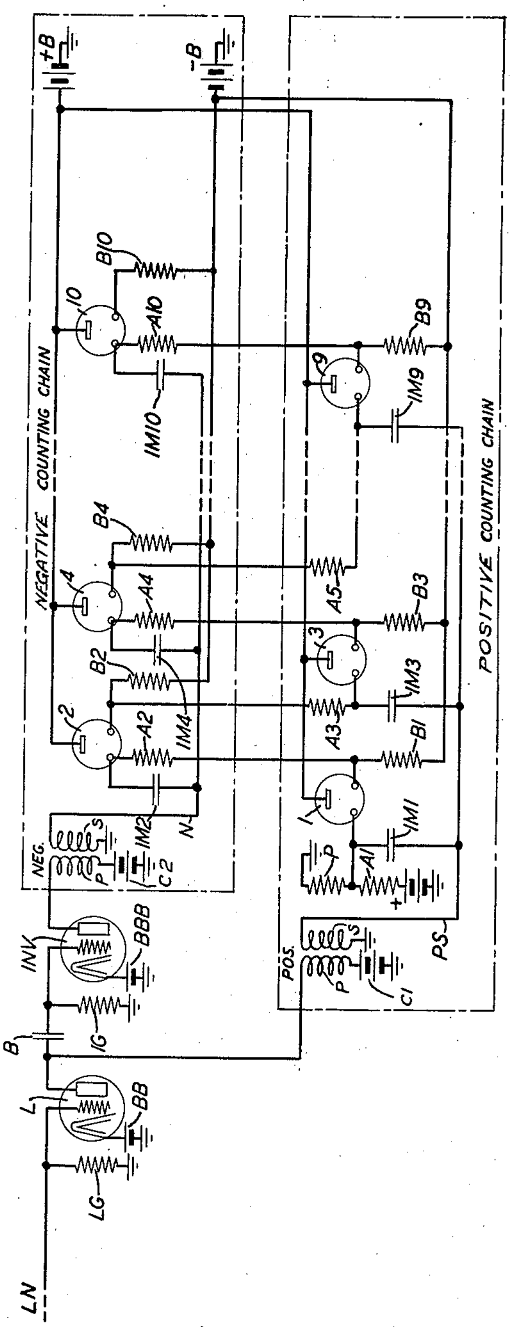
June 26, 1945. R. F. MASSONNEAU 2,379,093

SIGNALING SYSTEM

Filed Aug. 6, 1942



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Patented June 26, 1945

2,379,093

UNITED STATES PATENT OFFICE

2,379,093

SIGNALING SYSTEM

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Application August 6, 1942, Serial No. 453,842

4 Claims. (Cl. 315—323)

This invention relates to signaling systems and more particularly to a circuit adapted for response to current impulses comprising a succession of the positive and negative lobes of a sinusoidal current. In its preferred embodiment, the invention is exemplified by a circuit which includes an electronic device that responds to all impulses regardless of their polarity, an electronic device which operates to invert the negative half-cycle impulses, and two chains of gas-filled electronic devices of which one chain is used to register the positive half cycles of the wave train and the other chain is used to register the negative half cycles of the wave train. The electronic devices in both chains are so interconnected that an operated device in one chain primes a device in the other chain for subsequent operation by the succeeding impulse of opposite polarity. It is a feature of the present invention that a device in either chain may be primed immediately by an operated device in the other without danger of operating the prior device by the pulse that operated the device that does the priming, in contrast with known electronic or tube counting arrangements in which delaying means are interposed between an operated tube and the tube to be primed thereby in order to avoid the danger of operating the latter tube by the same impulse that operates the former.

The invention is illustrated in the accompanying drawing in which the grid of the vacuum tube L is connected to a line LN over which the impulses are received. The grid receives a normal negative bias through resistance LG, which has one of its two terminals connected to the grounded negative pole of battery BB, the positive terminal of said battery being connected to the cathode of the tube as a source of electron emission. The anode of tube L is connected to positive battery C1 through the primary winding (P) of transformer POS which has one terminal of its secondary winding (S) connected to ground and the other to one side of condensers IM—1, IM—3, IM—5, etc.

The anode of tube L is also extended to one side of condenser B and, therethrough, to bias resistor IG and the grid of inverter tube INV. As with the grid of the line tube L, the grid of the inverter tube INV is maintained at a normal negative bias through battery BBB the negative pole of which is grounded and connected to the lower terminal of resistor IG, while its positive pole is connected to the cathode of tube INV as a source of electron emission.

The anode of tube INV is supplied with positive potential from battery C2 via the primary winding (P) of transformer NEG. The secondary winding (S) of this transformer has one of its terminals connected to ground and the other to one side of condensers IM—2, IM—4, IM—6, etc.

The counting chain for recording the negative pulses is the upper chain shown in the drawing and is so designated. It comprises a number of gas-filled tubes 2, 4, 6, 8, and 10 of the type described in Patent No. 1,965,589, issued to T. E. Foulke on July 10, 1934.

These gas-filled tubes are of the type which are filled with a low pressure gaseous content which, for example, might be neon, argon, helium, mercury vapor or combinations of gases of this group. A tube of this character has the distinctive property that its gaseous content will become ionized and thus conducting on a certain "breakdown" potential which is determined by the electrode design, the nature of the gaseous content and its pressure, will be maintained in the condition of conductivity on a much lower potential, and may be quenched (or extinguished) by cutting off the positive battery supply applied to the anode or by momentarily reversing this battery so as to render the polarity thereof negative with respect to the polarity of the cathode battery supply. In the so-called "three-element" gas-filled tubes used in this invention by way of example, the three elements thereof are the cathode, the anode and the "control" anode. The cathode and control anode are spaced much closer together than are the cathode and the anode, the space separating the former two electrodes being generally designated as the "control gap" and the space separating the latter two electrodes being generally designated the "main gap." Tubes of this character have two steps to their operation in that a breakdown potential is first applied between the control anode and cathode and a sustaining potential is then applied between the cathode and the anode. As a consequence of the application of the breakdown potential the gas in the control gap is ionized to establish a current in the circuit which includes the control electrode and cathode. But once ionization of the control gap is effected, the difference of potential existing between the negative battery supply at the cathode and the positive battery supply at the anode will be sufficient to cause the gas in the main gap to be ionized, whereupon a current will then be established in the circuit which includes the cathode and the anode, the control anode thereafter exercising no control over the operation of the tube, thus making it possible to disconnect the firing potential therefrom and leave the conductivity of the tube exclusively under the control of the difference of potential between the cathode and anode.

The number of tubes in the positive counting chain is equal to one more than the number of positive impulses in the maximum pulse cycle. It will be assumed for the purposes of illustration that the maximum pulse cycle consists of five complete alternations of the sinusoidal current so that, since five positive half cycles would be the maximum to be registered, the positive counting chain would comprise six tubes as above indicated.

The main anodes of the tubes 2, 4, 6, 8, and 10 in the negative counting chain are all connected together and to a source of positive potential +B. The left or control electrodes of said tubes are connected to the other terminal of the individual condensers IM—2, IM—4, IM—6, etc., and to one terminal of the corresponding individual resistors A—2, A—4, A—6, etc., while the right electrode or cathode of each tube is connected to two resistors, namely, resistors B—2, B—4, B—6, etc., which are parallel and connected to a source of negative potential —B and to resistors A—3, A—5, A—7, etc., which are extended individually to the control electrodes of the tubes in the negative counting chain which are advanced one digit in the count.

The positive counting chain for registering the positive pulses is the lower chain shown in the drawing and is so designated. It comprises a number of gas-filled tubes 1, 3, 5, 7 and 9 which are similar to or identical with the tubes in the negative counting chain and are equal in number to the number of positive impulses in the maximum pulse cycle. Since it is assumed for the purposes of illustration that this cycle will consist of a maximum of five complete alternations of the sinusoidal signal current, the positive counting chain comprises the six tubes above indicated. The main anodes of the tubes in the positive counting chain are all connected to the source of positive potential +B. The left or control electrode of tube 1 is connected to the common terminal of condenser IM—1, resistor P and resistor A—1. The other terminal of resistor P is connected to the grounded or negative pole of a battery which has its positive pole connected to the other terminal of resistance A—1. Thus resistors P and A—1 form a potentiometer and their values are proportioned to cause a positive potential to be applied permanently to the control electrode of tube 1, but the value of this potential and the value of the negative potential supplied to the cathode of this tube from battery —B via resistor B—1 is insufficient to cause the tube to break down.

The left or control electrode of each of the remaining tubes in the positive counting chain is joined to the common terminal of an odd-numbered resistor A— extending to the cathode of the preceding even-numbered tube of the negative counting chain and the odd-numbered condenser IM— individual to the tube in the positive counting chain. The right electrode, or cathode, of each of the tubes in this chain is, on the other hand, connected to the common terminal of the even-numbered resistors A— extending to the control electrode of the succeeding even-numbered tubes in the negative counting chain and the odd-numbered resistor B— corresponding in designation to that of the tube in the positive counting chain to whose cathode it is connected. The lower terminal of all resistors B— are connected to the negative source of potential —B.

The operation of the circuit is as follows: assume a sinusoidal current to be present on line LN flowing to ground through resistor LG and that the first half of the cycle is the positive lobe of the current wave. The grid of the tube L, being negatively biased by battery BB and resistor LG to provide straight-line response of the current in the anode circuit of the tube L, the application of the positive half cycle to the grid of thus tube will have the effect of changing the negative bias to one less negative and thereby causing a change in the flow of current through the anode circuit, the circuit path extending from the positive pole of battery C1, primary winding (P) of transformer POS, anode of the tube L, cathode thereof to cathode battery BB. Now the control electrode of tube 1 is biased, as already mentioned, to a positive potential via the potentiometer made up of resistors P and A—1, and the cathode is negatively biased through resistor B—1 since the latter is connected to the negative source of potential —B. However, the difference in potential thus established between the control electrode and the cathode of tube 1 is not sufficient to "fire" or render the tube conducting. As a consequence no operations take place in the circuit prior to the reception of the positive half cycle of the signal current even though a less than firing potential difference exists permanently across the cathode and control anode of tube 1.

But when the first half of the positive half cycle of the current wave is applied to line LN and the current flow in the anode circuit of tube L is increased in consequence thereof, a positive current is produced in the circuit including the secondary winding (S) of transformer POS, said circuit tracing from ground through the secondary winding (S) of said transformer, conductor PS, condenser IM—1, through resistor A—1 to battery, and through resistor P to ground. This current has the effect of raising the positive potential of the control electrode of tube 1 to a value which establishes a "breakdown" difference of potential between it and the negative potential applied to its cathode, in consequence of which the tube is ionized and rendered conducting over its control gap and then over its main gap to establish a current therethrough from negative battery —B, cathode and anode electrodes of the tube to positive battery +B.

Upon tube 1 being rendered conducting through its main gap, current is drawn through resistor B—1 so that the potential of the cathode becomes more positive. This more positive potential is now applied to the left or control electrode of tube 2 through the resistor A—2, the right electrode or cathode thereof being negatively biased from negative battery —B via resistor B—2. Tube 2, however, does not break down upon the difference of potential thus established between its control electrode and cathode for the following reasons:

When the first half of the positive half cycle of the incoming signal current is applied to the grid of tube L and the anode current is increased in consequence thereof, the positive potential at the anode is reduced and, as a consequence, the potential through condenser B is reduced. This causes the grid of the inverter tube INV to become more negative. Since the grid of this tube is already negatively biased for straight-line operation by battery BBB connected to resistor IG, the more negative potential at the grid causes current in the anode circuit of the tube to be decreased, said current flowing through the primary winding (P) of transformer NEG. The direction of this current, however, is opposite to that of the current through the primary winding (P) of transformer POS, derived from the anode of tube L. And since the negative pole of battery C2 is connected to that terminal of the secondary winding (S) of transformer NEG which corresponds to the terminal of the secondary winding of transformer POS to which the negative pole of battery C1 is connected, it follows that while the anode current through the primary winding (P) of transformer POS produces rise of current in the positive direction in the circuit of the secondary winding (S) which is applied to the control electrode of tube 1 to raise the positive bias thereof, the current through the primary winding (P) of transformer NEG produces a rise of current in the negative direction in the circuit of its secondary winding which, being applied to the control electrode of tube 2 through the condenser IM—2, has the effect of reducing the value of the positive potential applied thereto from the cathode of tube 1 over resistor A—2. The difference between the negative potential applied to the cathode of this tube from battery —B through resistor B—2 and the resultant positive potential on the control electrode thereof will not be sufficient to fire said tube. Hence upon the application of the first half of positive half cycle of the signal wave to the grid of the line tube L, tube 1 only of the positive counting chain is operated.

When the direction of the crest of the positive half cycle is reached and, thereafter, the current changes in direction for the full swing down to the trough of the first negative half cycle (or second impulse) the negative bias on the grid of the line tube is increased, and it is evident that the impulses produced in the secondary winding of transformers POS and NEG in consequence thereof will be the opposites of those produced upon the application of the first half of the positive half cycle. That is, a negative impulse is produced in the secondary of transformer POS and a positive impulse is produced in the secondary of transformer NEG. Since tube 1 is already conducting, the negative impulse will have no effect upon this or any other tube in the positive counting chain except to cause the application of a negative potential to the control electrodes of tubes 3, 5, 7, etc., which cannot be fired on this account inasmuch as a negative potential is applied to their respective cathodes from battery —B. The positive impulse produced in the secondary of transformer NEG, however, now causes the positive potential resulting therefrom to be applied to the control electrode of tube 2 which, being added to the potential applied to this electrode from the cathode circuit of tube 1, will be sufficient to establish a breakdown difference of potential across its control gap and thereby cause tube 2 to be fired and produce a current flow in the circuit extending from negative battery at —B, resistor B—2, cathode and anode of tube 2 to positive battery at +B.

The current drawn through resistor B—2 has the effect of raising the potential of the cathode of tube 2 to a more positive value and this potential is now applied through resistor A—3 to the control electrode of tube 3, the positive value thereof being insufficient bias to fire the tube.

Thus the first positive half cycle of the sinusoidal current applied to the grid of tube L is registered by the operation of tube 1 in the positive chain and the first negative half cycle is registered in tube 2 in the negative chain. It is now evident that when, at the trough of the first negative half cycle, the current changes to the positive direction, the bias on the grid of tube L is effected in the same way as it was during the build-up of the current in the first half of the first positive half cycle at substantially the same point as in said first positive half cycle so that a positive impulse is produced in the secondary winding (S) of transformer POS and a negative impulse is produced in the secondary winding (S) of transformer NEG, the former impulse being effective to fire tube 3 which then causes a positive potential to be applied to the control electrode of tube 4 via resistor A—4 and the latter impulse being effective to apply a negative potential to this control electrode to reduce thereby the net positive bias on the grid and keep the tube from firing. In this way, the tubes in both chains are fired in succession as long as an incoming wave is present on the line LN or until the end of the tube chain is reached, the tubes firing alternately on the positive and negative half cycles.

Since the pulse cycle has been assumed to consist of a maximum of five sinusoidal alternations which provide five positive half cycles and five negative half cycles, it is evident from the above description of the operation of the circuit that the tenth impulse or fifth negative half cycle (assuming the signal wave to begin with a positive half cycle) will cause the operation of tube 10. When the current in the line reaches zero value, the bias on the grid of tube L will become normal. There is, however, a quantity of energy stored in the magnetic field of each of the transformers POS and NEG so that if the last pulse is negative, a negative pulse will be produced in transformer POS and a positive pulse will be produced in transformer NEG. Conversely, if the last pulse is positive, a positive pulse will be produced in transformer POS and a negative pulse will be produced in transformer NEG. The intensity of these pulses, however, is not sufficient to raise the positive potential of the control anode in the succeeding tube of either chain in the event that the signal wave train consists of less than the maximum of five complete alternations. By connecting a suitable signaling device (not shown) to the cathode of each of the tubes of the positive counting chain, and by connecting a similar signaling device (not shown) to the cathode of each of the tubes of the negative counting chain, the number of impulses received over the line may be counted, in each pulse cycle, by the number of such devices which have been operated.

The operated tubes in each of the counting devices may be restored to their original unoperated condition by opening the anode battery +B or by reversing the polarity thereof in any suitable manner well known to the signaling art, whereupon tubes 2—10 and 1—9 will restore and again become receptive to the positive and negative half cycles, respectively, of the next incoming signal wave.

What is claimed is:

1. A circuit for registering a train of positive and negative half cycles of an alternating current, comprising electronic means responsive to each half cycle of current and gas-filled electronic devices responsive thereto for registering each of said half cycles.

2. A circuit for registering a train of positive and negative half cycles of an alternating current, comprising means responsive to each half cycle of the current, means responsive to the negative half cycle of the current, and a plurality of gas-filled electronic devices responsive to both of said means in alternation to register each of the positive and negative half cycles in the train.

3. A circuit for registering a train of positive and negative half cycles of an alternating current, comprising a first electronic device responsive to each half cycle of the train, a second electronic device responsive to said first electronic device when operating in response to the negative half cycles of the train, a plurality of gas-filled electronic devices, and means interconnecting said gas-filled electronic devices and said first and second electronic devices whereby some of said gas-filled devices are rendered conductive to register the positive half cycles of current in response to the operation of said first electronic device and whereby others of said gas-filled devices are rendered conductive to register the negative half cycles in response to the operation of said second electronic device.

4. A circuit for registering a train of positive and negative half cycles of an alternating current comprising a first electronic device responsive to each half cycle of the train, a second electronic device responsive to said first electronic device when operating in response to the negative half cycles of the train, a group of gaseous conductor tubes each having a control electrode, a cathode and an anode, a source of negative potential connected to said cathodes, a source of positive potential connected to said anodes, an impedance network connecting the cathode of one tube with the control electrode of the next tube, means responsive to said first electronic device when operating in response to a positive half cycle of the train for rendering conductive the first tube in said group of gaseous conductor tubes whereby a positive potential derived from the cathode-anode circuit thereof is applied to the control electrode of the next gaseous conductor tube through the interconnecting network connecting the cathode of the first tube and the control electrode of the second tube, and means responsive to said second electronic device when responding to positive half cycles of the train for producing a negative potential for application to the control electrode of said next tube whereby the difference in potential between the net positive potential thereat and the negative potential connected to the cathode is insufficient to cause the operation of said next tube, said means responsive to said electronic device when responding to negative half cycles of the train being further responsive to produce a positive potential for application to the control electrode of said next tube whereby said positive potential is added to the positive potential derived from the cathode-anode circuit of the first tube to produce a difference of potential between the net positive potential at the control electrode of said tube and the negative potential at the cathode that will cause said next tube to be rendered conducting, and whereby a positive potential derived from the current through the cathode-anode of said second tube is applied to the control electrode of the third tube through the associated interconnecting impedance network.

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