the three grid tubes improves the operation of this circuit in

that the sweep voltage is of a truer saw-tooth form and as a result the rate of sweep of the beam across the screen in the oscillograph is more uniform.

It will be noticed that the synchronizing impulses for the tubes 30 and 31, regardless of whether they are derived from an internal or an external source, are applied by way of condensers C32 and C33 to the #2 grids of the tubes 30 and 31 respectively. In the circuit shown in Figure 2, there is a very slight tendency for the synchronizing voltage to appear in the sweep with the result that the rate of movement of the beam across the screen is not strictly uniform. Where this effect is particularly objectionable, the circuit shown in Figure 3 should then be used. The same adjustments that are possible in Figure 2 with respect to the duration and amplitude of the sweep as well as the zero base lines of the functions, are also possible in the circuit shown in Figure 3.

Figure 4 shows a relatively simple two-tube electronic switch, sweep and amplifier in which the tubes are identical and may be of the pentagrid type. In this circuit the tubes not only act as a source of switch voltage and sweep voltage, but also operate as amplifiers for the two input voltages. The frequency of operation of the system may of course be controlled by varying the size of the condensers C40 and C41, together with the size of the resistances R43 and R44. In this system, the input voltages are applied to the oscillator or #3 grid of each of the tubes and at the time one of the tubes is operating to supply the sweep voltage the same tube is also operating to amplify the input voltage and to apply the same to the vertical deflecting means of the cathode ray tube. The sweep voltage is supplied to the horizontal deflecting means of the cathode ray tube through the condenser C44 which is connected by an adjustable contact to the potentiometer resistance R42 which inter-connects the control grids of the two tubes.

In this circuit there is a slight tendency for the switch to lock in step with either or both of the signals and there is a tendency for a part of the signal to appear on the sweep. Both of these effects are due to the negative trans-conductance between the #3 grid and the screen grids 2 and 4 of the tubes. The latter effect is particularly noticeable when viewing a large number of signal cycles on one sweep cycle. Both of these effects are more noticeable with large input signals and both can be reduced by reducing the input signals (adjusting the resistances IR41 and IR42), or by increasing the value of the common plate load to as high as is consistent with the desired amplifier frequency response. The common plate load is represented by the resistance R48.

The sweep output of this circuit is constant in amplitude and is always in exact synchronization with the switch. To keep the gain constant during the amplifying part of the cycle for each stage, it is desirable that the screen potential be affected as little as possible by the varying charging current to the grid of the other stage. To accomplish this the screen load resistor R47 should be made as low as possible. It is also essential that the potential of the #1 grid be constant during the amplifying part of the cycle for each tube and this is accomplished by means of the grid current limiting resistors R40 and R41.

It is possible with this circuit to differentially adjust the amplitudes of the sweeps for the two functions by varying the resistance R42, to dif-

ferentially adjust the duration of the sweeps for the two functions by varying the resistance R45, and also to raise or lower the zero lines of the two functions by adjusting the resistance R47. These adjustments operate in the same manner as do the corresponding adjustments given above with respect to the disclosure shown in Fig. 2.

Figure 5 shows a circuit similar to the circuit shown in Figure 4 with the exception that a duodiode is used to improve the wave form and increase the amplitude of the sweep circuit and to increase the operating frequency of the system. With the type system shown it is possible to operate up to 750,000 cycles per second. If it is desired, and by proper compensation, it is possible that this frequency may be considerably extended.

The system disclosed in Figure 5 differs from that shown in Figure 4 in that the resistances R43, R44, R45 as well as the resistance R42, are omitted and the first grids of the pentagrids are connected each respectively to the cathodes of the duo-diode. The anodes of this tube are connected together and supply the sweep output by way of condenser C54. The source of anode potential for the duo-diode is connected through the variable resistance R52. The remainder of the system is the same as that shown in Figure 4 and further explanation is believed to be unnecessary.

In Figure 6 is shown a further form of my invention which has all of the advantages of the systems shown in Figures 4 and 5 with the additional advantage that the reaction of the signal on the sweep is materially reduced. This is due to the reduced negative trans-conductance between the outer control grid (grid #4) and the oscillator anode (grid #2). This system has a slight tendency for the switch to synchronize with either or both of the input signals and is sufficient in most cases to maintain the operation of the device in synchronization with the signal variations if such is desired. The condensers C60 and C61 are preferably made adjustable in order that the frequency of the device may be controlled in order to cause the circuit to operate at a predetermined frequency or to maintain the circuit operating in synchronization with fluctuations of the input of the one or the other of the input signals. The resistances R63 and R64 are generally adjusted when the capacitances of the condensers C60 and C62 are changed in order to improve this control.

By varying the resistance R65 it is possible to differentially control the duration or percentage of time that each function is amplified in order that the magnification of the horizontal component of the image formed on the oscillograph may be increased or decreased as desired. Also, by adjusting the resistance R62 it is possible to differentially vary the amplitudes of the successive horizontal sweeps.

The resistances R68 and R69 are for the purpose of maintaining proper potentials upon the electrodes of the tubes and the load resistances R66 are so chosen as to keep the gain constant during the amplifying part of the cycle for each stage.

From the above description of the circuits shown, it may be seen that a cathode ray tube oscillograph may be used to observe two or more functions simultaneously, the functions appearing on the screen alternately and in rapid succession. The circuits used are relatively simple and do not entail the use of a large number of

tubes nor a complicated circuit for producing the results.

When a cathode ray tube of the type shown in connection with Figure 1 is used, as it may be with any of the circuits shown in the drawings, the time lag of light decay of the luminescent target may be varied in accordance with the frequency of the sweep impulses, a target having a short time lag being used when high frequencies are employed and a target having a longer time lag being used when lower frequencies are employed.

It is to be understood that various modifications may be made in any or all of the systems disclosed without departing from the spirit and scope of the invention, and it is desired that only such limitations be placed on the device as are necessary in view of the prior art and the appended claims.

I claim as my invention:

1. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means for differentially controlling the duration or percent of time that each signal is amplified.

2. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means for differentially controlling the duration of alternate sweep impulses independently of the amplitudes of the impulses.

3. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means for differentially controlling the amplitudes of alternate sweep impulses.

4. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means

for differentially adjusting the zero base lines of the amplified signals.

5. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair of electron discharge tubes each having a plurality of control electrodes, means for individually impressing the input signals upon one control electrode of each of the tubes, respectively, and circuit means including another control electrode of each tube for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and whereby the amplified signal impulses are alternately supplied to the signal output.

6. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair of electron discharge tubes, means for impressing the input signals upon a control electrode of each of the tubes respectively, means for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and the amplified signal impulses are alternately supplied to the signal output, and means for differentially controlling the duration or percent of time that each signal is amplified.

7. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair of electron discharge tubes, means for impressing the input signals upon a control electrode of each of the tubes, respectively, means for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and the amplified signal impulses are alternately supplied to the signal output, and means for differentially controlling the duration of alternate sweep impulses independently of the amplitudes of the impulses.

8. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair of electron discharge tubes, means for impressing the input signals upon a control electrode of each of the tubes, respectively, means for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and the amplified signal impulses are alternately supplied to the signal output, means for differentially controlling the duration of alternately conducting and non-conducting periods and means for differentially controlling the amplitudes of alternate sweep impulses, said two last named means being independently operable.

9. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair of electron discharge tubes, means for impressing the input signals upon a control electrode of each of the tubes, respectively, means for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and the amplified signal impulses are alternately supplied to the signal output, and means for differentially controlling the amplitudes of alternate sweep impulses.

10. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, a pair

of electron discharge tubes, means for impressing the input signals upon a control electrode of each of the tubes, respectively, means for rendering the tubes alternately conducting and non-conducting in rapid succession whereby sweep impulses are supplied to the sweep output and the amplified signal impulses are alternately supplied to the signal output, and means for differentially adjusting the zero base lines of the amplified signals.

11. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and at least a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits individually, means whereby the operation of the last named means is controlled by said first named means to supply the signals to the signal output in succession and in synchronism with the sweep impulses, and means whereby said first pair of tubes may be operated in synchronism with an external source of impulses.

12. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means whereby said first pair of tubes may be operated in synchronism with the frequency of the one or the other of said input signals.

13. A system for controlling a cathode ray tube oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronism with the sweep impulses, and means whereby said first pair of tubes may be operated in synchronism with an external source of impulses or in synchronism with the frequency of the one or the other of said input signals.

14. A system for controlling a cathode ray tube

oscillograph comprising a sweep output, a signal output and a pair of signal input circuits, means including a pair of discharge tubes for supplying rapidly recurring sweep impulses to the sweep output, means including a second pair of discharge tubes for amplifying the signals from the input circuits, means to control the operation of said last named means by said first named means whereby the amplified signals are supplied to the signal output in succession and in synchronization with the sweep impulses, means for differentially controlling the duration of alternate sweep impulses, and means for differentially controlling the amplitudes of alternate sweep impulses, said two last named means being independently operable.

15. A system for controlling a cathode ray tube oscillograph comprising electronic means for producing rapidly recurring sweep impulses, a plurality of separate input circuits, means for successively switching from one input signal to another in synchronism with the sweep impulses, said last named means being under the control of said first named means, and means for differentially controlling the duration of alternate sweep impulses.

16. A system for controlling a cathode ray tube oscillograph comprising electronic means for producing rapidly recurring sweep impulses, a plurality of separate input signals, means for successively switching from one input signal to another in synchronism with the sweep impulses, and means for differentially controlling the amplitudes of alternate sweep impulses.

17. A system for controlling a cathode ray tube oscillograph wherein a plurality of signals may be caused to appear simultaneously comprising means for electronically producing a series of rapidly recurring sweep impulses, means whereby the signals may be independently and successively applied to the tube in synchronism with the sweep impulses, and means for differentially adjusting the zero base lines of the signals.

18. A system for controlling a cathode ray tube oscillograph wherein a plurality of signals may be caused to appear simultaneously comprising means for electronically producing a series of rapidly recurring sweep impulses, means whereby the signals may be independently and successively applied to the tube in synchronism with the sweep impulses, means for differentially controlling the duration of alternate sweep impulses, and means for differentially controlling the amplitudes of alternate sweep impulses, said two last named means being independently operable.

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