April 28, 1942. A. W. HORTON, JR., ET AL 2,281,441

ELECTRIC SIGNALING

Filed Jan. 21, 1941

FIG. 1

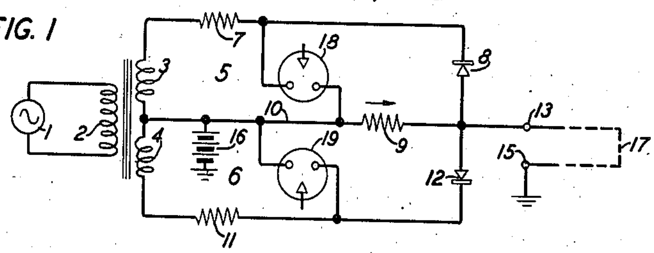


FIG. 2

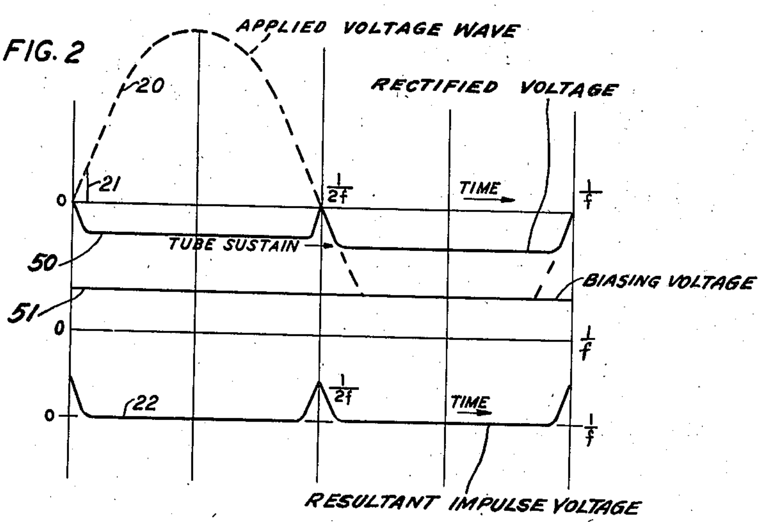
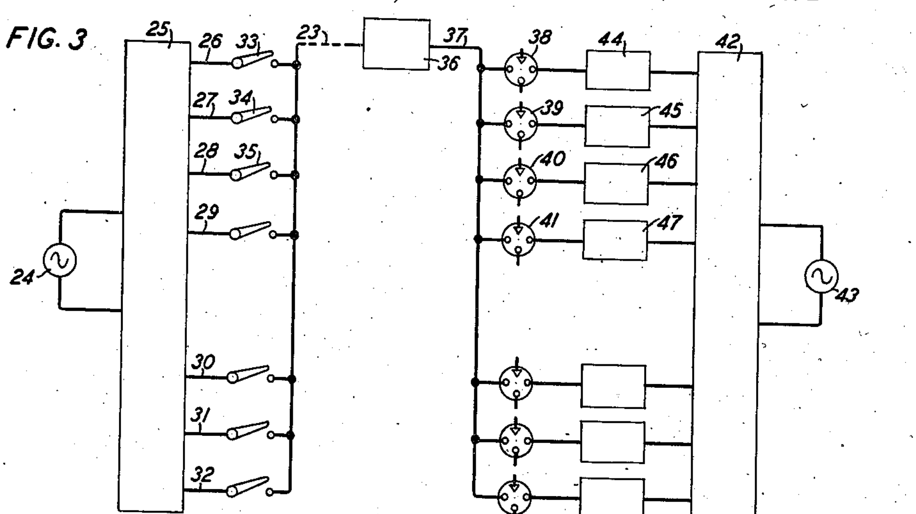


FIG. 3



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UNITED STATES PATENT OFFICE

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ELECTRIC SIGNALING

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5 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 phases in which the impulses occur to be varied with a high degree of accuracy; to obtain impulses that are uniform in amplitude and well defined in shape; and to realize other improvements in the generation and transmission of impulses.

These objects are attained by means of an impulse generator in which the voltage wave of a supply source is rectified and the resultant voltages applied to a resistance element, in which two discharge tubes serve respectively to limit the voltage of both alternations of the cycle to a definite value, and in which the impulses are produced by the change in voltage in the resistance element occurring during the successive intervals that the tubes are not conducting.

More specifically, an impulse generating system is provided comprising two circuit branches, each having a unilateral or rectifying element therein and a common branch including a resistance element in which the impulses are generated. When alternating current from the supply source is applied to the two circuit branches, the rectifying elements cause the current to flow in the same direction through the resistance element for both alternations of the cycle. Two discharge tubes are also provided, one for each branch of the circuit, each tube being connected in parallel with the common resistance and the associated rectifying element. Both of these tubes ionize when the supply voltage reaches a particular value and serve to limit the voltage applied to the common resistance. As the supply voltage wave declines below the sustaining value of the tubes, when the wave approaches zero value, both tubes cease to conduct, and current ceases to flow in the common resistance element. A biasing battery is provided in the impulse generating circuit having a voltage which opposes and neutralizes the limited voltage applied to the common resistance while the tubes are conducting. During the brief period, however, that the tubes are non-conducting, as the voltage wave is passing through zero, the voltage in the common resistance element, which has been in opposition to the biasing battery voltage, decreases and rises again. During this interval the voltage of the biasing battery predominates to produce the desired impulse.

A feature of the invention, therefore, is a generator in which an impulse occurs each time the supply wave passes through the zero value and in which the peak of each impulse produced occurs exactly at the point of time when the supply wave crosses the axis from one alternation to the next. With such a generator it is possible to fix the position of the impulse in time by controlling the frequency and phase of the supply source. By providing a plurality of these generators and supplying them with alternating current of desired phases impulses of corresponding phases are produced and may be used for signaling purposes.

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

In the drawing accompanying the specification:

Fig. 1 discloses an impulse generating system incorporating the features of this invention;

Fig. 2 is a graph depicting the formation and position of the impulses; and

Fig. 3 is a diagram of a signaling system incorporating the impulse generator.

Referring first to Fig. 1, the generating system shown therein comprises a supply source of alternating current 1 having any desired voltage and frequency. The supply source 1 is connected to the primary winding of a transformer, and the secondary windings 3 and 4 of the transformer are included respectively in two rectifying circuits 5 and 6. The rectifying circuit 5 also includes a resistance element 7, a rectifier 8, resistance element 9 and conductor 10. The rectifying circuit 6 includes, in addition to the secondary winding 4, the resistance element 11, the rectifier 12, the common resistance element 9 and the common conductor 10, which is connected to battery 16. One output terminal 13 of the impulse generator is connected to the resistance element 9. The other output terminal 15 is connected to ground. The terminals 13 and 15 may be connected to any desired impulse circuit, such as the circuit 17.

A space discharge tube 18, preferably of the gas-filled type, is connected across the rectifying circuit 5 for the purpose of limiting the current flowing through the resistance element 9 during half of each cycle of the voltage wave of the source 1. Similarly a discharge tube 19 is connected across the rectifying circuit 6 for the purpose of limiting the current flowing in the resistance element 9 during the alternate half of each cycle of the source 1.

In considering the operation of this impulse system it may be assumed that the curve 20 in Fig. 2 represents the voltage wave applied to the rectifying circuits 5 and 6 by the secondary windings 3 and 4 of the transformer, that the curve 50 represents the rectified voltage across resistor 9 as a result of voltage wave 20, that curve 51 represents the voltage of biasing battery 16, and that curve 22 represents the impulse voltage across resistor 9 which is the resultant of voltages 50 and 51. Also it may be assumed that as this wave passes through the zero value and commences to rise in the positive direction the upper terminal of winding 3 becomes positive and the lower terminal of winding 4 becomes negative in polarity. This initial voltage appearing across the winding 3 is not sufficient to discharge the tube 18 and is of the wrong polarity to cause current to flow through the rectifier 8 and resistance 9. The voltage across the other winding 4 is also insufficient in the beginning to discharge the tube 19, but the polarity of this voltage is such that current flows from the upper terminal of winding 4 over conductor 10 through resistance 9, rectifier 12 in the conducting direction, resistance 11 to the lower terminal of winding 4. As the voltage rises, the current in resistance 9 continues to increase, and the voltage across the tubes 18 and 19 rises. The value of resistance 9 is chosen sufficiently high to cause the voltage across the tube 19 to rise to the ionizing value at the desired point in the cycle of the applied voltage wave 20. When, therefore, the voltage wave 20 reaches the desired instantaneous value, represented by the ordinate 21 in Fig. 2, the tube 19 discharges. Also at this time the voltage across tube 18 will have reached the ionizing value, and hence this tube discharges. Tube 18 does not affect the current in resistance 9, however, since rectifier 8 does not permit current to flow during this half cycle. But, the tube 19, having discharged, maintains the voltage across its electrodes constant at the value 21 notwithstanding the continued increase in the applied voltage. Therefore, the voltage across the resistance element 9, and likewise the current flowing therein, remain at constant values.

The current in resistance element 9 flows in the direction indicated by the arrow, and the polarity of the resulting voltage is such that the output terminal 13 is made negative with respect to the positive pole of the biasing battery 16 by the amount of the voltage appearing across the resistance 9. The terminal 15 is connected to ground, and the conductor 10 is connected to the positive pole of biasing battery 16. The voltage of this battery may be chosen at a value substantially equal to the voltage generated in resistance 9 when either tube is conducting. Hence no voltage difference appears across the terminals 13 and 15, and no impulse is present in the impulse circuit 17.

This condition prevails while the voltage wave 20 is rising to its maximum value and until it again declines to the value represented by the ordinate 21. When the wave reaches the ordinate value 21, that is, as it approaches the zero value, the tube 19 quenches so that the current flowing in the resistance element 9 now becomes a function of the applied voltage wave. Also the tube 18 quenches as the voltage wave approaches the ordinate value 21. As the voltage wave 20 continues to decline toward the zero ordinate, the current in resistance element 9 declines correspondingly, and the voltage difference across the output terminals 13 and 15, due to battery 16, rises in value directly in proportion to the decline of the voltage across the resistance element 9. An impulse, therefore, appears in the circuit 17, which increases to its maximum value at the instant the applied voltage wave 20 reaches zero. As the applied voltage wave passes through the zero point and rises in the opposite direction current again flows through the element 9, in the direction indicated by the arrow, through the rectifier 8 and resistance element 7 to the upper terminal of the transformer winding 3. Similarly when the applied voltage wave reaches the ordinate value 21, tubes 18 and 19 discharge, and the tube 18 serves to limit and fix the voltage across the resistance element 9 until the applied wave again declines to the ordinate value 21. While the tube 18 is conducting the voltage across the resistance element 9 is limited to the same value as before mentioned, and no potential difference appears across the terminals 13 and 15. When the applied voltage wave 20 reaches the value 21 in the negative half of its cycle, the tubes 18 and 19 quench, and the voltage across the resistance 9 declines to cause the appearance of another impulse in the circuit 17.

Thus for each cycle of the applied wave two impulses of positive polarity are produced, and these impulses are accurately fixed at the point in time when the applied wave passes through the zero values. These impulses are illustrated by the curve 22 in Fig. 2 which shows the neutralizing effect of the biasing battery 16 during the major part of each alternation.

Obviously, the magnitude of the impulse may be controlled by varying the sustaining voltage of the discharge tubes 18 and 19.

If it is desired to have the generator produce negative impulses it is only necessary to reverse the polarity of biasing battery and to reverse the direction of rectifiers 8 and 12.

Fig. 3 illustrates one of the many useful applications of the impulse generating system shown in Fig. 1. Assume for example that it is desired to transmit a plurality of different signals over the single transmitting conductor 23. At the transmitting end of the line a source of alternating current 24 is provided. Also there is provided a suitable phase generator 25 whereby a plurality of different phases are derived from the original source 24. These phases, of which there may be ten for example, appear on the respective phase supply circuits 26, 27, 28, 29, 30, 31, 32. Voltages of any desired phases to represent the required signal are applied to the transmitting conductor 23 by any suitable selective means, such as the switches 33, 34, 35, etc.

At the receiving end of the system an impulse generator 36 is provided, like the generator disclosed in detail in Fig. 1. The generator 36 responds to the incoming wave of any particular phase and produces impulses in the output circuit 37, and these impulses are applied to the electrodes of a plurality of register tubes 38, 39, 40, 41, etc. At the same time impulses of each of the ten different phases are being applied to the other electrodes of the respective register tubes. These impulses are produced by a mechanism 42, similar to the mechanism 25, which derives the ten different phases from a supply source of alternating potential 43 of the same frequency as the source 24. The voltages of the ten different phases produced by the mechanism 42 are applied to ten respective impulse generators 44, 45, 46, 47, etc. These generators produce impulses like those produced by the generator of

Fig. 1, except that they are of the opposite polarity. For example, the generator **44** produces negative impulses of phase No. 1 and applies these impulses to the electrode of tube **38**, generator **45** produces negative impulses of phase No. 2 and applies them to the electrode of tube **39**, and so on for the remaining generators **46**, **47**, etc. The generator **36** however produces impulses of positive polarity and applies them over the common conductor **37** to all of the register tubes. Hence, when current of phase No. 1 is transmitted over the signal conductor **23** the positive impulses of this phase match with those applied to tube **38** and not with those applied to any of the remaining tubes. Consequently tube **38** is selectively operated to the exclusion of the other tubes to register the transmitted signal.

Register tubes suitable for use in a system of this kind are disclosed in the copending application of W. H. T. Holden, Serial No. 361,537, filed October 17, 1940. The Holden application also discloses impulse generators for generating impulses of opposite polarities.

What is claimed is:

1. The combination in an impulse system of an impulse conductor, an impedance element in circuit with said impulse conductor, two rectifying circuits including said impedance element in common, a source for producing an alternating voltage wave, means for applying said wave to said rectifying circuits, rectifiers in said circuits for causing current to flow in the same direction in said impedance element during both alternations of the cycle of said wave, discharge devices in both of said rectifying circuits which conduct and cease to conduct in response to the rise and fall of said wave, said devices when conducting serving to limit the current flowing in said impedance element, and means effective during the interval that said discharge devices are not conducting for producing an impulse in said impulse conductor.

2. The combination in an impulse system of an impulse conductor, a resistance element in circuit with said conductor, two rectifying circuits including said resistance element in common, a source for producing an alternating voltage wave, means for applying said wave to said rectifying circuits, rectifiers in said circuits for maintaining the same polarity for the voltages applied across said resistance element throughout the cycle of said voltage wave, discharge tubes in said rectifying circuits which conduct when said voltage wave rises to a definite value and cease to conduct when said wave falls to a definite value, said discharge tubes serving to limit to a definite value the voltage applied across said resistance element, and means effective during each interval that said discharge tubes are not conducting for producing an impulse in said impulse conductor.

3. The combination in an impulse system of an impulse conductor, a resistance element in circuit with said conductor, a source for producing an alternating voltage wave, two wave receiving circuits including said resistance element in common, means for applying said wave to said receiving circuits, rectifiers in said circuits for maintaining the same polarity for the voltages produced across said resistance element in response to said voltage wave, a separate discharge tube for each of said receiving circuits, said tubes serving to limit to a predetermined value the voltage across said resistance element, and a second source of voltage for neutralizing the voltage across said resistance element while said tubes are conducting and for producing an impulse in said impulse conductor in response to the voltage change across said resistance element during the period said discharge tubes are not conducting.

4. The combination in an impulse system of an impulse circuit, a resistance element in said impulse circuit, a source for producing an alternating voltage wave, two wave receiving circuits including said resistance element in common, means for applying said voltage wave to said receiving circuits, rectifiers in said receiving circuits for maintaining the same polarity for the voltages produced across said resistance element in response to said applied wave, a separate discharge tube connected to each of said receiving circuits, both of said tubes becoming conducting when said voltage wave reaches a predetermined value in either direction, said tubes serving when conducting to limit to a definite value the voltage across said resistance element, and a second source of voltage connected to said impulse circuit to oppose and neutralize the voltage across said resistance element while said tubes are conducting, said second source of voltage serving to produce an impulse in said impulse circuit in response to the change in voltage across said resistance element during the interval said tubes are not conducting.

5. The combination in an impulse system of an impulse conductor, an impedance element in circuit with said conductor, two rectifying circuits including said impedance element in common, a source for producing an alternating voltage wave, means for applying said wave to said rectifying circuits, rectifiers in said circuits for causing current to flow in the same direction in said impedance element during both alternations of the cycle of said wave, discharge devices in both of said rectifying circuits which conduct and cease to conduct in response to the rise and fall of said wave, said devices when conducting serving to limit the current flowing in said impedance element, and means effective during the interval said discharge devices are not conducting for producing in said impulse conductor an impulse having a maximum amplitude which occurs coincident with the passing of said alternating voltage wave through its zero value.

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