

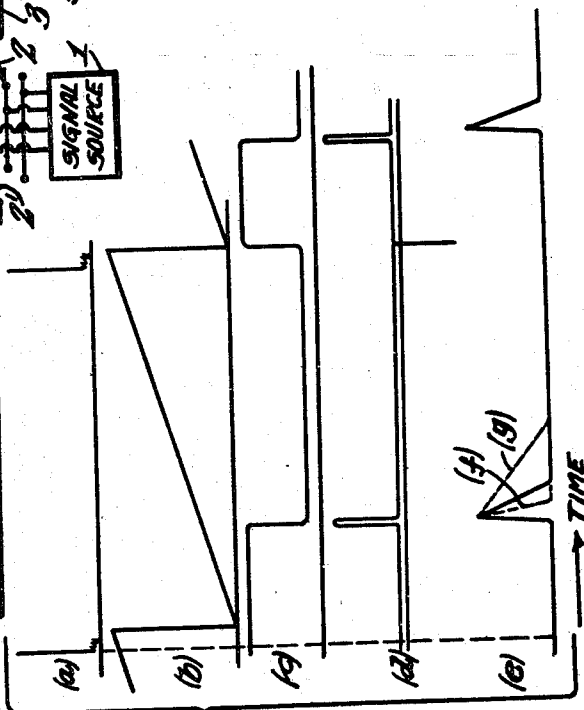
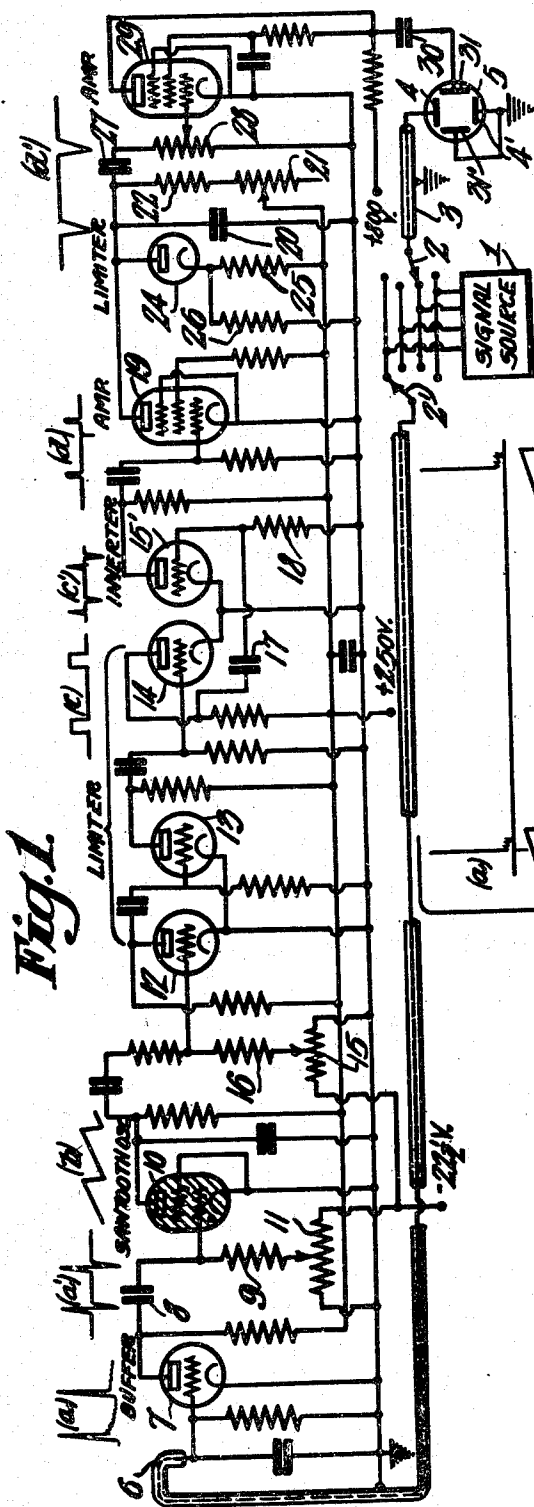
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J. G. WOODWARD

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OSCILLOGRAPH TIMING CIRCUIT

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OSCILLOGRAPH TIMING CIRCUIT

Junior Guy Woodward, Princeton, N. J., assignor
to Radio Corporation of America, a corporation
of Delaware

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This invention relates generally to electrical measuring systems and more particularly to an improved method of and means for indicating on a cathode ray oscillograph sequentially occurring transient voltage waveform characteristics.

A system for indicating the waveform characteristics of sequentially occurring transient voltages such as, for example, ignition voltages in internal combustion engines, has wide utility in the determination of ignition efficiency, and in the elimination of radio interference produced by such ignition circuits. Heretofore various systems have been devised to provide suitable timing voltages for use in oscillographic observation of such transient voltages. It should be understood that for most efficient observation of such transient voltages, the timing voltage must be substantially saw-tooth in waveform, and of extremely short time duration, since the total period of most transient voltages is extremely short. Transient voltages in ignition systems comprise a plurality of sequentially occurring voltage pulses characteristic of the sequentially applied ignition voltages to the several ignition plugs of the engine.

Heretofore oscillographic measurements of such ignition voltages have been attempted by applying the transient voltages directly to one deflecting element of the cathode ray oscillograph tube, and deriving from the same transient voltage a timing voltage which is applied directly to a second cathode ray deflecting element. The principal disadvantage of such systems is that considerable delay is inherent in all timing voltage circuits wherein a transient voltage waveform is shaped or otherwise employed to provide a synchronized saw-tooth timing voltage. Such delay results in a timing voltage which commences at a considerably later time than the beginning of the transient voltage under observation. Since usually the observation of the beginning of a transient voltage is of great importance, it is essential that the timing voltage applied to the oscillograph commence substantially coincidentally with the beginning of the transient voltage.

The instant system contemplates an improved method of and means for measuring sequentially occurring transient voltage waveform characteristics on a cathode ray oscillograph wherein a particular transient voltage is applied to a timing voltage generator to provide a synchronized saw-tooth timing voltage. A predetermined subsequent one of the sequentially occurring transient voltages is then applied to one deflecting ele-

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ment of the cathode ray oscillograph. The timing voltage is delayed a total amount equivalent to the time elapsing between the commencement of the initial transient voltage and the particular one under observation. The timing voltage thus delayed is then applied to the oscillograph to deflect the cathode ray along its timing coordinate. It will be seen that a system of the type to be described in detail hereinafter may be applied to observe selectively the ignition characteristics of each of the ignition plugs of an internal combustion engine, since the timing voltage may be delayed selectively to permit sequential observation of each successive ignition device.

Briefly, the timing voltage derived from the timing voltage generator should have a time duration of the order of the time duration of the longest one of the sequentially occurring transient voltages under observation. In operation, the invention provides an improved cathode ray oscillograph sweep circuit wherein the cathode ray trace is retained at one side of the oscillograph screen at all times except during the time interval during which the particular transient voltage is under observation. The trace is then caused to sweep rapidly across the screen during the time interval of the transient under observation. Provision is made for varying the time interval and the magnitude of the sweep voltage, as well as for controlling the phase relation thereof with respect to the sequentially occurring transients to be observed.

Among the objects of the invention are to provide an improved method of and means for measuring on a cathode ray oscillograph a plurality of sequentially occurring transient voltages to determine the waveform characteristics thereof. Another object of the invention is to provide an improved method of and means for making oscillographic measurements of sequentially occurring transient voltage waveform characteristics wherein substantially saw-tooth sweep potentials having a duration of the order of the duration of one of the transients is derived from said one transient, and wherein said sweep potential is delayed a predetermined interval for observation of the voltage waveform of a predetermined subsequent one of the sequentially occurring transient voltages. A further object of the invention is to provide an improved timing circuit for oscillographic measurements wherein a saw-tooth timing voltage is derived in response to the application to said circuit of a transient voltage. Another object of the invention is to

3 provide an improved sweep circuit for cathode ray oscillograph apparatus wherein a transient voltage is applied to key synchronously a saw-tooth oscillator, the saw-tooth oscillations are limited to provide substantially square waveform voltages, the square waveform voltages are differentiated and amplified to provide sequentially occurring positive pulses, said positive pulses are employed to discharge a linearly charged capacitor, and the voltage upon said capacitor is amplified to provide a substantially linear, rapid saw-tooth pulse sweep voltage.

The invention will be further described by reference to the accompanying drawing, of which Figure 1 is a schematic circuit diagram of one embodiment thereof, and Figure 2 is a family of graphs illustrative of the circuit operation of Figure 1. Similar reference numerals are applied to similar elements throughout the drawing.

Referring to Figure 1, a signal voltage source 1, such as, for example, the ignition plugs of an internal combustion engine, which provides a plurality of sequentially occurring transient voltages, is connected through a switch 2 and a shielded transmission line 3 to the vertical deflecting elements 4, 4' of a cathode ray oscilloscope 5. The switch 2 may be employed to select the particular transient voltage to be observed on the oscilloscope tube 5. One of the sequentially occurring transient voltages from the signal source 1 is connected for example, through a second switch 2', to the input terminals 6 of a sweep voltage generating circuit. The input terminals 6 of the sweep voltage generator circuit are connected to the control electrode circuit of a first buffer amplifier tube 7. Transient voltages of the type illustrated by the graph *a* will be applied to the control electrode circuit of the buffer amplifier tube 7. The anode circuit of the buffer amplifier tube 7 is connected, through the differentiating network comprising a series capacitor 8 and a shunt resistor 9, to key the control electrode of a gas tetrode 10 which is connected as a conventional keyed saw-tooth oscillator. The waveform of the differentiated signals applied to the control electrode of the saw-tooth oscillator 10 is indicated by the graph *a'*. The synchronized saw-tooth oscillations derived from the oscillator tube 10 are indicated by the graph *b*. Control of the value of the keying voltage applied for control of the saw-tooth oscillator tube 10 is obtained by a potentiometer 11 having its movable contact connected through the shunt resistor 9 to the oscillator control electrode 10. The potentiometer resistor is connected to the cathode of the oscillator tube 10 and to a source of negative grid bias potential.

The synchronized saw-tooth oscillations *b* are applied to the input circuit of a conventional three-stage limiter circuit which comprises the first, second, and third limiter tubes 12, 13, 14, respectively, which are connected in cascade arrangement. A phase control, comprising a second potentiometer 15, having its movable contact connected through a second shunt resistor 16 to the control electrode of the first limiter tube 12, determines the limiter tube grid bias voltage and thus the potential of the saw-tooth voltage *b* which is operable to actuate the limiter tubes 12, 13, 14, respectively. The resistive element of the second potentiometer 15, is connected to the cathodes of the limiter tubes and to the source of negative grid bias voltage mentioned heretofore. The output voltage from the anode of the third limiter tube 14, represented by the

4 graph *c*, comprises sequentially occurring positive pulses. The anode of the third limiter tube 14 is connected, through a second differentiating circuit comprising a series capacitor 17 and a shunt resistor 18, to the control electrode of an inverter-amplifier tube 15. The differentiated square wave pulses applied to the control electrode of the inverter-amplifier 15 are indicated by the graph *c'*.

10 The inverted, differentiated square wave signals *c'* are applied to the control electrode of a first pentode tube 19 from which is derived sequentially occurring positive square wave pulses which may be of short duration represented by the graph *d*. The anode circuit of the first pentode tube 19 includes a capacitor 20 which is rapidly and substantially completely discharged each time one of the positive pulses *d* is applied to the control electrode of the pentode tube 19. The capacitor 20 is charged at a substantially linear rate, and to a substantially uniform maximum voltage, through a variable resistor 21 and a fixed resistor 22 which are serially connected to the source of anode potential. Adjustment of the variable series resistor 21 varies the charging rate of the capacitor 20. The linearity and charging limits of the capacitor charging voltage are controlled by a diode rectifier tube 24. The anode of the diode 24 is connected to the anode of the first pentode tube 19. The cathode of the diode 24 is connected to the common terminal of a pair of serially-connected resistors 25, 26, which resistors are connected as a voltage divider across the anode voltage source. The voltage across the capacitor 20 is indicated by the graph *d'*.

35 The anode circuit of the first pentode tube 19 is connected, through a coupling capacitor 27 and a voltage dividing potentiometer 28, to the control electrode of a second pentode-amplifier tube 29. The voltage pulses *d'* on the capacitor 20 will, therefore, control the anode current of the second pentode-amplifier 29 to provide positive voltage pulses of the type shown in the graph *e* of Figure 2. The positive pulses *e* are applied, through an output coupling capacitor 30 to the horizontal deflecting elements 31, 31' of the cathode ray oscilloscope 5. It will be seen that the amplitude of the horizontal deflecting pulses applied to the horizontal deflecting elements 31, 31' will be determined by the setting of the movable contact of the third potentiometer 23.

40 Briefly reviewing the circuit operation, Figure 2, *a* indicates the selected sequentially occurring transient voltage pulse applied to the input circuit 6 of the sweep generator. Graph *b* indicates the saw-tooth voltages synchronously responsive to the applied transient voltage pulses *a*. Graph *c* indicates the square wave pulses 16 derived from the output of the third limiter tube 15 in response to the saw-tooth pulses *b* applied to the first limiter tube 13. Graph *d* indicates the resulting narrow positive pulse applied to the first pentode tube 19, after differentiation of the square-wave pulse *c*. Graph *e* indicates the positive saw-tooth pulse derived from the output pentode-amplifier 29 and applied to the horizontal deflecting elements 31, 31' of the oscillograph tube 5. The dotted saw-tooth waves *f*, *g*, on graph *e*, indicate the different timing of the saw-tooth sweep potentials derived from the output amplifier 29 which may be provided by adjustment of the series resistor 21 in the charging circuit of the capacitor 20. It should be understood that the resistor 21 may be fixed and the value of the capacitance varied to control the sweep

timing. The timing delay of the output sweep potential will be determined by the adjustment of the phase control potentiometer 15. The magnitude of the output sweep potentials will be determined by the setting of the third potentiometer 28 connected in the input circuit of the second pentode amplifier 29.

Thus the invention described comprises an improved method of and means for generating sweep potentials for measurements of sequentially occurring transient voltage waveform characteristics wherein the sweep potential is responsive to a predetermined one of said sequentially occurring transient voltages, and is delayed a predetermined interval for observation on an oscillograph tube of the waveform characteristics of a predetermined subsequent one of said transient voltages. It should be understood that any type of sequentially-occurring transient voltages may be investigated, and that the specific ignition measuring system described is purely illustrative of one application of the invention.

I claim as my invention:

1. The method of indicating on a cathode ray oscillograph sequentially occurring transient voltage waveform characteristics comprising deriving from one of said transient voltages sweep potentials having a duration of the order of the duration of one of said transients, applying said sweep potentials to deflect said ray along a first coordinate of said oscillograph, and coincidentally with the occurrence of said sweep potentials applying a predetermined subsequent one of said transient voltages to deflect said ray along a second coordinate of said oscillograph.

2. The method of indicating on a cathode ray oscillograph sequentially occurring transient voltage waveform characteristics comprising deriving from one of said transient voltages sweep potentials having a duration of the order of the duration of one of said transient voltages, delaying said sweep potentials a period equal to a predetermined number of said transient periods, applying said delayed sweep potentials to deflect said ray along a first coordinate of said oscillograph and coincidentally with the occurrence of said delayed sweep potentials applying said sequentially occurring transient voltages to deflect said ray along a second coordinate of said oscillograph for indicating the waveform of a subsequent one of said transient voltages determined by the length of said delay period.

3. The method of indicating on a cathode ray oscillograph transient voltage waveform characteristics of a plurality of sequentially excited sparking devices comprising deriving from one of said devices sweep potentials having a duration of the order of the duration of the excitation of said one device, delaying said sweep potentials an interval equivalent to the difference between the initial excitation times of predetermined ones of said sequentially excited devices, applying said delayed sweep potentials to deflect said cathode ray along a timing coordinate of said oscillograph, and coincidentally with the occurrence of said delayed sweep potentials applying potentials derived from a predetermined subsequent one of said devices to deflect said cathode ray along a second coordinate of said oscillograph.

4. Apparatus for indicating the waveform of a plurality of sequentially occurring transient voltages including means for deriving a timing potential from one of said transient voltages of duration of the order of the duration of one of said voltages, a cathode ray oscillograph having ray

generating means and ray deflecting means, delay means for applying said timing potential to said ray deflecting means to deflect said ray along a timing coordinate thereof, and means for applying a predetermined subsequent one of said transient voltages to said ray deflecting means to deflect said ray along a second coordinate thereof.

5. Apparatus for indicating the waveform of a plurality of sequentially occurring transient voltages including means for deriving a timing potential from one of said transient voltages of duration of the order of the duration of one of said voltages, means for delaying said timing potential a predetermined number of said transient voltage periods, a cathode ray oscillograph having ray generating means and ray deflecting means, means for applying said delayed timing potential to said ray deflecting means to deflect said ray along a timing coordinate thereof, and means for applying a predetermined subsequent one of said transient voltages to said ray deflecting means to deflect said ray along a second coordinate thereof.

6. Apparatus for indicating the waveform of a plurality of sequentially occurring transient voltages including means for deriving a timing potential from one of said transient voltages of duration of the order of the duration of one of said voltages, means for delaying said timing potential a predetermined number of said transient voltage periods, a cathode ray oscillograph having ray generating means and ray deflecting means, means for applying said delayed timing potential to said ray deflecting means to deflect said ray along a timing coordinate thereof, means for selecting a predetermined subsequent one of said transient voltages, and means for applying said predetermined subsequent one of said transient voltages to said ray deflecting means to deflect said ray along a second coordinate thereof.

7. Apparatus for indicating the waveform of a plurality of sequentially occurring transient voltages including means for deriving a timing potential from one of said transient voltages of duration of the order of the duration of one of said voltages, means for delaying said timing potential a predetermined number of said transient voltage periods, a cathode ray oscillograph having ray generating means and ray deflecting means, means for applying said delayed timing potential to said ray deflecting means to deflect said ray along a timing coordinate thereof, and means for applying at least a portion of a predetermined subsequent one of said transient voltages to said ray deflecting means to deflect said ray along a second coordinate thereof.

8. Apparatus for indicating the waveform of a plurality of sequentially occurring transient voltages including means for deriving a timing potential from one of said transient voltages of duration of the order of the duration of one of said voltages, means for selecting a predetermined portion of said timing potential to correspond to the delay of a predetermined number of said transient voltage periods, a cathode ray oscillograph having ray generating means and ray deflecting means, means for applying said selected portion of said timing potential to derive a timing deflection voltage, means for applying said timing deflection voltage to said ray deflecting means to deflect said ray along a timing coordinate thereof, and means for applying at least a portion of a predetermined subsequent one of said transient voltages to said

ray deflecting means to deflect said ray along a second coordinate thereof.

9. Apparatus for deriving a delayed timing potential from a pulse signal source including a differentiating network, means for connecting said source to said network to derive therefrom pulses coincidental with the rate of change of magnitude of said pulse signal, a keyed oscillation circuit, means for applying said differentiated signals to key said oscillation circuit to provide a saw-tooth pulse in response to each of said input signal pulses, means for limiting said saw-tooth pulses to derive substantially square wave pulses, means for differentiating said square wave pulses, a capacitor, means for charging said capacitor, means responsive to said differentiated square wave pulses for discharging said capacitor and means responsive to the charging voltage on said capacitor for deriving said timing potential.

10. Apparatus for deriving a delayed timing potential from a pulse signal source including a differentiating network, means for connecting said source to said network to derive therefrom pulses coincidental with the rate of change of magnitude of said pulse signal, a keyed oscillation circuit, means for applying said differentiated signals to key said oscillation circuit to provide a saw-tooth pulse in response to each of said input signal pulses, means for limiting said saw-tooth pulses to derive substantially square wave pulses, means for differentiating said square wave pulses, adjustable means for delaying said differentiated square wave pulses, a capacitor, means for charging said capacitor, means responsive to said delayed differentiated square wave pulses for discharging said capacitor, and means responsive to the charging voltage on said capacitor for deriving said timing potential.

11. Apparatus for deriving a delayed timing potential from a pulse signal source including

a differentiating network, means for connecting said source to said network to derive therefrom pulses coincidental with the rate of change of magnitude of said pulse signal, a keyed oscillation circuit, means for applying said differentiated signals to key said oscillation circuit to provide a saw-tooth pulse in response to each of said input signal pulses, means for limiting said saw-tooth pulses to derive substantially square wave pulses, means for differentiating said square wave pulses, adjustable means for delaying said differentiated square wave pulses, a capacitor, means including a diode-limiter for charging said capacitor, means responsive to said delayed differentiated square wave pulses for discharging said capacitor, and means responsive to the charging voltage on said capacitor for deriving said timing potential.

J. GUY WOODWARD.

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