Jan. 2, 1945. K. SCHLESINGER 2,366,357

ELECTRONIC RELAY

Filed May 30, 1942 2 Sheets-Sheet 1

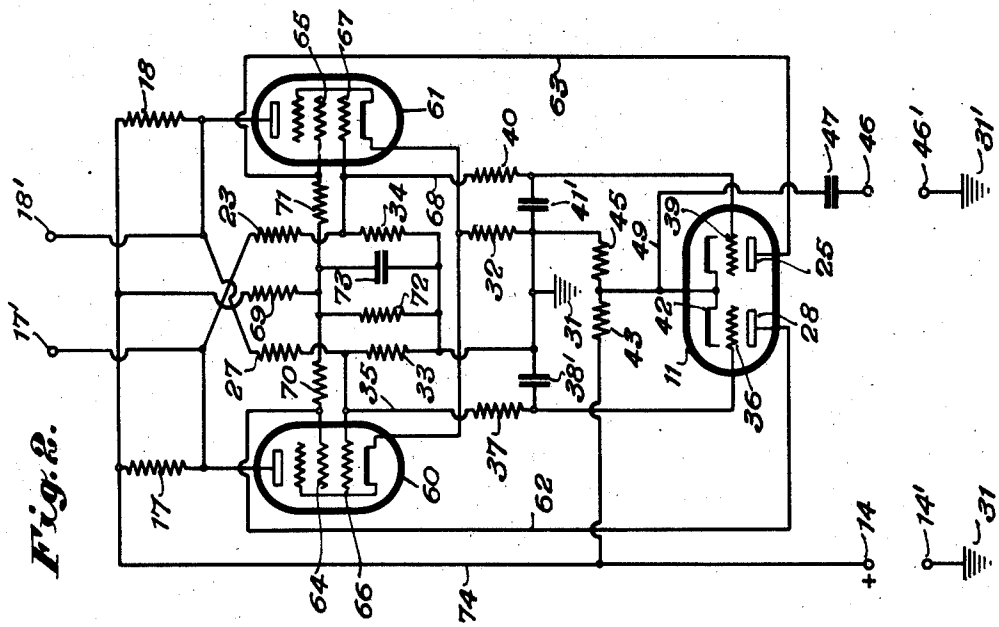


Fig. 2.

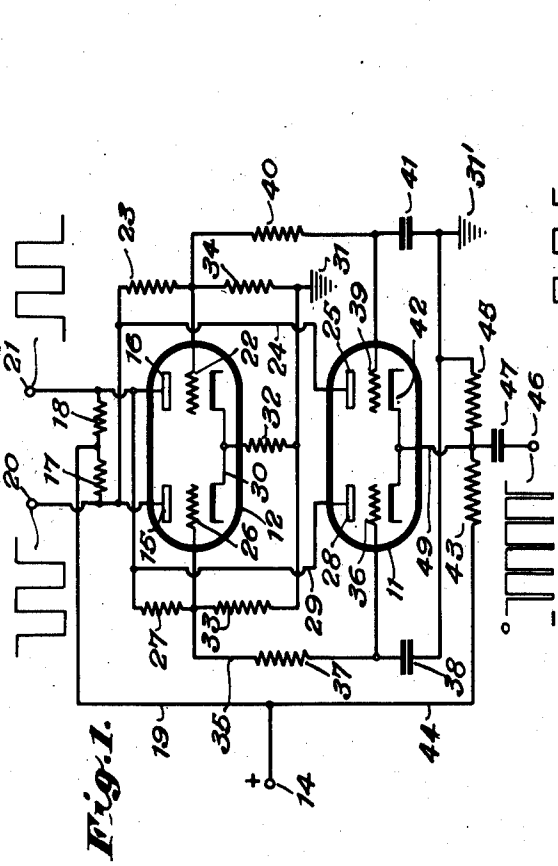


Fig. 1.

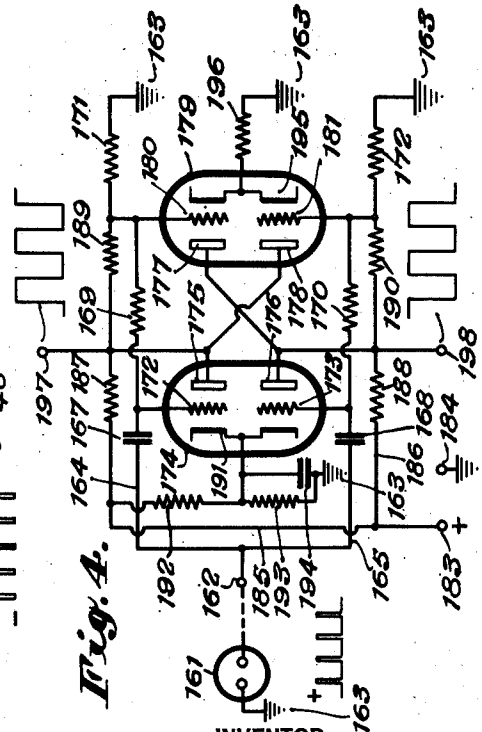


Fig. 4.

INVENTOR
Kurt Schlesinger
BY H. B. Sawyer
ATTORNEY

Jan. 2, 1945. K. SCHLESINGER 2,366,357

ELECTRONIC RELAY

Filed May 30, 1942 2 Sheets-Sheet 2

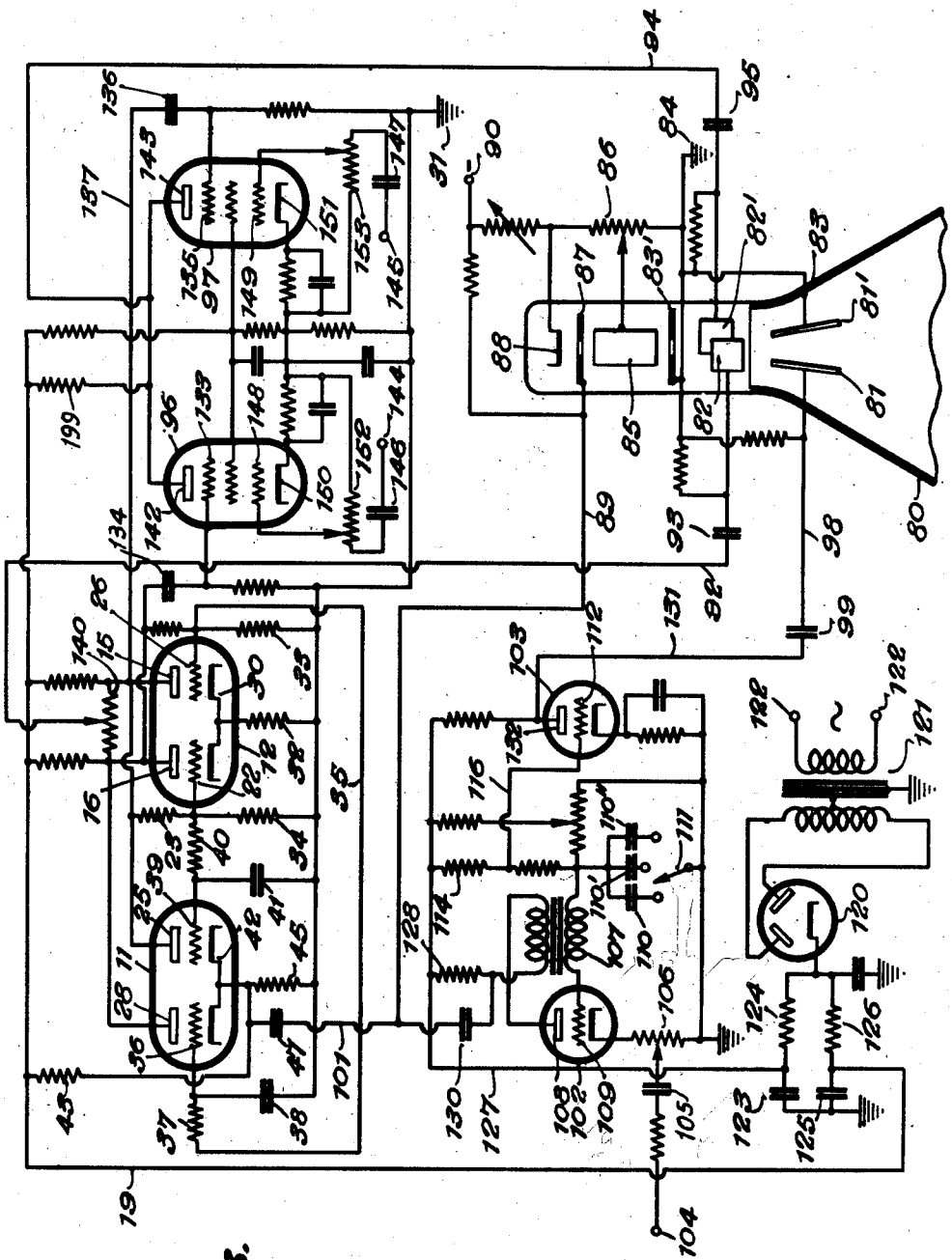


Fig. 3.

INVENTOR
Kurt Schlesinger
BY H. S. Grover
ATTORNEY

Patented Jan. 2, 1945

2,366,357

UNITED STATES PATENT OFFICE

2,366,357

ELECTRONIC RELAY

Kurt Schlesinger, West Lafayette, Ind., assignor to Radio Corporation of America, a corporation of Delaware

Application May 30, 1942, Serial No. 445,253

13 Claims. (Cl. 171—95)

This invention relates to electronic apparatus and is particularly concerned with electronic relays and square wave generators which are capable of operating under the control of driving impulses supplied from an external source.

In the prior art, many systems for producing square waves have been described from time to time. Most devices of such a nature are in the form of oscillators. In many instances, some such devices of the prior art operate on the principle of the multi-vibrator and, as such, they continuously perform their oscillations. They are subject, however, to the material disadvantage that they cannot be properly synchronized by input pulses or signals, except over a relatively narrow range of frequency which has been found to be rather close to the natural period of the system.

Other arrangements of the prior art which have been used for square wave generators and electronic relays have embodied uses of the so-called gas filled tubes, such as those known by the trade name "Thyratron." In many respects switching circuits of this general type satisfy many operational conditions to be expected from a relay and square wave generator, but they are subject to the substantial disadvantage that the presence of the gas filling within the switching tubes usually leads to prematured aging of the stage which is conductive during the standby period in the operation.

It is, accordingly, an object of the present invention to provide an electronic relay and square wave generator unit which is of an inherently non-oscillatory character, so that in the absence of driving or controlling impulses, the system will be in a non-operating state, by which is meant the condition of operation will be of non-changing character pending the receipt of a controlling or "triggering" impulse.

Further, the present invention has, as one of its aims and objects, that of providing an extremely rapid switching of the transient in the square waves from the lower to the higher levels, or vice versa, which usually occupy an extremely short period of time, for example, a time period not exceeding 100 micro-seconds.

A further object of the invention is to provide a circuit of the character hereinabove referred to which embodies only high vacuum tubes and which functions with an efficiency at least as great as that of the gas filled tubes.

A further object of the invention is to provide a circuit of the square wave generator and relay type which is capable of responding to controlling pulses over a wide range of frequencies and thus capable of functioning and operating as an electronic commutator throughout an especially wide frequency range.

A further object of the invention is to provide an electronic relaying and square wave generator system for use in co-operative relationship with a cathode ray oscilloscope so as to enable an observer of the luminescent pattern traced upon the tube to observe simultaneously two distinct transient phenomena.

A further object of the invention is to provide a relaying and square wave generator system for use with cathode ray oscillograph apparatus for observing multiple transients in which the true wave forms of the plurality of transients are shown in their entirety without any visible interruption because of the switching action and thus to provide a system wherein the switching action in its totality occurs following a predetermined completion of reproduced transient effects.

Further objects and advantages of the invention are those of providing apparatus which overcomes one or more difficulties and defects of the prior art by simplified inexpensive and efficiently operating circuit instrumentalities.

Still other objects and advantages will become apparent from a reading of the following specification and claims in connection with the accompanying drawings, wherein

Fig. 1 represents a schematic representation of the circuit of a square wave generator;

Fig. 2 represents a modification of the circuit of Fig. 1;

Fig. 3 represents the inclusion of a circuit of the general character shown by Fig. 1 with a cathode ray oscilloscope or oscillograph for observing multiple transients, and,

Fig. 4 is a further modification of the circuit arrangement of Fig. 1.

Referring now to the drawings for a further understanding of the invention, it will be seen that the square wave generator herein disclosed is capable of producing square wave outputs from controlling supplied impulses. Accordingly, the square wave generator herein disclosed forms a specific part of a synchronizing signal generator more particularly disclosed and claimed in companion application Serial No. 452,921, filed May 30, 1942, wherein the square wave generator and electronic relay arrangement has been disclosed in co-operative relationship with a system whereby synchronizing impulses of the now accepted R. M. A. type for television apparatus are generated and developed.

In one preferred form of the invention as it is disclosed in this application, the square wave generator unit comprises a pair of vacuum tubes 11 and 12 which may, for instance, each be of the general type known in the art as the type 6N7, which are thus understood to be twin triodes, although it is obvious that separate triodes may also be used, if desired.

In the arrangement as it is disclosed by Fig. 1, the tube 11 will be understood to serve as the driver tube and the tube 12 will be understood to constitute the electronic relay tube. The circuit of the electronic relay 12 resembles, in some respects, the well known multi-vibrator in that the plate and control electrode elements are cross connected, but, it must be noted, the use of usual capacitive connections is avoided.

In the preferred form of the circuit, a source of positive voltage is connected at the terminal point 14 and supplied to the plate or anode elements 15 and 16 of the tube 12 through the resistor elements 17 and 18 by way of the conductor 19, which connects intermediate the resistors 17 and 18. Output energy from the system is derived from the terminal points 20 and 21 connected to the plate or anode elements 15 and 16 respectively. Connections are made from the plate element 15 of the first half of the relay tube 12 to the control electrode 22 of the second half of the tube by way of the resistor element 23, and also a connection is made by way of the conductor 24 from the plate or anode element 15 to the plate or anode element 25 of the second half of the driver tube 11. Similarly, the plate or anode element 16 of the second half of the relay tube 12 connects to the control electrode or grid 26 of the first half of this relay tube 12 by way of the resistor 27 and, as was the case with the connection of the plate or anode element 15 of the relay tube 12 to the plate or anode element 25 of the driver tube 11, the plate or anode element 16 of the second half of the relay tube 12 connects to the plate or anode 28 of the first half of the driver tube 11 by way of a similar conductor 29.

The cathode elements 30 of the relay tube 12 connect to ground 31 by way of the cathode resistor 32 and, similarly, a leak resistor 33 is provided between ground 31 and the control electrode 26 of the first half of the tube, and, likewise, a leak resistor 34 connects between ground 31 and the grid or control electrode 22 of the second half of the relay tube 12.

Connections to the driver tube 11 from the relay tube 12 are also made by way of the conductor 35 connecting the control electrode 26 of the first half of the relay tube 12 to the grid or control electrode 36 of the first half of the driver tube 11. This connection is made by way of the time constant circuit comprising the resistor element 37 and the condenser 38, which condenser element 38 has one terminal connected to ground 31' and the other terminal connected both to the control electrode 36 and to the lower end of the resistor 37. Similarly, the second half of the relay tube 12 connects with the second half of the driver tube in such a manner that the grid or control electrode 22 of the relay tube 12 connects to the grid or control electrode 39 of the driver tube 11 by way of a similar time constant circuit comprising the resistor 40 and a capacitor 41, which latter element also has one of its terminals connected to ground 31' and the other terminal connected to the lower end of the resistor 40 and also to the control electrode 39.

Biasing voltage for the cathode elements 42 of the driver tube 11 is provided by means of the resistor 43 connected by way of the conductor 44 to the terminal 14, whereat high positive potential for the plate or anode elements of each of the relay and driver tubes 12 and 11 is provided, so that normally the cathode elements 42 are biased positively relative to ground 31' from the source connected to the terminal 14 through the second biasing resistor 45 which connects to ground 31'.

Impulse potentials arranged for controlling the driver and relay unit are applied from an appropriate source (not shown) so connected at the terminal point 46 that the signals are applied by way of the condenser 47 to control the tube 11. Thus, if the applied impulses are applied with negative polarity at the terminal point 46, the cathode elements 42 of the driver tube 11 will be carried in the negative direction. The wave representations shown adjacent the input terminal 46 and the output terminals 20 and 21 are intended to represent schematically the general form of the input and the output signals or waves in the system.

In the operation of the arrangement hereinabove disclosed, it is seen that the tube arrangement 12 is essentially resistance coupled with mutual feedback provided by the resistors 23 and 34 on the one hand, and 27 and 33 on the other hand. Consequently, it becomes apparent that the system is stable in only two conditions of operation and that is with either the left half or the right half, also called the first half and the second half, of the tube 12 cut off respectively, so that at the plate or anode elements 15 and 16 only two levels of voltages are available, as are shown by the curves adjacent the output terminal points 20 and 21.

If it is desired to drive this relay tube 12 by a series of applied impulses of substantially uniform polarity occurring at an arbitrary repetition rate, this is then provided by means of the driver tube 11 to which the impulses shown adjacent the input terminal 46 are applied.

It can be seen that the two plate or anode elements 28 and 25 of the first and second halves of the driver tube 11 are in parallel with opposite plate or anode elements 16 and 15, respectively, of the relay tube 12. The control electrodes 36 and 39 of the driver tube 11 are also in parallel with like control electrodes 26 and 22, respectively, of the relay tube, and are connected with this relay tube by way of the retardation or time constant circuits comprising the resistor 37 and condenser 38 on the one hand, and the resistor 40 and the condenser 41 on the other hand. Therefore, in the stationary condition and in a non-operative state, the grid bias on the grids 36 and 26 and upon the grids 39 and 22 are mutually identical, but by virtue of the application of positive bias to the cathode elements 42 from the source of positive voltage connected to the terminal 14, this cathode is maintained at sufficiently high positive bias relative to the anode elements 28 and 25 that both halves of the tube are cut off. Any controlling signal pulses applied from the input terminal point 46 by way of the condenser 47 and the conductor 49 to the cathode elements 42 are intended, in the arrangement of Fig. 1, to be of negative polarity so as to overcome the effect of the positive cathode bias applied from the connection of positive voltage to the source 14. If, now, an impulse of negative polarity is applied to the input terminal 46, only one of the two halves

of the driver tube 11, that is the half in which the grid or control electrode 38 or 39 was of less negative bias prior to the arrival of the impressed impulses, will give a negative and amplified plate current peak. If it is assumed, for instance, that this is the left hand half or first half of the driver tube 11, then it becomes apparent that the right hand half of the tube is blocked and that the left half of the relay tube 12 also becomes conducting, with its right hand half also non-conducting and the plate or anode element 16 then at the higher positive voltage level, as is indicated by the voltage curve appearing at the terminal point 21. This causes then a voltage peak of negative polarity to appear across the resistor 18, and this voltage peak is transmitted back to the grid or control electrode of the previously conducting half of the relay tube 12 by the voltage divider arrangement provided by way of the resistors 27 and 33. Accordingly, the first half of the relay tube 12 will now become non-conducting with the effect that the electronic relay jumps into the other stable condition with the two triode sections changing in the operational state.

Under these circumstances it will be seen that the retardation or time delay circuits provided by the resistor 37 and the condenser 38 become of importance, as does the time delay circuit provided by the resistor 40 and the condenser 41. It becomes apparent at once that without the inclusion of the time delay circuits, the potential instantaneously effective on the grid or control electrode 26 of the tube 12 would be transmitted without delay to the grid or control electrode 36 of the tube 11, which would form a sort of undesirable feedback with the result that the driving action of the tube 11 would tend to be completely cancelled and the complete functioning of the system arrested in the absence of such delay. The delay circuits, however, take care of preventing the grid bias on the driving tube 11 from changing its value for the duration of the driving impulses as impressed upon the terminal point 46. The delay circuit also introduces a delay for any change in the grid bias immediately effective after the relay tube 12 has shifted from one state of operation to the other. However, it should be understood that the delay circuit provided by either the resistor 37 and condenser 38, or by the resistor 40 and condenser 41, does not introduce any undesirable inertia effects into the operation of the relay tube 12, but the main effect of the time constant of the time delay circuit in the operation of the system is that it prevents the system from following pulses occurring at a higher frequency than unity divided by the time constant.

In an experimental set-up, the time constant circuit provided by the resistor 37 and condenser 38 or the resistor 40 and condenser 41 was of the order of 50 micro-seconds, so that it becomes apparent that the relay tube 12 will be capable of following and performing extremely high frequency relaying action while of course there is no low frequency limit on the output of the square waves.

Fig. 2 discloses a modification of the arrangement of Fig. 1, and in this figure, various common parts have like reference numerals.

From what has been explained, it is apparent that the arrangement of Fig. 1, while providing square waves of desired character, is generally of the type where, in some instances, some sharp negative peaks may occur in the output due to the action of the driver stage. Generally speaking, such negative peaks are without objection, but in some applications in the arrangement of the system it is particularly desirable that the negative peaks be avoided, so that the arrangement of Fig. 2 provides a suitable arrangement for accomplishing this aim and objective, and this is done through the use of two separate relay tubes 60 and 61 which are of the tetrode or screen grid type, instead of the single relay tube disclosed by Fig. 1.

In the arrangement of Fig. 2, it will be seen that the output pulses from the driving tube 11 are fed by way of the conductors 62 and 63 to the screen electrodes 64 and 65 respectively, rather than directly into the plate and output circuits of the relay tube, as shown by Fig. 1. It will be noted, particularly in this connection, that, generally speaking, the connections from the plate to the screen and the grid to the grid of the tubes of Fig. 2 are reversed, as compared to the arrangement of Fig. 1.

In the arrangement of Fig. 2, the grid or control electrode 66 of the relay tube 60 is connected with the grid or control electrode 36 of the driver tube 11 by way of conductor 35 and the time constant circuit comprising the resistor 37 and the condenser 38', which latter element also connects to ground at 31. The condenser element forming a part of the time constant circuit is designated in Fig. 2 as 38' since it is usually smaller than the condenser shown in Fig. 1. Similarly, the control electrode 39 of the driver tube 11 connects with the grid or control electrode 67 of the relay tube 61 by way of the conductor 68 and the time constant circuit comprising the resistor 40 and the condenser 41', similar to the connection made to the control electrode 66 of the tube 60.

It will be seen, from the arrangement shown by Fig. 2, that suitable potentials for the screen electrodes of the tubes 60 and 61 are provided by way of the voltage divider arrangement in the form of the resistors 69, 70, 71 and 72, of which the latter is by-passed by a condenser 73, connected to receive energy from the source of potential connected between the terminals 14 and 14' and fed to supply voltages for all of the tubes 11, 60 and 61 by way of the conductor 74. Output energy from the relay tubes 60 and 61 is derived at the terminals 17' and 18' respectively, in accordance with the controlling impulses supplied to the cathode 42 of the driver tube 11 by way of suitable connections made at the terminal points 46 and 46'.

The high frequency response of the arrangement of Fig. 2 is, generally speaking, about twice that of the arrangement of Fig. 1 but, as contrasted with the arrangement of Fig. 1, three separate tubes are included against the two tubes of the arrangement of Fig. 1, although a twin pentode tube could be substituted for tubes 60 and 61, if desired, without any substantial circuit modifications.

In a further application of the arrangement of Fig. 1 particularly, a modification of the system is shown by Fig. 3 where the square wave generator unit has been combined with the cathode ray oscillograph device to enable an observer to view on the screen or target of the cathode ray tube, simultaneously two waves which it is desired to observe. As shown by the arrangement of Fig. 3, the square wave generator comprising the driver tube 11 and the relay tube 12 is substantially in accordance with the arrangement of Fig. 1, as are the time delay circuits comprising

the resistor-condenser combination 37—38 and 40—41.

In the arrangement shown by Fig. 3, the transients to be observed will be produced on the screen or target (not shown) of the cathode ray tube conventionally represented as 80. This tube includes the usual arrangement of the deflector plate pairs 81—81' and 82—82', herein shown as electrostatic plates for deflecting the beam in two mutually perpendicular patterns. A conductive coating forming the second anode 83 of the tube is connected to ground 84 by way of the conductor shown, and one deflecting plate 81' of the plate pair 81—81' is maintained at the resultant second anode voltage. The second anode element 83' is connected ahead of the first deflecting plate pair 82—82', and next adjacent this anode element 83' is the first anode 85, which is maintained at a suitable potential relative to the cathode 88 by means of the connection to the adjustable tap of the potentiometer 86.

The control electrode 87 is connected adjacent the cathode emitter 88 and suitable control potentials for providing blanking, for instance, on the beam return path or "snap-back" are applied by way of the conductor 89 connected to the control electrode on the one hand, and to the beam blanking control means (later to be described herein) on the other hand.

At the terminal point 90 a suitable source of negative potential relative to ground 84 is connected. This voltage source is provided for the purpose of applying proper bias to the control electrode 87 at the same time maintaining the cathode at a predetermined potential relative to the first and second anode elements 85, 83' and 83 as indicated.

Deflection potentials for deflecting the beam developed within the tube in one of its two directions of deflection are provided by the conductor 92 and the capacity coupling 93, so that a connection is provided directly to the relay tube 12. A second connection by way of the conductor 94 and the capacitor 95 is provided for supplying energy to the deflecting plate from the output of the amplifier tubes 96—97, later to be described. Similarly, deflection voltage from a deflection voltage generator is applied by way of the conductor 98 and the capacity coupling 99 for deflecting the developed cathode ray beam in a direction mutually perpendicular to the direction of deflection provided by the plate pair 82—82'.

Considering now the square wave generator unit comprising the driver tube 11 and the relay tube 12, energy for driving this combination is supplied by way of the conductor 101 and the capacity 47 from a deflection voltage generator which is capable of producing suitable driving impulses. Generally speaking, this sweep generator is similar to that disclosed particularly by my co-pending application Serial No. 434,805, filed March 16, 1942, wherein the sweep generator unit consists essentially of a blocking oscillator tube 102 and an amplifier tube 103, as explained in the last referred to co-pending application.

Generally speaking, there is provided in this arrangement a connection for a source of synchronizing impulses which may be provided by way of the terminal connection 104 and fed to the oscillator tube 102 by way of the condenser 105 and into the cathode circuit by way of the potentiometer connection 106. The feedback transformer 107 is connected, as shown, between the plate 108 and control electrode 109 of the tube 102, and as was indicated in my above mentioned co-pending application, a substantially linear saw-tooth voltage wave is then adapted to appear across any of the selected capacity elements 110 which may be connected in circuit by the switching arm 111, so that linear amplification of the developed saw-tooth voltage wave may be carried on in the amplifier tube 103 without distortion.

This connection of the output energy from the oscillator tube 102 to the control electrode 112 of the amplifier tube 103 is provided by the indicated connection through the resistors 114 and 115 and the conductor 116, as was explained in the aforesaid co-pending application. Suitable voltages for operating all of the tubes in the system are provided by the rectifier tube 120 connected by way of the transformer 121 in known manner with the source of voltage applied to the terminal points 122, which voltage source is preferably such that the supplied energy is fed to the transformer at the power supply frequency of 60 cycles. Connected to the output of the rectifier tube 120 are two separate filter chains comprising the condenser and resistance filter combinations 123—124 and 125—126 respectively, at which the desired voltages are developed and across which condensers appear currents of predetermined magnitude, it being appreciated that the current rating supplied by way of the conductor 19 for the driver and relay tubes and the amplifiers 96 and 97 is, generally speaking, higher than that supplied by way of the conductor 127 to energize the oscillator and amplifier tubes 102 and 103.

In the oscillator combination, the energy developed across the plate or output resistor 128, which is connected with the plate coil of the transformer 107 is, strictly speaking, of negative polarity so as to provide the impulses which may be fed by way of the connection 101 and the coupling condenser 47 to the cathode 42 of the driver tube of the square wave generator. These impulses occur at the saw-tooth frequency and thus trigger the driver tube-relay tube combination in such a way that the output from the relay tubes are pulses occurring at one-half the saw-tooth frequency, as is evident from the detailed description of Fig. 1 and the curves drawn therewith. At the same time, the negative impulses, which occur at the saw-tooth frequency, are caused to appear in the conductor 89 which connects to the control electrode 87 of the cathode ray tube, so that they can be used to blank out the cathode ray during the return motion of its deflection, that is, during the snap-back period while the beam is moving most rapidly. The cathode ray tube control electrode 87 thus couples to the oscillator 102 by way of the conductor 89 and the coupling condenser 130.

Output energy from the amplifier tube 103 is derived from the conductor 131 connected to the plate or anode element 132 of this tube, and this is supplied by way of the coupling condenser 99 and conductor 98 to deflect the beam in the cathode ray tube by the application of potential between the deflecting plate elements 81 and 81'. The output energy from the relay tube 12 is supplied from the plate or anode element 16 to the screen electrode 133 of the first relay tube 96 by way of the condenser 134, and, similarly, the screen electrode 135 of the amplifier tube 97 is energized through a coupling condenser 136 and the conductor 137 so that it re-

ceives energy output from the plate or anode 15 of the first half of the relay tube 12.

At the same time that the energy output from the relay tube 12 is being supplied to the amplifier units 96 and 97, this output is also being supplied by way of the conductor 92, so as to control the vertical shifting or displacement of the wave traces produced upon the luminescent target or screen (not shown) of the cathode ray tube 80 so that successive transients, as they appear upon the tube screen, shall be shifted or displaced relative to each other, and the rapid deflection, as applied from the deflection unit comprising the tubes 102 and 103, shall not follow successive identical traces, but rather be shifted laterally so that the arrangement becomes particularly useful for studying phenomena of time lag or relative phase shift between two signals. It is, of course, evident that in such use the two "zero lines" are displaced, but, even so, this is desirable as it gives a better opportunity to compare wave phenomena. For this purpose a suitable volume control is provided in the form of the potentiometer 140 connected between the plate or anode elements 15 and 16 and the conductor 92 connected to the adjustable tap of this potentiometer.

The energy output from the square wave generator and relay unit, as it is applied to the amplifier tubes 96 and 97 on the screen grid elements thereof, controls the amplification so that there appears in the output conductor 94 connected to the plate elements 142 and 143 of the tubes 96 and 97 respectively, suitable amplified energy and input signals applied to terminal points 144 and 145 respectively, which is controlled in accordance with whether or not the first or the second half of the relay tube 12 is in operation, so that one or the other of the tubes 96 and 97 will be amplifying the signal energy impressed at the terminal points 144 and 145 which represent the two transients to be observed through the application thereof to the deflecting plate element 82'. The impressed transients are fed to the tubes 96 and 97 by way of the coupling condensers 145 and 147 respectively, so as to be applied between the control grids 148 and 149 and the cathodes 150 and 151 respectively of these tubes by way of the potentiometer connections 152 and 153, as shown.

The driver tube 11, as above explained, controls the operation of the relay tube 12 so that one-half of the relay tube or the other half thereof is in a conductive state. Thus, with the plate members 15 and 16 of relay tube 12 being connected to the grid electrodes 135 and 133 of tubes 97 and 96 it can be seen that one or the other of the last named tubes is conducting in accordance with which of the relay tube halves draws current. The tubes 96 and 97 have their anode or plate elements 142 and 143 connected to the source of positive voltage in conductor 19 through a common load resistor 199 and these plate or anode elements likewise connect to the deflecting electrode 82' through conductor 94 and the coupling condenser 95. The input signals which represent the two transients to be observed are continuously and independently applied at terminal points 144 and 145 and depending upon which of tubes 96 and 97 conduct either of these transients is applied to the deflecting electrode 82'. With the arrangement as disclosed the relay tube 12 is so triggered that each half thereof draws current on every second cycle of the oscillator 102 and consequently the transients applied at terminal points 144 and 145 alternately influence the deflecting electrode 82'.

With the slider on potentiometer 140 in a midpoint position, as shown by Fig. 3, the two produced transient tracings on the cathode ray tube 80 appear along the same axis. With the slider moved to the right or left, that is, toward the connection to anode or plate 15 or toward or to the connection to anode or plate 16 will determine whether the transients traced for the signals applied at terminals 144 and 145 shall be moved to a position above or below each other. In other words, the adjustment of the tapping point on potentiometer 140 determines the relative displacement of the two transient tracings produced.

The circuit arrangement of Fig. 4 shows a still slightly further modification which is particularly adaptable for use where the controlling pulses are of positive polarity as contrasted with the negative polarity pulse control shown by the arrangements of Figs. 1, 2 and 3.

In the arrangement of Fig. 4, the input voltage is schematically represented as being the source 161 which connects between the terminal point 162 and ground 163 and feeds its energy by way of the conductors 164 and 165 through the coupling condensers 167 and 168 of the delay circuit including the resistors 169 and 170 respectively which connect to ground 163 by way of the leak resistors 171 and 172. In this way, a positive pulse from the source 161 is fed to the grid or control electrodes 172 and 173 respectively of the driver tube 174 which has its plate or anode elements 175 and 176 cross connected to the plate or anode elements 177 and 178 respectively of the relay tube 179 and, as above pointed out in connection with the description of Fig. 1, the grid or control electrodes 180 and 181 of the relay tube 179, in an inoperative state of the tubes 174 and 179, have a potential corresponding respectively to the grid or control electrodes 172 and 173 of the driver tube 174.

The arrangement, as it is disclosed by Fig. 4, provides that positive potential for the plate or anode elements of the driver and relay tubes 174 and 179 may be applied at the terminal points 183 and 184, of which the latter is connected to ground, for instance, 163, and, accordingly, the positive voltage for the plate or anode elements of the tubes is applied by way of the conductors 185 and 186 and the resistors 187 and 188. The resistors 189 and 190 respectively form, with the resistors 187 and 188, a voltage divider by which suitable bias is applied to the grid or control electrodes 180 and 181 of the relay tube 179.

For the purpose of applying a constant bias to the cathode element 191 of the driver tube 174, suitable bleeder resistors 192 and 193 are connected with the conductor 185 which carries the positive voltage from the source connected to the terminal 183, and the other terminal of these resistors connects, as indicated, to ground at 163, so that the cathode elements 191 have a constant bias and the cathodes are blocked from ground by means of the condenser element 194. Similarly, the cathodes 195 are biased relative to ground by means of the resistor 196, as indicated.

Output energy from the system is derived at the terminals 197 and 198 respectively, and the output voltages are, relatively speaking, as indicated by the wave forms immediately adjacent each output terminal. Similarly, the impressed input voltage is of the general nature indicated

by the wave form adjacent the input source schematically represented as 161.

The action of the circuit of Fig. 4, generally speaking, is substantially like that explained in connection with Fig. 1, provided the impedance of the source 161 is generally small as compared to the leakage of the resistors 169 and 170, which are preferably of the general order of one megohm.

Further, generally speaking, the arrangement of Fig. 4 is so constituted that the power taken from the source is usually less than explained in connection with the modification of Fig. 1, and similarly, the reaction of the system upon the source is also generally reduced.

A still further advantage of the arrangement of Fig. 4 is that it is possible, in this connection, to take advantage of the gain provided by the driver tube 174, with the result that the system has an increased voltage sensitivity which enables it to respond fully to input and controlling pulses which are of lesser magnitude, generally speaking, than those applied with the system of Fig. 1, wherein the control is under the influence of negative pulses.

It is, of course, apparent that many and other modifications may be made in this system without departing from the spirit and scope of the foregoing disclosure, and therefore I believe myself to be entitled to make and use any and all of these modifications which fall fairly within the spirit and scope of the invention and the hereto appended claims.

What I claim is:

1. A signalling circuit including thermionic driver tube means which include a first and a second independent electron path and wherein collector and control electrode means are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein collector and control electrode means are also included in each path, means to parallelly connect the control electrode means of the first path of the driver and relay means and to similarly connect the control electrode means of the second electron paths of said driver and relay means, means to connect the collector electrode means of the first electron path of the driver and the second electron path of the relay tube and to similarly connect the collector electrode means of the second path of the driver means and the first path of the relay means, a time delay circuit included in the connection between the parallelly connected control electrode means of each of the driver and relay paths, and terminal means for applying impulse signals to the thermionic driver means, and terminal means for deriving output energy from the thermionic relay means.

2. An electron tube circuit including thermionic driver tube means which comprise a first and a second independent electron path and wherein collector and control electrode means are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein collector and control electrode means are also included in each path, means to parallelly connect the control electrode means of the first electron paths of the driver tube and relay tube means and to similarly connect the second electron paths of said driver tube and relay tube means, means to connect the collector electrode means of the first electron path of the driver tube means and the second electron path of the relay tube means and to similarly connect the collector electrode means of the second path of the driver means and the first path of the relay means, impedance means included in the connection between each of the said parallelly connected control electrode means of each of the driver and relay paths, terminal means for applying controlling impulse signals to the said driver tube means, and terminal means for deriving output energy from the said relay tube means.

3. A signal keying circuit including thermionic driver tube means which include a first and a second independent electron path and wherein collector and control electrode means are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein collector and control electrode means are also included in each path, means to parallelly connect the control electrode means of the first electron paths of the driver means and relay means and to similarly connect the second electron paths of said driver means and said relay means, means to connect the collector electrode means of the first electron path of the driver means and the second electron path of the relay means and to similarly connect the collector electrode means of the second path of the driver means and the first path of the relay means, terminal means for applying impulse signals to the driver tube means to initiate an electron flow in one of the said electron paths thereof and thereby control an electron flow in one of the electron paths of the relay tube means, time delay means included in the interconnection of the control electrode means between the driver and relay means, said time delay means being adapted to control the rate at which the conductivity conditions of the alternate electron paths of said driver tube are able to follow changes in conductivity of the said relay means, and terminal means for deriving output energy from the relay means.

4. A signalling circuit including thermionic driver tube means which include a first and a second independent electron path and wherein a collector means, a control electrode means and a cathode are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein a collector means, a control electrode means and a cathode are also included in each path, means to parallelly connect the control electrode means of the first path of the driver and relay means and to similarly connect the control electrode means of the second electron path of said driver and relay means, means to connect the collector electrode means of the first electron path of the driver and the second electron path of the relay tube and to similarly connect the collector electrode means of the second path of the driver means and the first path of the relay means, means to connect all of the cathodes to a common point of fixed potential, a pair of time delay circuits each including a series resistor and condenser combination, the resistor element of said time delay circuits being included in the connection between the parallelly connected control electrode means of each of the driver and relay paths and the condensers of said circuits being connected between the driver tube means control electrodes and the said point of fixed potential, terminal means for applying impulse signals to the control electrode to cathode circuit of each electron path of the driver tube means, and ter-

minal means for deriving output energy from the thermionic relay means.

5. A signalling circuit including thermionic driver tube means which include a first and a second independent electron path and wherein an electron emitter, a collector electrode and control electrode means are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein an electron emitter and a plurality of cold electrode means are also included in each path, means to parallelly connect the control electrode means of the first electron path of the driver tube means and one of the cold electrodes of the relay tube means, and means to similarly connect the control electrode means of the second electron paths of said driver tube means and a cold electrode of the relay tube means corresponding to that connected in the first parallel connection, means to connect the collector electrode means of the first electron path of the driver and an independent cold electrode of one of the electron paths of the relay tube means and to similarly connect the collector electrode means of the second path of the driver means and an independent cold electrode in the other electron path of the relay means, means to connect all of the electron emitter electrodes to a point of substantially constant potential, a pair of time delay circuits having one element connected to the point of fixed potential, said delay circuits each being included in the connection between the control electrode of the driver means and the said connected cold electrodes of the relay means, terminal means for applying impulse signals to the said thermionic driver means, and terminal means for deriving output energy from the thermionic relay means.

6. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing a cathode ray beam and a target upon which the cathode ray beam is adapted to impinge to produce a record, electrode means for deflecting the cathode ray beam in two directions each substantially normal with respect to the other, commutating means comprising thermionic driver tube means and thermionic relay tube means, said driver tube means including a first electron path and a second independent electron path and having a collector electrode means and a control electrode means included in each of said paths, and said relay tube means also including a first electron path and a second independent electron path and having a collector electrode means and a control electrode means included in each of said paths, means for parallelly connecting the control electrode means of the first electron paths of each of the driver means and the relay means and to similarly connect the control electrode means of the second electron paths of each of said driver means and said relay means, means to connect the collector electrode means of the first electron path of the driver means and the collector electrode means of the second electron path of the relay means and to similarly connect the collector electrode means of the second path of the driver means and the collector electrode means of the first electron path of the relay means, impedance means included in the connection between each of the said connected control electrode means of the driver and relay means, a deflection generator for developing substantially sawtooth wave formations connected to deflect the electron beam of the cathode ray tube in one of its two directions of deflection, means for energizing the driver tube means of the commutator with impulses at a frequency corresponding to the saw-tooth frequency generated by said deflection generator means, means for deriving from the relay means of said commutator pulse energy of alternating positive and negative polarity from the collector electrode means of the said relay means, and means for biasing the other of said deflecting means by said pulse energy alternately, and means responsive to the output of the said relay means for applying a multiplicity of transients for observation alternately to the said last named deflecting means.

7. The system claimed in claim 6 comprising, in addition, a plurality of amplifying means to which independent transient signals are applied, and means for rendering said amplifier tubes operative and inoperative under the control of the output energy from said relay means, and means for applying the triggering impulses supplied to the said driver tube also to control the beam production within the cathode ray tube.

8. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing and modulating a cathode ray beam and a target element upon which the said cathode ray beam is adapted to impinge, a pair of deflecting electrode means for deflecting the developed cathode ray beam relative to the target in two mutually perpendicular directions, a plurality of terminal connections for connecting to a plurality of signal circuits, electron tube amplifiers connected to receive energy from each terminal connection, said electron tube amplifiers having a common output circuit and means for connecting one of the pair of beam deflecting means to the said common output circuit, a sweep generator means for developing substantially saw-tooth wave energy, means for applying said saw-tooth wave energy to the second of said pair of beam deflecting means, a commutating means comprising a driver tube means and a relay tube means, said driver tube and relay tube means each including a first and a second independent electron path with control electrode means and collector electrode means included in each path, means for parallelly connecting the control electrode means of the first electron paths of each of said driver and said relay means and for similarly connecting the control electrode means of the second electron paths of each of said driver and said relay means, means to connect the collector electrode means of the first electron path of the driver means and the collector electrode means of the second electron path of the relay means and to similarly connect the collector electrode means of the second electron path of the driver means and the collector electrode means of the first electron path of the relay means, a time constant circuit included as a part of the connection between the said collector electrode means of the said driver to relay paths, means for developing pulse energy at a frequency corresponding to the frequency of the said sweep circuit generator, connection means for simultaneously applying said developed pulse energy to trigger the electron paths of the driver tube means and simultaneously to suppress instantaneously the developed electron beam in the said tube, means for developing from the separate electron paths of the relay tube means energy alternately varying between minimum and maximum values, connection means for supplying said energy to the said amplifiers for alter-

nately rendering the independent amplifiers operative and inoperative at a rate coinciding with the rate at which pulse energy is developed, and a second connection for simultaneously biasing the deflecting electrode means to which the transient signals are applied by fixed amounts, so that alternate wave traces are displaced one from the other by predetermined amounts.

9. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing and modulating a cathode ray beam and a target element upon which the said cathode ray beam is adapted to impinge, a pair of deflecting electrode means for deflecting the developed cathode ray beam relative to the target in two mutually perpendicular directions, a plurality of terminal connections for connecting to a plurality of signal sources, electron tube amplifier means connected to receive energy from each terminal connection, said electron tube amplifiers having a common output circuit and means for energizing one of the pair of beam deflecting means to the said common output circuit for deflecting the developed cathode ray beam in one of its directions of traverse of the target under the control of the signal output from the said amplifiers, a sweep generator means for developing substantially saw-tooth wave energy, and means for applying said saw-tooth wave energy to the second of said pair of beam deflecting means for deflecting said beam along a timing axis in a direction mutually perpendicular to the direction of deflection initiated by the output energy from said amplifiers, a commutating means comprising a driver tube means and a relay tube means, said driver tube and relay tube means each including a first and a second independent electron path with control electrode means and collector electrode means included in each path, means for parallelly connecting the control electrode means of the first electron paths of each of said driver and said relay means and for similarly connecting the control electrode means of the second electron paths of each of said driver and said relay means, means to connect the collector electrode means of the first electron path of the driver means and the collector electrode means of the second electron path of the relay means and to similarly connect the collector electrode means of the second electron path of the driver means and the collector electrode means of the first electron path of the relay means, a time constant circuit included as a part of the connection between the said collector electrode means of the said driver to relay paths, means for developing pulse energy at a frequency corresponding to the frequency of the said sweep circuit generator, connection means for simultaneously applying said developed pulse energy to trigger one or the other of the electron paths of the driver tube means and simultaneously to suppress instantaneously the developed electron beam in the said tube, means for developing from the separate electron paths of the relay tube means energy alternately varying between minimum and maximum values, connection means for supplying said energy from the relay to key the said amplifiers and alternately rendering the independent amplifiers operative and inoperative at a rate coinciding with the rate at which pulse energy is developed, and a second connection means for simultaneously supplying the relay output energy to the deflecting means to provide a bias whereby alternate wave traces are displaced one from the other by predetermined amounts.

10. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing and modulating a cathode ray beam and a target element upon which the said cathode ray beam is adapted to impinge, a pair of deflecting electrode means for deflecting the developed cathode ray beam relative to the target in two mutually perpendicular directions, a plurality of terminal connections for connecting to a plurality of transient signal circuits, an electron tube amplifier connected to receive energy from each terminal connection, said electron tube amplifiers having a common output circuit and means for connecting one of the pair of beam deflecting means to the said common output circuit, a sweep circuit generator means for developing substantially saw-tooth wave energy, and means for applying said saw-tooth wave energy to the second of said pair of beam deflecting means, a commutating means comprising a frequency dividing and switching amplifier tube means, means for developing pulse energy at a frequency corresponding to the saw-tooth frequency generated by the said sweep circuit generator, connection means for simultaneously applying said developed pulse energy to trigger the frequency dividing and switching amplifier tube means and to suppress instantaneously the developed electron beam in the said tube, and connection means for supplying output energy from the said frequency dividing and switching amplifier to alternately render the independent transient signal amplifiers operative and inoperative at a rate corresponding to half that of the saw-tooth energy, and a second connection for simultaneously biasing by fixed amounts the deflecting electrode means to which the transient signals are applied so that alternate wave traces are displaced one from the other.

11. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing and modulating a cathode ray beam and a target element upon which the said cathode ray beam is adapted to impinge, a pair of deflecting electrode means for deflecting the developed cathode ray beam relative to the target in two mutually perpendicular directions, a plurality of terminal connections for connecting to a plurality of transient signal circuits, an electron tube amplifier connected to receive energy from each terminal connection, said electron tube amplifiers having a common output circuit and means for connecting one of the pair of beam deflecting means to the said common output circuit, a sweep circuit generator means for developing asymmetric saw-tooth wave energy, and means for applying said saw-tooth wave energy to the second of said pair of beam deflecting means, a commutating means comprising a frequency dividing and switching amplifier tube means, means for developing pulse energy at a frequency corresponding to the saw-tooth frequency generated by the said sweep circuit generator, connection means for simultaneously applying said developed pulse energy to trigger the frequency dividing and switching amplifier tube means and to suppress instantaneously the developed electron beam in the said tube, connection means for supplying output energy from the said frequency dividing and switching amplifier to alternately render the independent transient signal amplifiers operative and inoperative at a rate corresponding to half that of the saw-tooth energy, a second connection for simultaneously biasing by fixed amounts the deflecting electrode

means to which the transient signals are applied so that alternate wave traces are displaced one from the other, and means to initiate each alternate scanning cycle at a like time in the scanning cycle of the timing axis path.

12. Cathode ray oscillograph apparatus comprising a cathode ray tube having means included therein for developing and modulating a cathode ray beam and a target element upon which the said cathode ray beam is adapted to impinge, a pair of deflecting electrode means for deflecting the developed cathode ray beam relative to the target in two mutually perpendicular directions, a plurality of terminal connections for connecting to a plurality of transient signal circuits, an electron tube amplifier connected to receive energy from each terminal connection, said electron tube amplifiers having a common output circuit and means for connecting one of the pair of beam deflecting means to the said common output circuit, a sweep circuit generator means for developing substantially saw-tooth wave energy, and means for applying said saw-tooth wave energy to the second of said pair of beam deflecting means, a commutating means comprising a frequency dividing and switching amplifier tube means, means for developing pulse energy at a frequency corresponding to the saw-tooth frequency generated by the said sweep circuit generator, connection means for simultaneously applying said developed pulse energy to trigger the frequency dividing and switching amplifier tube means and to suppress instantaneously the developed electron beam in the said tube, connection means for supplying output energy from the said frequency dividing and switching amplifier to alternately render the independent transient signal amplifiers operative and inoperative at a rate corresponding to half that of the saw-tooth energy, a second connection for simultaneously biasing by fixed amounts the deflecting electrode means to which the transient signals are applied so that alternate wave traces are displaced one from the other, and means for interlocking the switching and timing of the deflection paths to align the successive wave traces with regard to each other.

13. A signalling circuit including thermionic driver tube means which include a first and a second independent electron path and wherein collector and control electrode means are included in each path, thermionic relay tube means which include a first and a second independent electron path and wherein a collector, a control electrode, and at least a screen electrode means are also included in each path, means to parallelly connect the control electrode means of the first path of the driver and the relay means and to similarly connect the control electrode means of the second electron paths of the said driver and relay means, means to connect the collector electrode means of the first electron path of the driver and the screen electrode element of the first electron path of the relay tube means and to similarly connect the collector electrode means of the second path of the driver means and the second path of the relay means, a time delay circuit included in the connection between the parallelly connected control electrode means of each of the driver and relay paths, terminal means for applying impulse signals to the thermionic driver means, and terminal means for deriving output energy from the thermionic relay means.

KURT SCHLESINGER.