April 28, 1942. N. I. HALL 2,280,949

ELECTRIC SIGNALING

Filed Jan. 21, 1941 2 Sheets-Sheet 1

FIG. 1

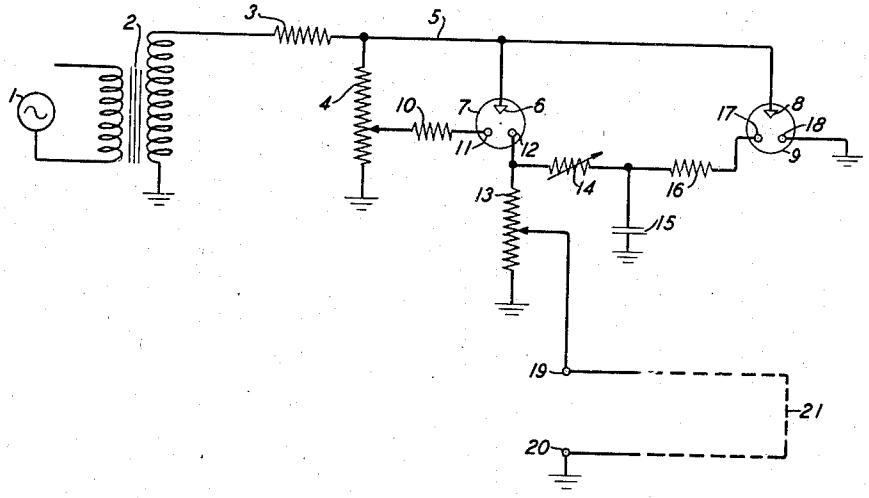
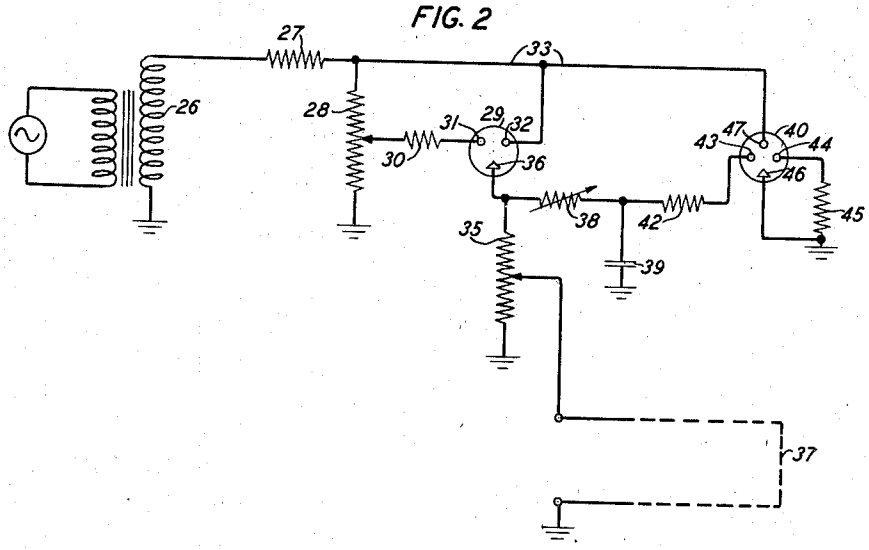


FIG. 2



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Filed Jan. 21, 1941 2 Sheets-Sheet 2

FIG. 3

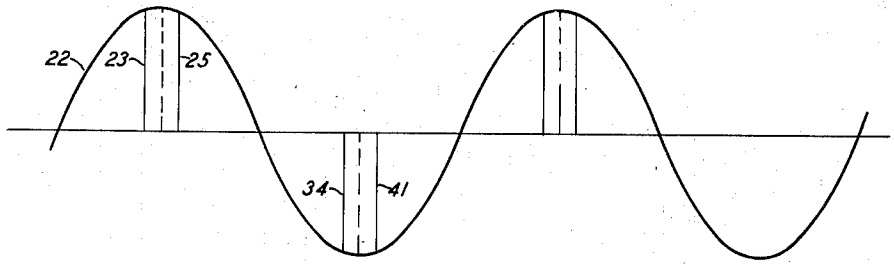
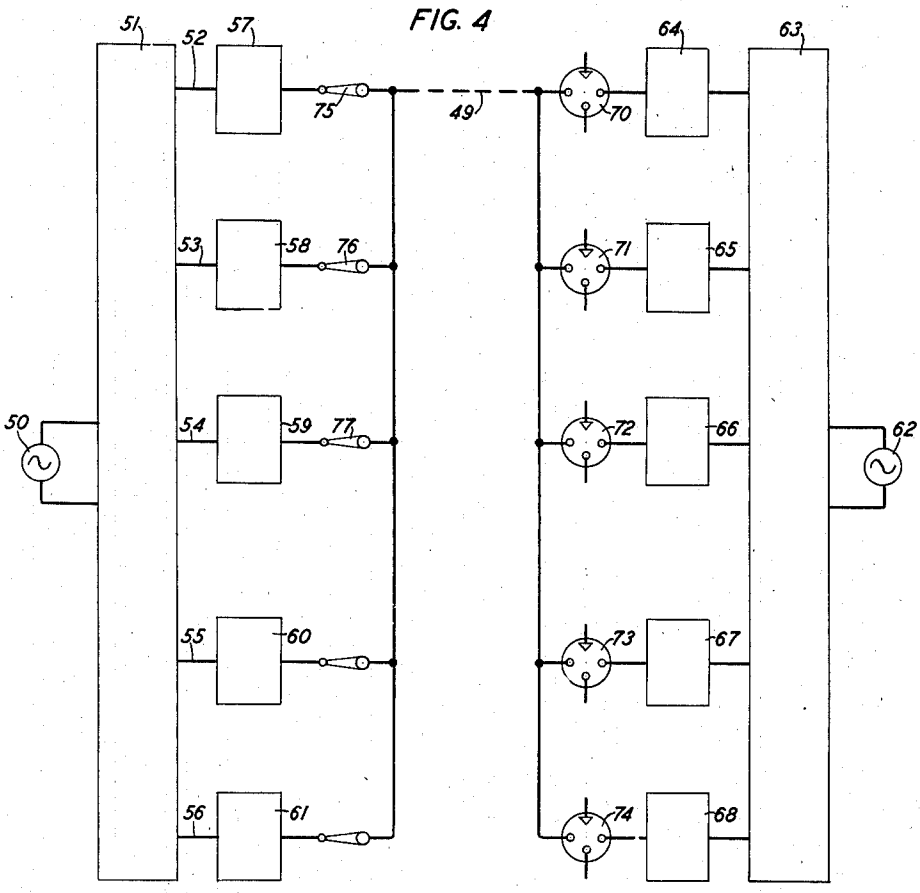


FIG. 4



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UNITED STATES PATENT OFFICE

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ELECTRIC SIGNALING

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Application January 21, 1941, Serial No. 375,200

6 Claims. (Cl. 250—27)

This invention relates to signaling and particularly to the generation and transmission of electric signals and impulses.

The objects of the invention are to obtain impulses which are accurately fixed in time; to enable the duration of the impulse to be controlled with precision; to control the shape and amplitude of the impulse; and to realize other improvements in the generation and transmission of electric impulses.

These objects are realized in accordance with the present invention by means of an impulse generator comprising a discharge tube which ionizes to start the impulse when the voltage wave of an alternating supply source reaches a definite value, a condenser which accumulates a charge to measure the impulse interval, and a second discharge tube which ionizes in response to the charge accumulated by the condenser at the end of the measured interval to quench the first tube, thereby terminating the impulse. More specifically, the alternating voltage is applied to the control gap of a discharge tube by means of a potentiometer which may be adjusted to cause the tube to ionize at any desired position in the cycle of the voltage wave. When the tube ionizes, current from the alternating source flows through the discharge circuit and sets up a voltage across a resistance element therein. This voltage produces an impulse in the impulse circuit to which the resistance element is connected. Also the voltage across the resistance element causes a condenser to charge through a variable resistance which controls the time interval necessary for the condenser to reach a predetermined voltage. This time interval may be selected at will to determine the length of the impulse. When the condenser charge reaches the predetermined value, it causes the ionization of a second discharge tube, and the flow of current through the main discharge circuit of the second tube quenches the first discharge tube to terminate the impulse.

A feature of the invention is an impulse generating system in which the phase of the impulse may be controlled by varying the position in the alternating voltage wave at which the discharge tube ionizes. A related feature of the invention is an impulse generating system in which the length of the impulse is controlled by varying the time required for charging the condenser, which in turn causes the second discharge tube to ionize and terminate the impulse.

Still another feature of the invention is a generating system in which the shape of the impulse is controlled by determining the relative positions in the voltage wave of an alternating supply source at which the impulse commences and terminates.

These and other features of the invention will be described more fully in the following detailed specification.

In the drawings accompanying the specification:

Fig. 1 discloses an impulse generating system designed to produce impulses of positive polarity;

Fig. 2 is a generating system designed to produce impulses of negative polarity;

Fig. 3 is a graph illustrating the phase and shape of the impulses; and

Fig. 4 is a diagram of a signaling system incorporating the impulse generators.

The generating system disclosed in Fig. 1 comprises a supply source of alternating voltage 1 connected to the primary winding of a transformer 2. One end of the secondary winding of the transformer is grounded, and the other terminal is connected through a resistance element 3 and a potentiometer resistance element 4 to ground. The junction of the resistance elements 3 and 4 is connected by a conductor 5 to the anode 6 of a discharge tube 7 and to the anode 8 of a second discharge tube 9. The adjustable terminal of the potentiometer 4 is connected through a resistance element 10 to the control electrode 11 of the tube 7. The cathode 12 of tube 7 is connected through a potentiometer resistance element 13 to ground and also through a variable resistance 14 to the upper terminal of condenser 15, the lower terminal of the condenser being grounded. The other terminal of condenser 15 is also connected through a resistance element 16 to the control electrode 17 of tube 9. The cathode 18 of the tube 9 is connected to ground.

The impulse generator has two output circuit terminals 19 and 20. The terminal 19 is connected to the movable contact of the potentiometer 13, and the terminal 20 is connected to ground. The impulses may be delivered to any desired impulse circuit 21 connected to the output terminals 19 and 20.

Considering the operation of the impulse system shown in Fig. 1, it may be assumed that the curve 22 of Fig. 3 represents the voltage wave produced by the secondary winding of the transformer 2. As the voltage wave 22 enters its positive half cycle current flows in a path traceable from the upper terminal of the secondary wind-

ing of transformer 2, resistance 3, resistance 4 to ground. The voltage produced by the flow of current through the potentiometer resistance 4 is applied across the control gap 11—12 of tube 7 in a circuit that may be traced from the movable contact of the potentiometer, resistance 10, electrodes 11 and 12, resistance 13 and thence to the grounded terminal of potentiometer resistance 4. When the voltage wave 22 reaches the instantaneous value represented by the ordinate 23, the voltage applied across the gap 11—12 is sufficient to ionize the tube. Thereupon current immediately flows in the main discharge circuit of the tube, which may be traced from the upper terminal of the transformer winding, resistance 3, conductor 5, anode 6, cathode 12, resistance 13 to ground. The flow of current in this circuit sets up a voltage across the resistance 13, and a portion of this voltage, depending upon the setting of the potentiometer contact, is applied to the terminals 19 and 20 to produce a positive impulse in the circuit 21.

At the same instant the impulse appears across the terminals 19 and 20 the voltage across the resistance 13 causes charging current to flow into the condenser 15. The charging circuit may be traced from the upper terminal of resistance 13 through the variable resistance element 14, condenser 15 to ground and thence to the grounded lower terminal of resistance element 13. The rate of charge depends upon the setting of the variable resistance 14, and this setting is selected so that the charge on condenser 15 will reach the ionizing voltage of the tube 9 at the instant it is desired to have the impulse terminate. When the condenser 15 reaches its predetermined voltage, which may be chosen to occur at the time the voltage wave 22 reaches the instantaneous value represented by the ordinate 25, the control gap 17—18 of the tube 9 ionizes. The discharge circuit of the condenser may be traced from the upper pole thereof through the resistance 16, electrodes 17 and 18 to ground. The instant the tube 9 ionizes, its main discharge circuit is closed, and current flows over conductor 5, anode 8, cathode 18 directly to ground. The impedance of the discharge circuit of tube 9 is comparatively low, and serves as a shunt circuit around the discharge gap of the tube 7. Therefore, the voltage across the anode and cathode gap of the tube 7 is immediately lowered below the sustaining value, and the tube 7 quenches. When the tube 7 quenches, current ceases to flow through the resistance element 13, and the impulse in the circuit 21 is terminated. As the voltage wave 22 declines and approaches the zero value the voltage across the anode-cathode gap of the tube 9 falls below the sustaining value, and the tube 9 quenches.

Thus the impulse commences at a time in the cycle of the wave 22 corresponding to the ordinate 23 and terminates at a predetermined later time corresponding to the ordinate 25. The location of these ordinates may be varied by varying the potentiometer 4 and the variable resistance element 14. If it is desired to produce an impulse having a flat top the ordinates 23 and 25 should be selected in the neighborhood of the maximum instantaneous value of the wave since the rate of change is less in this region.

During the negative half cycle of the voltage wave 22 no impulse is produced by the generating system since the discharge tube 7 does not permit current to flow in this direction through the anode-cathode circuit.

The generating system shown in Fig. 2 is similar to the one disclosed in Fig. 1, except that it is designed to produce negative instead of positive impulses. When the voltage wave 22 enters its negative half cycle current flows from the lower or grounded terminal of the secondary transformer winding 26 to the grounded terminal of potentiometer resistance 28 thence through said resistance and resistance 27 to the upper terminal of winding 26. As the voltage wave reaches its ordinate value 34 the control gap of the tube 29 is ionized over a circuit traceable from the movable contact of potentiometer 28, resistance 30, control electrode 31, cathode 32, conductor 33 to the upper terminal of potentiometer resistance 28. As soon as the tube 29 ionizes discharge current flows from the grounded terminal of potentiometer resistance 35 thence through said resistance, anode 36, cathode 32, conductor 33, resistance 27 through the secondary winding 26 to ground. The flow of current through the resistance 35 in this direction produces a negative impulse in the impulse circuit 37. Also the voltage of the anode 36 causes current to flow through the variable resistance element 38 to charge the condenser 39.

When the condenser 39 reaches a predetermined voltage, which occurs a definite interval following the commencement of the impulse, namely, when the voltage wave 22 reaches the ordinate 41, the tube 40 is ionized. The discharge circuit of condenser 39 may be traced from the upper terminal of said condenser, resistance 42, control gap of electrodes 43 and 44, resistance 45 to ground. The ionization of the gap between the electrodes 43 and 44 causes the main discharge gap of the tube to ionize, and current now flows through the tube from ground, anode 46 to cathode 47, conductor 33, resistance 27 through the winding 26 to ground. The impedance of the discharge circuit of the tube 40 is so low that the tube 29 is quenched, and current ceases to flow through the resistance element 35. Hence the impulse terminates in the circuit 37. As the voltage wave 22 approaches the zero axis the main discharge gap of the tube 40 quenches, and relay 48 releases.

Hence impulses of negative polarity are generated during the negative alternations of the voltage wave 22, and the phase and duration of these impulses may be controlled by adjusting the potentiometer 28 to determine the starting point of the impulse and by adjusting the variable resistance 38 to determine the terminating point of the impulse.

Fig. 4 illustrates one of the many useful applications of the impulse generating systems shown in Figs. 1 and 2. Assume for example that it is desired to transmit a plurality of different signals over the single transmitting conductor 49. At the transmitting end of the line there are provided a source of alternating current 50 and a suitable phase generator 51 whereby a plurality of different phases are derived from the source 50. The phase generator 51 has a plurality of output circuits, each of which supplies voltage of a different phase. If ten different phases are required, there will be ten output circuits 52, 53, 54, 55, 56, leading respectively to ten impulse generators 57, 58, 59, 60, 61. These generators are like the one shown in detail in Fig. 1 and produce positive impulses in their output circuits.

At the receiving end of the system a source of alternating current 62 of the same frequency as the source 50 and a phase generator 63, similar

to generator 51, are provided. The output circuits of the phase generator 63 are connected respectively to the impulse generators 64, 65, 66, 67, 68. These generators, like the one shown in Fig. 2, produce negative impulses in their output circuits.

The signals transmitted over the conductor 49 are registered by discharge tube registers 70, 71, 72, 73, 74. To this end the signaling conductor 49 is connected in multiple to the electrodes of all of these register tubes, and the impulse generators 64, 65, 66, etc., are connected individually to the electrodes of the respective tubes.

When it is desired to transmit a signal over the conductor 49, one or more of the impulse generators 57, 58, etc., at the transmitting end are connected to the line 49 by means of selective switches 75, 76, 77, and positive impulses of the corresponding phases are sent over the line 49. At the receiving end of the system these incoming impulses are all applied to the electrodes of the ten register tubes 70, 71, 72, etc. For each incoming positive impulse of a particular phase there is applied to some one of the register tubes a negative impulse of the same phase. Therefore, the voltage applied to this particular tube is the sum of the positive and negative voltages and is sufficient to ionize the tube. None of the remaining tubes, however, has a negative impulse applied simultaneously with the incoming positive impulse, and hence only one of the tubes ionizes in response to each incoming signal impulse. The register tubes serve in any well-known manner to utilize the registered signals received over the signaling conductor. For example, a system illustrating the utility of signals registered on tubes of this character is disclosed in the copending application of W. H. T. Holden, Serial No. 361,537, filed October 17, 1940.

In the generating systems disclosed herein the discharge tubes employed may be of any suitable type such as those having cold cathodes and gas-filled envelopes. However, it will be understood that the invention is not limited to the use of tubes of any particular type and that tubes having hot cathodes or tubes that are controlled electrostatically may be employed if desired.

The four-element tube shown in Fig. 2 and those illustrated in Fig. 4 may be of the type described in detail in the application of W. H. T. Holden, Serial No. 258,128, filed February 24, 1939.

What is claimed is:

1. The combination in an impulse system of a discharge tube, an impulse conductor, a source of alternating voltage, circuit means for applying said source to said tube to cause the discharge of said tube when the wave of said voltage source reaches a definite value, a discharge circuit having a resistance element therein through which current flows following the discharge of said tube, the resultant voltage across said resistance element serving to produce an impulse in said impulse conductor, a condenser, circuit means for applying to said condenser the voltage of said resistance element to charge said condenser to a given voltage in a predetermined interval following the discharge of said tube, a second discharge tube, circuit means connecting said condenser thereto for causing the discharge of said second tube at the end of said predetermined interval, and a discharge circuit for said second tube for quenching said first tube to terminate said impulse.

2. The combination in an impulse system of a discharge tube having a main discharge gap and a control gap, an impulse circuit, a source of alternating voltage, circuit means for applying said source to the control gap of said tube to cause the discharge thereof when the wave of said voltage source reaches a predetermined value, a discharge circuit including the main gap of said tube, a resistance element in said discharge circuit through which current flows in response to the discharge of said main gap following the discharge of said control gap, the resultant voltage across said resistance element serving to produce an impulse in said impulse circuit, a condenser, circuit means for applying to said condenser the voltage across said resistance element to charge said condenser to a given voltage in a predetermined interval of time, measuring the desired length of said impulse, a second discharge tube, circuit means connecting said condenser thereto for causing the discharge of said second tube at the end of the measured interval, and a main discharge circuit for said second tube for quenching said first tube to terminate said impulse by terminating the flow of current in said resistance element.

3. The combination in an impulse system of a discharge tube, an impulse conductor, a source of alternating voltage, circuit means for applying said source to said tube to cause the discharge of said tube, means for varying in the cycle of the wave of said voltage source the time of the discharge of said tube, a discharge circuit having a resistance element therein through which current flows following the discharge of said tube, the resultant voltage across said resistance element serving to produce an impulse in said impulse conductor, a condenser, circuit means for applying to said condenser the voltage of said resistance element to charge said condenser to a given voltage in a predetermined interval following the discharge of said tube, and means responsive to the voltage on said condenser at the end of said predetermined interval for quenching said tube to terminate said impulse.

4. The combination in an impulse system of a discharge tube, an impulse conductor, a source of alternating voltage, circuit means for applying said source to said tube to cause the discharge of said tube, means for varying the time in the cycle of the wave of said alternating voltage when said tube discharges, a discharge circuit having an impedance element therein through which current flows following the discharge of said tube, the resultant voltage across said element serving to produce an impulse in said impulse conductor, a condenser, circuit means for applying to said condenser the voltage of said impedance element to charge said condenser, means for varying the time required to charge said condenser to a predetermined voltage, a second discharge tube, circuit means connecting said condenser to said second tube to cause the discharge thereof when said condenser reaches said predetermined voltage, and a discharge circuit for said second tube for quenching said first tube to terminate said impulse.

5. The combination in an impulse system of a discharge tube, an impulse circuit, a source of alternating voltage, circuit means for applying said source to said tube to cause successive discharges of said tube in response to the successive cycles of the alternating voltage, a discharge circuit having a resistance element therein through which current flows in response to each discharge

of said tube, the resultant voltages across said resistance element serving to produce a succession of impulses in said impulse circuit, a condenser, circuit means for applying to said condenser the voltages of said resistance element to charge said condenser to a given voltage in a predetermined interval following each discharge of said tube, a second discharge tube, circuit means connecting said condenser thereto for causing the discharge of said second tube at the end of each said predetermined interval, and a discharge circuit for said second tube for quenching said first tube to terminate each of said impulses.

6. The combination in an impulse system of a discharge tube, an impulse circuit, a source of alternating voltage, circuit means for applying said source to said tube to cause successive discharges of said tube in response to the successive cycles of the alternating voltage, a discharge circuit having a resistance element therein through which current flows in response to each discharge of said tube, the resultant voltages across said resistance element serving to produce a succession of impulses in said inpulse circuit, a condenser, circuit means for applying to said condenser the voltages of said resistance element to charge said condenser to a given voltage in a predetermined interval following each discharge of said tube, a second discharge tube, circuit means connecting said condenser thereto for causing the discharge of said second tube at the end of each said predetermined interval, and a discharge circuit for said second tube for shunting the current flowing in the discharge circuit of said first tube to quench said first tube and to terminate said impulses.

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