Dec. 9, 1947. S. I. TOURSHOU ET AL 2,432,180

RADIO PULSE-ECHO SYSTEM

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Fig. 1.

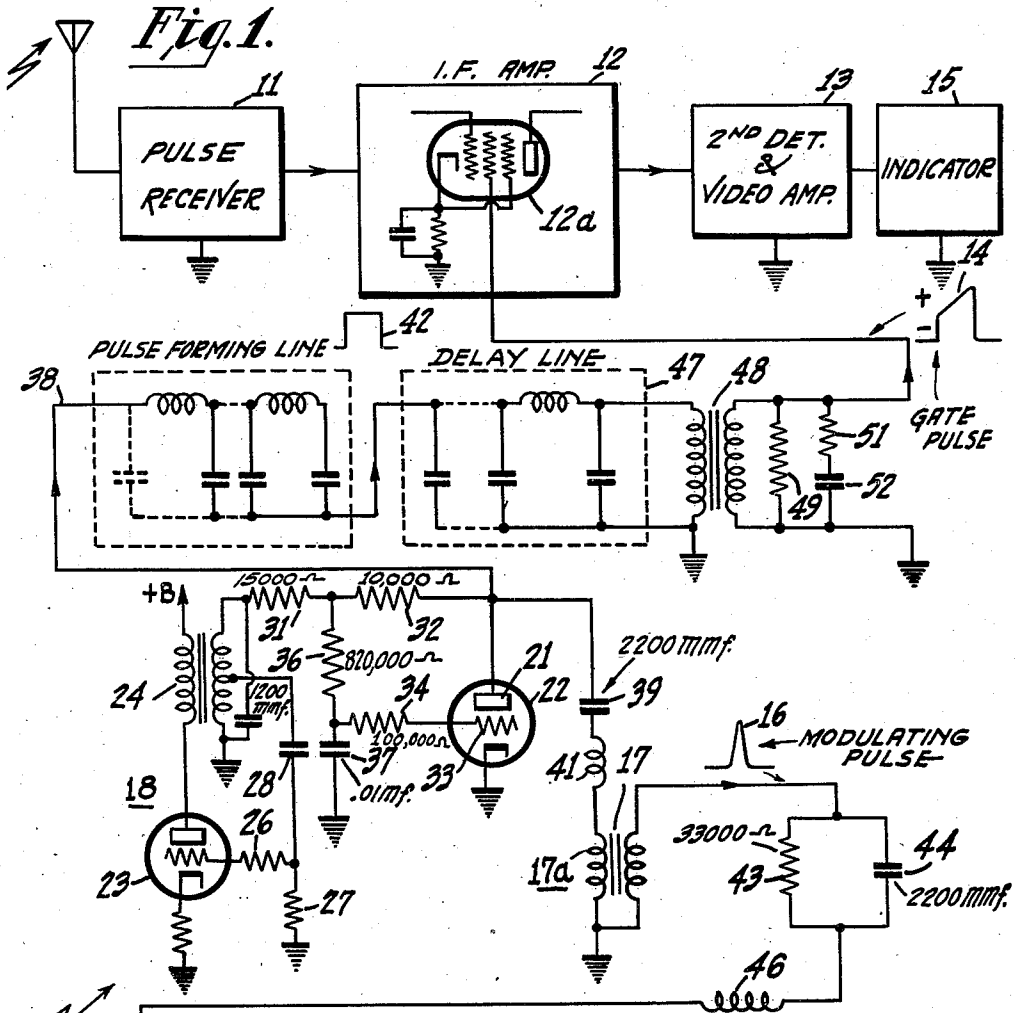
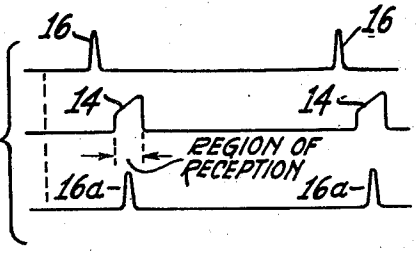


Fig. 1a.



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Fig. 2.

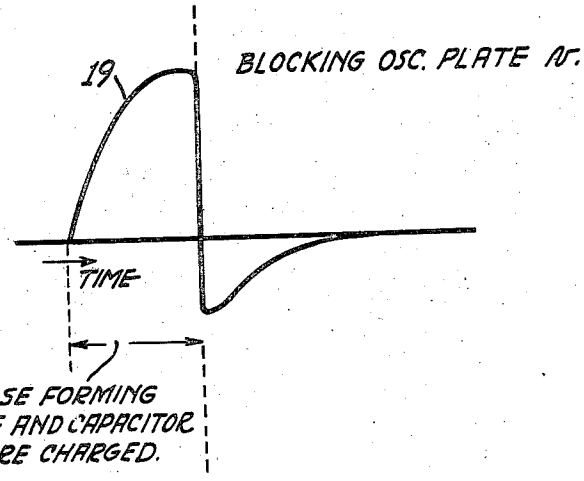


Fig. 3.

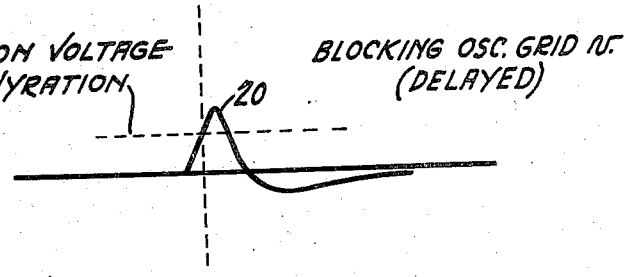
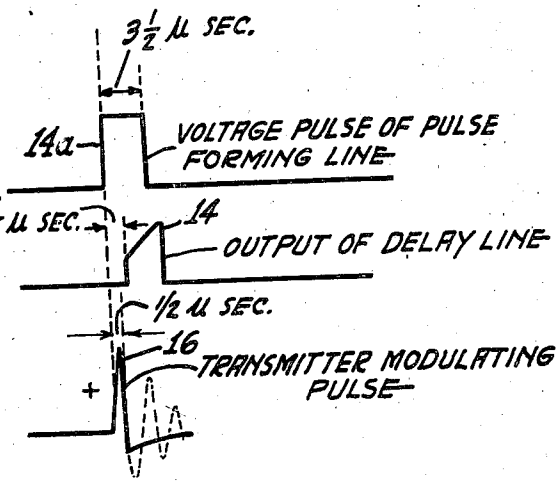


Fig. 4.

Fig. 5.

Fig. 6.



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RADIO PULSE-ECHO SYSTEM

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6 Claims. (Cl. 250—27)

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Our invention relates to pulse-echo radio systems and particularly to the production of electrical pulses.

One object of the invention is to provide an improved and simplified circuit for producing two groups of periodically recurring pulses.

Another object of the invention is to provide an improved method of and means for producing a delayed electrical pulse.

A further object of the invention is to provide an improved method of and means for producing two groups of periodically recurring pulses which have a fixed time relation to each other.

A further object of the invention is to provide a receiver that will draw a comparatively small amount of +B or high voltage direct current.

In one embodiment of the invention a circuit is provided for producing periodically recurring narrow pulses for pulse modulating a radio transmitter and for producing periodically recurring pulses of greater width to function as "gate" pulses for the pulse receiver. These two groups of pulses are produced by means of a blocking oscillator or the like which applies very wide pulses to a pulse forming delay line or network to charge the capacitors of the line during each wide pulse and which also applies the very wide pulses to a separate capacitor to charge it also during each blocking oscillator pulse. At about the peak of each blocking oscillator pulse a gas or vapor tube, which is connected for discharging said line and said capacitor, is ignited by a delayed blocking oscillator pulse so that the pulse forming line and the separate condenser discharge therethrough. This produces a "gate" pulse which appears at the end of the pulse forming line. It also produces a narrow transmitter modulating pulse which appears across the secondary of a transformer that is connected in series with said separate capacitor and said vapor tube.

Also, according to one feature of the invention, the pulse forming line is so connected to a delay network that the "gate" pulse is retarded the desired amount without affecting the operation of the pulse forming line.

Other objects, features and advantages of the invention will appear from the following description taken in connection with the accompanying drawing in which

Figure 1 is a circuit and block diagram of a pulse-echo system embodying the invention,

Figure 1a is a group of graphs illustrating the operation of the system of Fig. 1, and

Figures 2 to 6 are graphs illustrating the operation of the pulse forming circuits shown in Fig. 1.

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In the several figures, similar graphs are indicated by similar reference characters.

Fig. 1 shows the invention applied to a pulse-echo system comprising a radio pulse transmitter oscillator 10, a radio pulse receiver 11, an intermediate-frequency amplifier 12, a second detector and video amplifier unit 13, and a suitable indicator 15 for indicating the reception of reflected pulses. The amplifier 12 is adjusted so that it will pass received signals only during the occurrence of a gate pulse 14 which, in the example illustrated in the drawing, is applied with positive polarity to the screen grid of an intermediate-frequency amplifier tube 12a.

In a preferred receiver the I.-F. amplifier comprises a plurality of I.-F. amplifier tubes in cascade and the gate pulse 14 is applied to the screen grids of all these tubes except one or more which may be the last I.-F. tube which has a manual gain control voltage applied to its screen grid. It will be noted that there is no D.-C. voltage applied to the screen grids of the I.-F. tubes (with the exception of the last I.-F. tube) with the result that there is a substantial saving in the +B power supply since it does not have to supply screen grid and anode currents continuously.

The oscillator 10 is modulated by a voltage pulse 16 which appears across the secondary of a transformer 17. The apparatus for producing the gate pulse 14 and the modulating pulse 16 comprises a suitable pulse producing oscillator such as a free-running or self-oscillatory blocking oscillator 18 which applies wide positive voltage pulses 19 (Fig. 2) to the anode 21 of a gas or vapor tube 22 such as a Thyratron.

The blocking oscillator 18 is of conventional design and comprises a vacuum tube 23, a feedback transformer 24, grid leak resistors 26 and 27 and a grid capacitor 28 connected between the junction point of resistors 26 and 27 and a point on the secondary of the transformer 24. A source of sine wave voltage may be substituted for the blocking oscillator 18 if desired.

The high potential end of the secondary of transformer 24 is connected through resistors 31 and 32 to the anode 21 of the vapor tube 22 for applying to the anode 21 a positive pulse 19 (Fig. 2). The same positive pulse 19 is applied across a resistor 33 and a capacitor 37 whereby a delayed pulse 20 (Fig. 3) appears across capacitor 37. The delayed pulse 20 is applied to the grid 33 of the tube 22 through a resistor 34. The capacitor

37 and the resistor 36 are given such values as to introduce a suitable phase shift in the voltage pulse 20 to ignite the tube 22 preferably a short time after the pulse 19 has reached its maximum positive value as will be apparent from a comparison of Figs. 2 and 3.

The gate pulse is produced by a pulse-forming line 38 in the form of a network having series inductors and shunt capacitors which has its inductor side connected to the anode 21 of the vapor tube 22 so that it is charged by the first portion of the blocking oscillator pulse 19. At the same time that the line 38 is being charged, a capacitor 39, which is connected between the anode 21 of tube 22 and the primary 17a of transformer 17, is also charged. An inductor 41 is also included in series with the capacitor 39 and the transformer primary 17a unless the leakage inductance of transformer 17 is itself large enough for producing a pulse 16 of the desired width when the capacitor 39 is discharged. Changing the amount of inductance in the circuit in series with capacitor 39 changes the width of the pulse 16 since this pulse actually is one half-cycle of a damped sine wave in a series resonant circuit as indicated by the dotted lines in Fig. 6. However, this damped wave is substantially of the form shown by the solid line since the tubes 40 and 45 put a low impedance load across the secondary of transformer 17.

The delayed pulse 20 on the grid 33 of the vapor tube 22 causes the tube 22 to ignite or break down at about the time the blocking oscillator pulse 19 has applied a maximum charge to the pulse-forming line 38 and to the capacitor 39. When the tube 22 breaks down, it discharges the line 38 to form a pulse 14a of a width or duration that is equal to the time required for a wave to travel from one end of the line 38 to the other end of the line and back. In the example given, this pulse width is 3½ microseconds.

The breakdown of vapor tube 22 also discharges the capacitor 39 through the inductor 41 and the primary 17a of transformer 17 whereby the narrow pulse 16 is produced. In the present example the width of pulse 16 is ½ microsecond. By making transformer 17 a voltage step-up transformer, the pulse 16 may be made of high enough amplitude so that when applied to the anodes of the tubes 40 and 45 of the radio-frequency oscillator 10 the oscillator oscillates during the application of the pulse. In the example illustrated, there is no D. C. voltage on the oscillator anodes. The oscillator 10 is conventional in design having a tuned line 50 in the plate circuit and having the cathodes of tubes 40 and 45 operated above ground potential at the radio frequency.

The modulating pulse 16 preferably is applied to the oscillator 10 through resistor-capacitor biasing elements 43 and 44, respectively, and through a radio-frequency choke coil 46. During the pulse 16 the D. C. anode current of the oscillator tubes 40 and 45 flows through the biasing elements 43 and 44 to charge the capacitor 44 whereby the anodes of tubes 40 and 45 become negative somewhat before the end of the modulation pulse 16 resulting in a sharper cut-off of the oscillations; also, they are held negative long enough to prevent any positive components that might follow the pulse 16 from energizing the oscillator 10.

Referring again to the production of the gate pulse 14a, the pulse 14 from the pulse-forming line 38 is delayed the desired amount by a delay

network 47 which comprises series inductors and shunt capacitors, the amount of delay being about one and one-half microsecond, for example, as indicated in Fig. 5.

The output end of the delay line 47 is connected to a transformer 48 shunted by a resistor 49 to provide a non-reflecting termination. Also, means preferably are provided for sloping the front edge of the gate pulse 14 whereby the sensitivity or gain of the intermediate frequency amplifier 12 is the greatest when reflected pulses 16a (Fig. 1a) are received from the more distant part of the pulse reception region. This also results in an improved signal-to-noise ratio. The pulse sloping means may comprise a resistor 51 and a capacitor 52 connected in series with each other and in shunt to the transformer 48. It may be noted that the gain of the receiver as plotted against time has a greater slope than that of the gate pulse 14 since this pulse is applied to a plurality of I. F. amplifier tubes in cascade.

In order that the two lines or networks 38 and 47 shall perform their pulse forming and pulse delaying functions independently of each other, the series inductor side of network 47 is connected to that side of network 38 which is opposite its series inductor side. The end of the network 38 remote from the charging end is open-circuited and, therefore, reflecting. The impedance looking into the input end of the network 47 is substantially equal to the surge impedance of the network 38.

We claim as our invention:

1. In a pulse-echo system, means for producing periodically recurring electrical voltage waves each of positive polarity and of comparatively long duration, a pulse-forming delay line and a gas or vapor tube connected to discharge said line for forming a pulse when said tube is ignited, a capacitor and a pulse-forming circuit connected in series with the cathode-anode impedance of said tube, means for applying said voltage waves simultaneously to said line, to the anode of said tube and to said capacitor, and means for discharging said line and said capacitor through said tube after each has been charged by one of said voltage waves.

2. In a pulse-echo system, means for producing periodically recurring electrical voltage waves each of positive polarity and of comparatively long duration, a pulse-forming delay line and a gas or vapor tube connected to discharge said line when said tube is ignited, a capacitor and a pulse-forming circuit connected in series with the cathode-anode impedance of said tube, means for applying said voltage waves simultaneously to said line, to the anode of said tube and to said capacitor, and means for also applying said voltage waves to the control electrode of said tube slightly delayed with respect to the voltage waves applied to said anode whereby said line and said capacitor are both discharged through said tube after being charged by one of said voltage waves.

3. In a pulse-echo system, means for producing periodically recurring electrical voltage waves each of positive polarity and of comparatively long duration, a pulse-forming delay line and a gas or vapor tube connected to discharge said line to form a pulse when said tube is ignited, a capacitor and an inductor connected in series with the cathode-anode impedance of said tube to form a pulse when said capacitor is discharged, means for applying said voltage waves simultaneously to said line, to the anode of said tube

and to said capacitor, and means for also applying said voltage waves to the control electrode of said tube slightly delayed with respect to the voltage waves applied to said anode whereby said line and said capacitor are both discharged through said tube after being charged by one of said voltage waves.

4. In combination, a pulse-forming delay network comprising series inductors and shunt capacitors and having input terminals at one end of the network and a reflecting termination at the other end of the network, one of said terminals being common to both ends of the network, a second delay network comprising series inductors and shunt capacitors and having input terminals and output terminals and having a substantially non-reflecting termination at its output end, said terminals of the second network including a terminal that is common to both ends of the network, the common terminal of one of said networks being connected to the input terminal of the other network which is not common to both ends of the network, and means connected to the two remaining input terminals of the two networks for periodically charging and discharging said first network whereby periodically recurring delayed pulses are produced.

5. In combination, a pulse-forming delay network comprising series inductors and shunt capacitors and having input terminals at one end of the network and a reflecting termination at the other end of the network, one of said terminals being common to both ends of the network, a second delay network comprising series inductors and shunt capacitors and having input terminals and output terminals and having a substantially non-reflecting termination at its output end, said terminals of the second network including a terminal that is common to both ends of the network, the common terminal of said first network being connected to the input terminal of the other network which is not common to both ends of the network, and means connected to the two remaining input terminals of the two networks for periodically charging and discharging said first network whereby periodically recurring delayed pulses are produced at the output terminals of said second network.

6. In combination, a pulse-forming delay network comprising series inductors and shunt capacitors and having input terminals at one end of the network and a reflecting termination at the other end of the network, one of said terminals being common to both ends of the network, a second delay network comprising series inductors and shunt capacitors and having input terminals and output terminals and have a substantially non-reflecting termination at its output end, the input impedance of the second network being substantially equal to the surge impedance of the first network, said terminals of the second network including a terminal that is common to both ends of the network, the common terminal of said first network being connected to the input terminal of the other network which is not common to both ends of the network, means connected to the two remaining input terminals of the two networks for charging said first network, and means for periodically discharging said first network whereby periodically recurring delayed pulses are produced at the output terminals of the second network.

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