

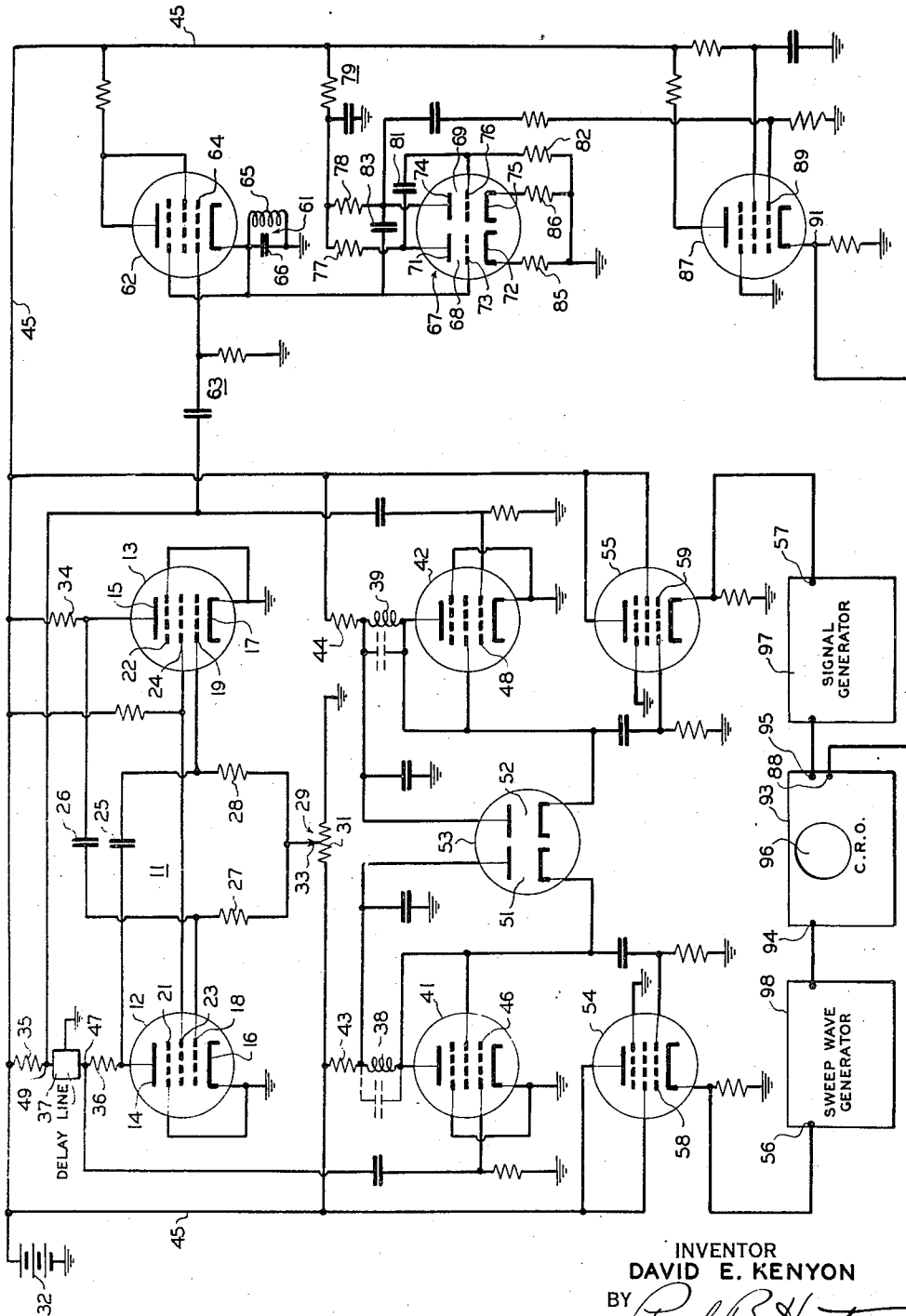
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PULSE GENERATOR

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PULSE GENERATOR

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The present application is a continuation-in-part of my copending application Serial No. 470,693, filed December 30, 1942.

The invention relates to electronic circuits and concerns pulse-forming circuits particularly.

It is an object of my invention to provide improved electronic circuits and methods for controlling electric currents.

It is another object of my invention to provide an arrangement for generating pulses and controlling pulse duration and spacing by the natural constants of a tuned or resonant circuit.

Still another object of my invention is to provide an arrangement for controlling interruption of current in a resonant element.

Still another object is to provide an arrangement for making pulse duration correspond to a half-cycle of oscillation.

Still another object is to provide an arrangement for sustaining natural oscillations.

A further object of the invention is to provide an arrangement for forming marking pulses and controlling them in time duration and frequency.

Other and further objects and advantages will become apparent as the description proceeds.

In carrying out my invention in its preferred form, I provide resonant elements and electric discharge devices or valves for controlling the currents therein. I arrange the circuits so that currents flowing in the resonant elements are interrupted abruptly by the discharge devices to initiate trains of oscillations which may be cut-off after the first half-cycle in order to form pulses having a pulse duration equal to a half-cycle of an oscillation in the resonant circuit or element. Trigger circuits are employed for controlling the frequency of initiation of the pulse-forming oscillations.

A better understanding of my invention will be afforded by the following detailed description considered in connection with the accompanying drawing, and those features of the invention which are believed to be novel and patentable will be pointed out in the claims appended hereto.

The single figure of the drawing is a circuit diagram of one embodiment of my invention.

In the form of apparatus illustrated in the drawing, there is a repeating trigger circuit 11 which may take the form of a multivibrator type of circuit comprising two stages represented by electric discharge devices or valves 12 and 13. The devices 12 and 13 may take the form of vacuum tubes and are shown for the sake of illustration as pentode tubes. As shown, the tubes 12 and 13 comprise anodes 14 and 15, grounded cathodes 16 and 17, control electrodes or grids 18 and 19, suppressor grids 21 and 22, and screen grids 23 and 24, respectively. The anodes and control grids are conventionally cross coupled by means of coupling condensers 25 and 26 and grid leak resistors 27 and 28. The control grids 18

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and 19 may be positively biased, and for providing adjustment of the repetition rate of the multivibrator circuit 11, an adjustable bias-providing potentiometer 29 may be provided. The potentiometer 29 comprises a resistor 31 connected across a source of anode supply current 32 and an adjustable tap 33, to which the control grids 18 and 19 are connected through the resistors 27 and 28, respectively.

The anode of one of the tubes, for example the anode 15, is connected to the positive terminal of the power supply 32 in a conventional manner through a load resistor 34. The anode of the other multivibrator tube, in this case the anode 14, however, is connected to the positive terminal of the supply source 32 through an anode resistor which is split into two parts 35 and 36. For providing the desired delay between the direct and delayed pulses to be triggered by the multivibrator circuit 11, a delay line 37 is interposed between the anode resistor parts 35 and 36 in series therewith.

For inducing oscillations, a pair of resonant elements 38 and 39 may be provided. The elements 38 and 39 may take the form of anode impedances or chokes, the distributed capacity of which combined with the inductance serve to form inductance-capacity resonant circuits.

For controlling current in the chokes 38 and 39, a pair of electric discharge devices or valves 41 and 42 may be provided. The devices 41 and 42 are shown as taking the form of triode-connected pentode vacuum tubes. The chokes 38 and 39 are included in the anode circuits of the tubes 41 and 42, and preferably decoupling resistors 43 and 44 are also connected in series with the chokes 38 and 39 to the positive bus 45 connected to the positive terminal of the power supply 32.

The tube 41 includes a control electrode or grid 46 which is resistance-capacity coupled to a junction terminal 47 between the delay line 37 and the anode resistor 36 of the tube 12. Likewise, the tube 42 includes a control electrode or grid 48 which is also resistance-capacity coupled to the anode circuit of the tube 12. In this case, however, the coupling is to the other end of the delay line 37, namely, to a junction terminal 49 between the delay line 37 and the anode resistor 35 of the tube 12.

For extinguishing oscillation in the chokes 38 and 39 upon reversal of polarity, unilateral current-conducting devices or rectifiers 51 and 52 are connected across the chokes 38 and 39, respectively. The rectifiers 51 and 52 may, if desired, take the form of diode vacuum tube elements enclosed in a single envelope 53 to form a twin diode tube.

In order to isolate the tubes 41 and 42 from possible reaction from output circuits, stages 54 and 55 may be provided, which serve as buffers

between the tubes 41 and 42 and pulse output terminals 56 and 57, respectively. The terminal 56 serves as the direct pulse output terminal and the pulse terminal 57 as the delayed pulse output terminal. The buffers 54 and 55 may also be triode-connected pentode vacuum tubes having control electrodes or grids 53 and 59 resistance-capacity coupled to the anodes of the choke current control tubes 41 and 42. For reducing the input impedance of the terminals 56 and 57, the buffers 54 and 55 may be connected as cathode follower stages.

For providing marker pulses which are synchronous with the direct and delayed pulses produced at the terminals 56 and 57, another resonant circuit 61 and an associated current-controlling tube 62 may be provided. The tube 62 may also take the form of a triode-connected pentode by way of example and is connected to the common power supply source 32 by means of the positive bus 45. The resonant circuit 61 in this case, however, is connected in the cathode circuit of the tube 62 instead of the anode circuit. For causing the tube 62 to interrupt current in the resonant circuit 61, with the same frequency as the occurrence of the pulses at the terminals 56 and 57, a resistance-capacity coupling 63 is provided between a suitable point in the multivibrator circuit 11, for example the terminal 43, and a control electrode 64 in the tube 62.

The resonant circuit 61, as shown, may comprise an inductance 65 in parallel with a separate condenser 66. For sustaining oscillations in the resonant circuit 61 and avoiding any loading thereof, a negative resistance element or untuned amplifier 67 may be provided.

The amplifier 67, as shown by way of illustration, takes the form of a pair of triode vacuum tube elements 68 and 69 which may be mounted in a common envelope to form a twin triode, although my invention is not limited to the use of triode elements. In the arrangement illustrated, the triode element 68 comprises an anode 71, a cathode 72, and a control electrode or grid 73, and the triode 69 comprises corresponding elements 74, 75 and 76.

The anodes 71 and 74 are connected through anode impedances or resistors 77 and 78 to the positive bus 45 of the power supply 32, preferably through a resistance-capacity decoupling circuit 79. The grids and anodes of the twin triode amplifier 67 are cross coupled by resistance-capacity elements, comprising a coupling condenser 81 between the anode 71 and the control grid 76 with an associated grid leak resistance 82 and a coupling condenser 83 between the anode 74 and the control grid 73 without any grid leak resistor corresponding to the element 82. The control grid 73 is grounded, instead; through the inductance 65. For bias and stabilization, cathode resistors 85 and 86 may be provided.

It will be observed that the amplifier 67 is connected in a manner analogous to a multivibrator circuit or resistance-capacity coupled two-stage feed-back oscillator. The arrangement is such, however, that the amplifier 67 cannot oscillate and must follow the voltage variations in the inductance 65 so that it acts merely as a feed-back amplifier which is untuned and does not affect the period of the resonant circuit 61. To prevent oscillation as a multivibrator, the control grid 73 of the triode 68 is tied to ground (below cathode potential) through the inductance 65.

Marker pulses may be taken from a suitable point in the circuit of the amplifier 67. Preferably, however, a clipper and buffer stage 87 is interposed between the amplifier 67 and a clipper output terminal 88. The stage 87 may take the form of a pentode vacuum tube connected as a cathode follower having a control electrode 89 resistance-capacity coupled to the anode 74 of the twin triode amplifier 67 and having a cathode terminal 91 connected to the clipper output terminal 88. The circuit constants may be so chosen that the output of the amplifier 67 overdrives the amplifier 87 and thereby causes clipping of negative half-cycles.

The timing or determination of the repetition rate of the generated pulses is controlled by the multivibrator-triggering circuit 11. The tubes 12 and 13 become alternately conducting at a rate determined by the circuit constants and the setting of the pulse frequency potentiometer 29. Whenever the conduction is shifted from the tube 13 to the tube 12 rendering the tube 12 conducting, the sudden flow of current through the anode resistor 35 produces a sharp potential drop at the terminal 41 which is transmitted through the condenser coupling to the control grid 46 of the tube 41 which normally conducts current. The negative impulse applied to the grid 46, however, drives the tube 41 beyond cut-off and abruptly interrupts the flow of current in the choke 38. An inductive voltage thereupon appears in choke 38 and transfers a positive potential to the control grid 53 of the buffer 54. During the first half-cycle of the train of oscillations which tends to be induced in the choke 38, the grid 53 remains at positive potential, and a positive half-cycle appears at the direct pulse terminal 56. The oscillation in the choke 38 is extinguished in the next half-cycle; however, by the rectifier 51 which short circuits the choke 38 for voltage of reversed polarity which tends to be induced during the second half-cycle.

A similar action takes place in the elements comprising the choke 39, the current-extinguishing tube 42, and the buffer 55. However, the control grid 48 of the tube 42 is coupled to the other end 49 of the delay line 37 so that a negative impulse corresponding to that from the terminal 47 is not applied to the control grid 43 until the negative impulse at the terminal 47 is propagated along the delay line 37 to the other end 49. It will be understood that a delay line is a circuit element resembling a transmission line having such electrical length that the desired time delay is involved in the transmission of the pulse from one end of the line to the other. The resistance of the resistor 35 is made equal to the characteristic impedance of the line 37. The delay line 37 may, of course, be a compact unit comprising relatively large inductances and condensers in the form of an artificial transmission line.

At the same time that a negative impulse is transmitted to the tube 42 to form the delayed pulse at terminal 57, the negative impulse is also transmitted to the control grid 54 of the tube 62 to drive the tube 62 beyond cut-off and extinguish the current which is normally flowing through the inductance 65 of the resonant element 61. The interruption of current in the inductance 65 induces a voltage therein which drives the control grid 73 of the amplifier 67 negative. Since the output of the amplifier 67 is fed back to the resonant circuit 61 through the coupling condenser 83, it acts as a negative resistance and tends to sustain the oscillations in the resonant circuit 61.

so long as the control grid 64 remains beyond cut-off. At the end of the gate of the multivibrator 11, when current shifts back from the tube 12 to the tube 13, the potential of the grid 64 of the tube 62 rises, causing the tube 62 to become a short circuit for the resonant circuit 61, and the oscillations therein are extinguished. Thus, for each cycle of the multivibrator 11, the complete circuit produces a direct pulse at the terminal 56, and a delayed pulse at the terminal 57, followed by a train of marker pulses at the terminal 58. The pulse from the terminal 56 may be used for tripping the sweep-wave of a cathode ray oscilloscope 93 or a synchroscope having sweep and signal terminals 94 and 95. The pulse from the terminal 57 may be used for tripping phenomena to be observed in a cathode ray oscilloscope screen 96, such phenomena being produced for example by a generator 97, and the sweep wave by a generator 98, and the marker pulses from the terminal 58 may also be thrown upon the cathode ray oscilloscope screen 96 to serve as a time scale.

As many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above description or shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A delayed pulse generator comprising tripping circuit means, regenerative feed-back means for producing sustained oscillation of the tripping means, a delay line included therein, a pair of resonant elements, current interrupting means associated with said resonant elements, couplings between the ends of said delay line and said interrupting means, oscillation extinguishing means connected to said resonant elements, and means for forming pulses corresponding to initial half-cycles of oscillation in said resonant elements.

2. A delayed pulse generator comprising a pair of pulse forming circuits of the interrupted-current choke type, means tripping said pulse forming circuits, and delay means interposed between said tripping means and one of said pulse forming circuits.

3. A marker pulse generator comprising a trigger circuit, a resonant circuit, a current interrupter for said resonant circuit triggered by said trigger circuit, an untuned, regenerated feed-back, stabilized amplifier so coupled to said resonant circuit as to supply energy thereto, and a buffer stage driven by said amplifier.

4. A marker pulse generator comprising, in combination, a resonant circuit having constants determining pulse width, current interrupting means for said resonant circuit to induce oscillations therein, and a resistance-capacity coupled two-stage feed-back amplifier so coupled to said resonant circuit as to supply energy thereto, whereby a stabilized marker pulse appears as the output of said amplifier.

5. In combination, an oscillator of the electric discharge device type having an inductance-capacity resonant circuit for determining the frequency thereof, and a trigger circuit connected for abruptly varying direct-current flow through the resonant circuit, and an amplifier acting as a negative resistance connected to initiate oscillation of said circuit immediately at an amplitude substantially as great as the sustained oscillation amplitude.

6. In combination, a resonant circuit having a predetermined natural period of oscillation, means for shock-exciting said resonant circuit, and a negative-resistance unit coupled to said resonant circuit for sustaining oscillation.

7. In combination, an intermittently triggered tuned oscillatory circuit, a resistance-capacity coupled amplifier stage coupled to said resonant circuit, and a second amplifier stage coupled to said first stage and having a feed-back connection to said first stage, said couplings being so arranged that energy is supplied to said resonant circuit by said amplifier stages.

8. In combination, an electric discharge device having a cathode lead with a tuned circuit therein whereby oscillation may be induced in said tuned circuit by interrupting discharge in the device, an amplifier with a control grid and a non-inductive regenerative feed-back coupling to the grid, and means connecting said tuned circuit to said grid for sustaining oscillation in said tuned circuit.

9. In combination, an electric discharge device having a cathode lead with a tuned circuit therein whereby oscillation may be induced in said tuned circuit by interrupting discharge in said device, an amplifier with a control grid and a regenerative feed-back coupling to the grid, and a connection between said grid and said tuned circuit for sustaining oscillation in said tuned circuit, whereby resumption of discharge rapidly damps out said oscillation.

10. In combination, a cathode ray oscilloscope having sweep wave and signal wave input terminals, means coupled to the signal wave input terminals for generating a phenomena to be observed in the oscilloscope, a sweep wave generator coupled to the sweep wave input terminals, means for tripping the sweep wave generator, means for later tripping the phenomena-generating means, and means for supplying marker pulses to said signal wave input terminals, said marked pulses being initiated simultaneously with the tripping of said phenomena-generating means.

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