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SIGNALING SYSTEM

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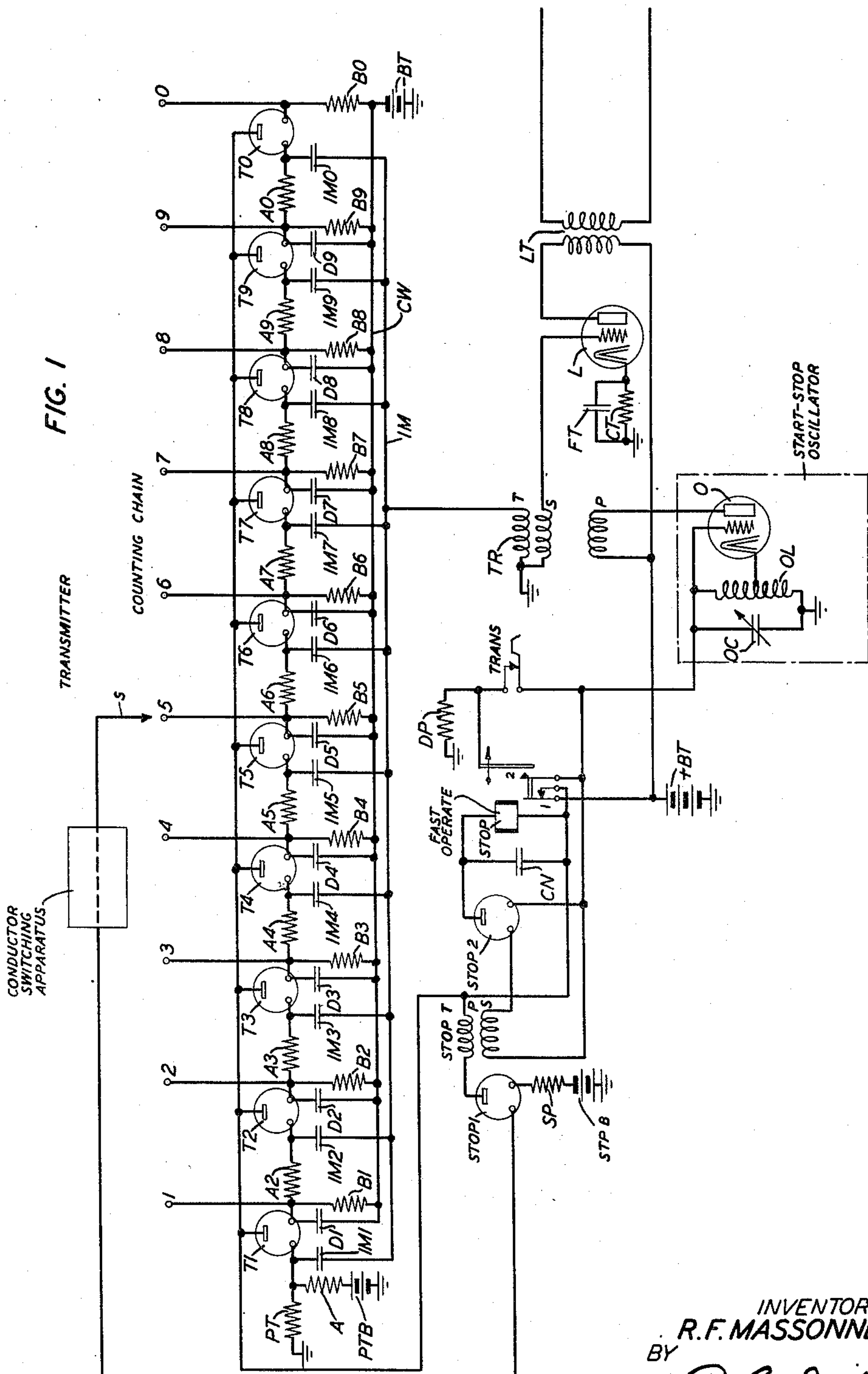

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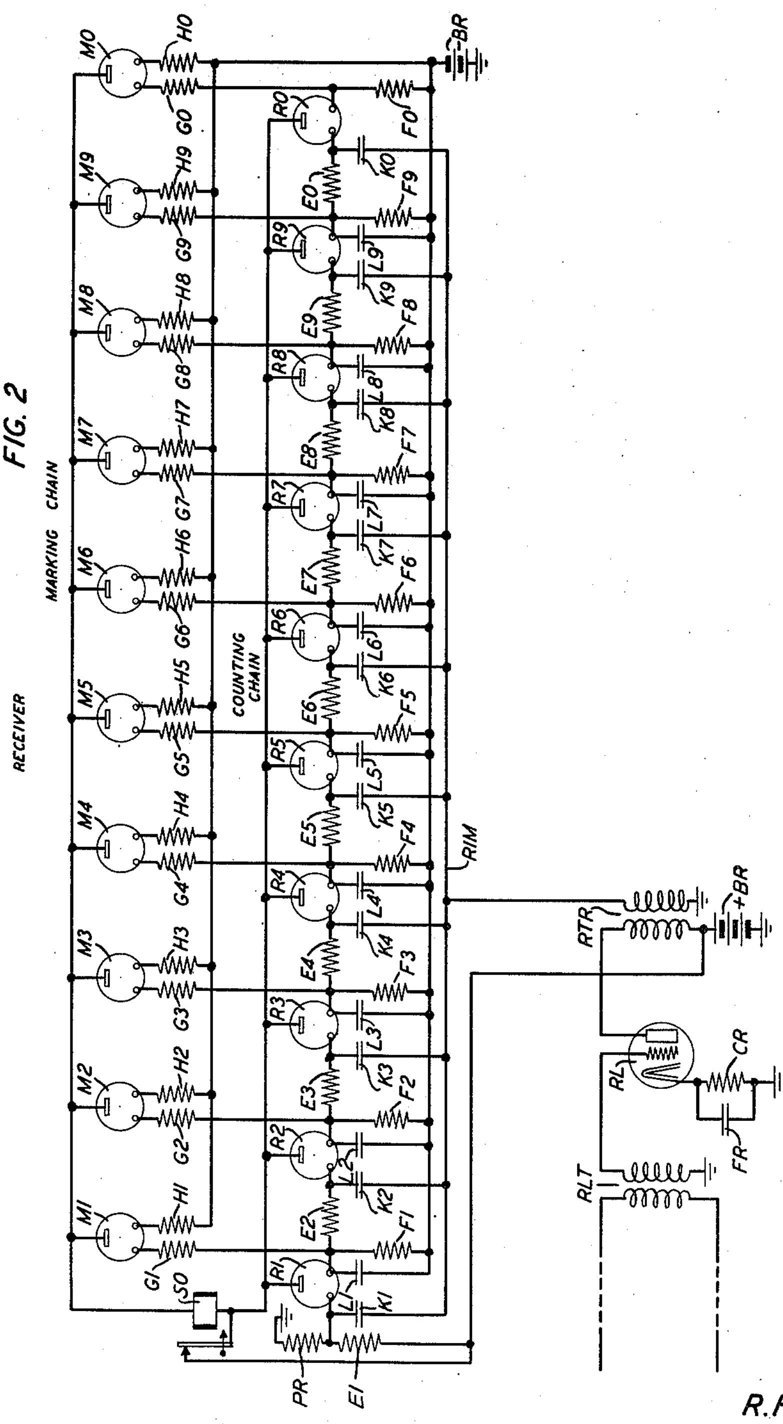
FIG. 2



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SIGNALING SYSTEM

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4 Claims. (Cl. 177—353)

This invention relates to signaling systems and more particularly to a transmitter and receiver therefor which are connected to each end of a transmission medium for counting the number of half cycles, whole cycles or a multiple of whole cycles of a substantially sinusoidal current produced by the transmitter. In its specific application, the invention makes use of two electronic cycle counters one of which, located at the transmitter, is adapted to count such cycles and stop when a predetermined number thereof have been produced, and the other of which, located at the receiver, is adapted to receive the cycles, produce an indication when a predetermined number of cycles has been received, and then reset the receiver to respond to the next series of a predetermined number of cycles. Because the transmitted current wave is sinusoidal in character, speeds of transmission may be obtained over ordinary telephone lines with or without repeaters which are not possible, for example, with the squared wave dial type of pulses or ordinary direct current pulses.

The invention consists essentially of a transmitter which generates a counted number of positive and negative half cycles of a continuous alternating current, and a receiver which counts the half cycles and indicates how many have been received, both transmitter and receiver being also capable of adaptation for operation to count whole cycles or multiples of whole cycles depending upon which of the three it is desired to use.

The invention is illustrated in the accompanying drawings, in which:

Fig. 1 shows the transmitter; and

Fig. 2 shows the receiver, said figures to be placed end to end from left to right in the order named to disclose the invention completely.

The transmitter, shown in Fig. 1, comprises a start-stop oscillator which is normally damped by the resistance of resistor DP connected to the negative grounded pole of the battery +BT, the damping path being over the normally closed contacts of key TRANS. This oscillator, which is only conventionally indicated, is disclosed in the joint copending application of W. T. Rea and J. R. Wilkerson, Serial No. 432,823 filed on February 28, 1942. Upon the removal of the damping battery from the grid of its oscillator tube O by the operation of key TRANS, the oscillator operates to produce an alternating current the initial transient of which so very nearly approaches the first positive half cycle of the sustained alternating current wave produced thereafter that, in the application of the oscillator to the present invention, the transient is utilized as one of the positive half cycles or part of the whole cycle, to be transmitted and counted. The structure of this "start-stop" oscillator and the manner in which it operates to reshape the transient to resemble substantially the initial part of a component cycle of the current wave do not constitute a part of this invention, reference being made to the above-mentioned copending application for a complete disclosure of its component parts and a description of its operation.

The anode of the oscillator tube O is connected to one terminal of the primary winding P of the three-winding transformer TR, the other terminal of said primary winding being connected to positive battery +BT. The secondary winding S of transformer TR is connected to the grid of the line tube L and to negative battery while the tertiary winding T of said transformer has one of its terminals connected to negative battery and the other connected in parallel by way of conductor IM to ten condensers IM1 . . . IM0.

The part of the transmitter which is used to count the number of half cycles, whole cycles and multiples of whole cycles of the current wave produced by the start-stop oscillator comprises ten three-element gas-filled electronic tubes T1 . . . T0. These gas-filled tubes are of the type which are filled with a low pressure gaseous content which, for purposes of illustration, might be neon, argon, helium, mercury vapor or combinations of gases of this group. A tube of this character, shown and described in Patent No. 1,965,589, granted to T. E. Foulke on July 10, 1934, has the characteristic that its gaseous content will become ionized and conducting on a certain "breakdown" potential applied between its cathode and anode the value of which is determined by the electrode design, the nature of the gaseous content and its pressure. The tube, once ignited, will be maintained in the condition of conductivity on a much lower potential than the breakdown potential, and may be quenched entirely either by cutting off the positive battery supply connected to the anode or by momentarily reversing the polarity of this battery so as to render it negative with respect to the potential applied to the cathode. In the so-called "three-element" gas-filled tube, which is used in the present invention by way of example, the tube is provided with three electrodes, namely, the cathode, the anode and a "control" anode. The cathode and the control anode are spaced much closer together than are the cathode and the anode, the space separating the former two being generally designated as the "control" gap and that between the latter two as the "main" gap. Tubes of this character have two steps to their operation in that the breakdown potential is applied between the control anode and the cathode to produce ionization of the gas in the control gap and thereby establish a current in the circuit of the ionized gap, which includes the control electrode and cathode and the external circuit therebetween. Once the control gap is ionized and rendered conducting, the lower difference of potential applied between the cathode and the anode will be sufficient to cause the main gap to be ionized also, whereupon a current will be established in the circuit which includes the cathode and anode and the external circuit therebetween. The control anode thereafter exercises no control over the subsequent conductivity of the tube and the firing potential originally applied thereto may then be disconnected therefrom.

The tubes T1 . . . T0 of the transmitter counting chain have all their anodes multiplied together and connected to the positive battery supply +BT through the No. 1 contacts of relay STOP. Each of the cathodes, on the other hand, is connected to the common terminal of a network of two resistors A— and B— and a condenser D—, the other terminal of resistor A— being extended to the control anode of the succeeding tube in the chain while the other terminals of each of the condensers D and of each of the resistors B— are multipled to conductor CW and thence extended to the source of negative potential —BT. Thus, considering tubes T1 and T2, for example, the cathode (the right electrode) of tube T1 is connected to the common terminal of condenser D1 and resistors A2 and B1, the latter resistor, with condenser D1 bridged around it, being connected to the common wire CW and to the source of negative potential —BT, while resistor A2 is connected to the control anode (left electrode) of tube T2. Corresponding and identical impedance networks interconnect the cathodes of tubes T2, T4, T6, T8 and T0 with the control anodes of tubes T3, T5, T7 and T9.

The common terminal of each of the impedance networks connected to the cathode is further extended to a terminal 1 . . . 0, all of which for purposes of counting control, may be those of a switch or a relay network to which conductor S may be automatically connected depending upon the number of half cycles, whole cycles or multiples of whole cycles which is to be produced by the start-stop oscillator for transmission to the receiver and, therefore, to be counted by the transmitter for controlling the starting and stopping of the oscillator as described hereinafter. Inasmuch as the selective connection of conductor S to any one of the terminals 1 . . . 0 may be accomplished by countless well-known means depending upon the use to which the transmitter is to be put, the facilities for such connections are merely indicated.

The control anode of each tube except tube T1 in the counting chain of the transmitter is not only connected to the interposing resistor A— as above described, but also to one terminal of a condenser IM— which has its other terminal connected to the common wire IM to which is connected the corresponding terminals of all other condensers IM— from the control anodes of the several tubes. Conductor IM is extended to the ungrounded terminal of the tertiary winding T of transformer TR and to one terminal of the condenser IM1 which has its other terminal connected to the control anode of tube T1.

The control anode of tube T1 is further connected to the common terminal of the potentiometer made of resistors PT and A, the former having its other terminal connected to the grounded negative pole of battery PTB and the latter having its other terminal connected to the positive pole of said battery. The ohmic value of resistors PT and A are so proportioned that a positive biasing potential is constantly applied to the control anode of tube T1, and the value of this potential is such that, with negative potential constantly applied to the cathode of the tube from battery —BT via conductor CW and resistor B1, the difference between the two potentials is less than that required to ionize the control gap of the tube and thus maintain it in the unconducting condition. In passing, it should be noted that the negative battery —BT is also applied to the control anode of each of the other tubes through resistor A— interposed between the cathode of the preceding tube and the cathode of the succeeding one. However, since this battery is also applied to the cathode of each of the tubes through their respective resistors B—, no difference of potential is available between their respective control anodes and cathodes to activate them.

The remainder of the electronic equipment of the transmitter comprises gas-filled tubes STOP1 and STOP2. The control anode of the former tube is connected to conductor S through the conductor switching apparatus, its cathode is connected to negative battery STPB through resistor SP and its anode is connected to a terminal of the primary winding P of transformer STOPT the other terminal of said primary winding being connected to battery +BT through the No. 1 contacts of relay STOP which is both slow release and fast operate. The control anode of tube STOP2 is connected to a terminal of the secondary winding S of transformer STOPT which has its other terminal connected to the cathode of tube STOP2, to the grid of the oscillator tube O, to the stationary spring of the No. 2 contacts of relay STOP and to the moving spring of key TRANS. The anode of this tube is connected to the other terminal of relay STOP, the winding of said relay being bridged by condenser CN which, as will be described hereafter, merely functions to by-pass alternating currents that might interfere with the operation of the relay.

The receiver, shown in Fig. 2, is connected to the transmitter over a suitable transmission medium which, on the transmitter side, is coupled thereto by transformer LT and, on the receiver side, by transformer RLT. The receiver comprises an impulse receiving amplifying tube RL having its grid connected to the output winding of transformer RLT and its anode to positive battery +BR through the input winding of transformer RTR, a gas-filled tube counting chain R1 . . . R0 substantially similar to the counting chain of the transmitter and a gas-filled tube marking chain M1 . . . M0. In contrast with the counting chain of the transmitter in which the common terminal of the impedance network connected to the cathode of each of the tubes T1 . . . T0 is extended to the terminal of a switch for selection control purposes, the corresponding common terminal of the impedance connected to the cathode of each of the tube R1 . . . R0 of the counting chain of the receiver is extended, through a resistor G—, to the control anode of a marking tube M—, there being one such tube M— for each of the counting tubes R—. The cathodes of all marking tubes M1 . . . M0 are supplied with negative potential from battery source —BR through an appropriate resistor H— for each cathode, while the anodes thereof are multipled and connected to the winding of relay S0 which, through its normal contacts and winding, furnishes positive potential from battery +BR to the anodes of all the marking tubes M1 . . . M0 while, through its contacts alone, it furnishes positive potential to the anodes of all the counting tubes R1 . . . R0. As will be made evident hereinafter, the function of the marking tube is to record the reception of a pulse which corresponds in number to that of the counting and marking tubes. While the signaling system disclosed and described herein by way of example is arranged for repetitive operation in that a predetermined number of whole cycles is produced by the transmitter for response by the receiver, the latter registering the reception of the succession of pulses by the operation of correspondingly numbered marking tubes, it is obvious that the group of marking tubes shown in the drawing may be typically representative of a digit register of which as many may be provided as would be necessary to register the digits of a number, a steering circuit (not shown) being provided under such circumstances which, in response to the operation of relay S0 after receiving a group of pulses indicative of a digit as hereinafter set forth, would cause the outer terminal of each of the resistors G— to be disconnected from the control anodes of the marking tubes of one register and connected to the control anodes of the corresponding tubes M— of the next register wherein the number of full cycles corresponding to the succeeding digit would be recorded. Steering circuits of the kind indicated are old in the switching art, and the manner in which a suitable one of them can be adapted with the receiver of this invention when expanded to include a plurality of groups of marking tubes as digit registers, is so obvious to anyone skilled in the art that no attempt has been made to include such a steering register as part of the disclosure. The subject is mentioned because the invention is arranged by way of example for the repetitive transmission and reception of one group of full cycles on one marking chain which functions, so to speak, as a single digit register. That is, after the operation of key TRANS to a locking position, the transmitter sends repeated trains of alternating current cycles, the number of cycles in the train being determined by the counting tube T— to which conductor S is connected. This, however, is not to be understood as limiting the invention to the means by which, for the sake of simplicity, its operation is described as hereinafter set forth.

The operation of the signal system is as follows: Referring to Fig. 1, counting tubes T1 . . . T0 are assumed to be extinguished and key TRANS is assumed to be unoperated. That is, with the two contacts of key TRANS closed, the start-stop oscillator is damped by the negative bias applied to the grid of tube O over resistor DP and the consequent steady current then flows in the circuit, which circuit may be traced from ground, lower portion of the winding of oscillator coil OL, cathode-anode of tube O, primary winding P of transformer TR to positive battery +BT. The potential available at the common terminal of the upper and lower portions of coil OL is applied to give a negative charge to condenser OC the capacity of which is adjusted to produce resonance between the coil and the condenser so that, when the bias is removed from the grid of tube O, the energy stored in the coil OL and the condenser OC will oscillate to produce the desired alternating current. Now assume that conductor S is connected to one of the ten terminals 1 . . . 0, say, terminal 5. When, thereafter, key TRANS is operated, biasing potential is removed from the grid of tube O and the charge accumulated upon condenser OC initiates the operation of the oscillator whereby, according to the above-mentioned copending application of Rea and Wilkerson, a continuous alternating current wave is produced having a first positive wave and, beginning from the 0 point of operation, is practically sinusoidal in character and substantially equal to the maximum intensity of succeeding half waves. This alternating current is produced through a circuit which includes the primary winding P of transformer TR, a corresponding current being induced in the secondary and tertiary windings S and T, respectively, of said transformer. The potential due to the current wave in the secondary winding S, being applied to the grid of the line tube L, the current through the anode circuit of said tube is modulated to produce a similar though amplified wave through the input circuit of transformer LT, causing thereby the induction, over the transmission medium, of a corresponding wave or impulse in the input circuit of transformer RLT which, in turn, causes a change in the potential applied to the grid of receiving tube RL from the negative value derived through the grounded output winding of transformer RLT to a more positive value induced thereupon by the transmitted positive half-wave.

The wave produced in the tertiary winding T of transformer TR is applied to the control anode of tube T1 via condenser IM1. The control anode of this tube, it will be recalled, is already positively, through insufficiently, biased by the potentiometer PT—A to cause the breakdown of the tube. But when the positive potential produced by the wave is superimposed upon the positive potential supplied to this control anode by the potentiometer, the resultant positive potential thereon is of a value such that the difference between it and the negative potential applied to the cathode from battery —BT is at least equal to the breakdown potential needed to ionize the control gap of the tube, in consequence of which the tube is rendered conducting through said gap and, immediately thereafter, rendered conducting through the main gap. When the impulse terminates, the potential at the control anode is reduced to the potential supplied through the potentiometer, but the tube itself will remain conducting through its main gap over a circuit extending from negative battery —BT, conductor CW, resistor B1, cathode-anode path within the tube, No. 1 contacts of relay STOP to positive battery +BT.

In describing the above action relative to the firing of tube T1 upon the first positive half-cycle, no account has been taken of condenser D1 which is bridged across resistor B1. This condenser, however, has the effect of retarding the rise of positive potential at the cathode of the tube as a result of the current drawn through resistor B1. When the control gap of the tube is ionized, a relatively small quantity of current passes through the control anode-cathode circuit and condenser D1 begins to charge. However, since the main gap is ionized almost immediately after the control gap, condenser D1 will be in a partially charged state at the time current begins to pass through the main anode-cathode circuit so that, at this time, the current path for the main gap circuit is still through the condenser with little, if any, current flowing through resistor B1. Hence during the time that condenser D1 is being charged, the positive potential at the cathode terminal of the tube builds up very slowly. Since resistor A2 interconnects the cathode of tube T1 and the control anode of tube T2, the time when the maximum positive potential available at the cathode of tube T1 is applied to the full charging of condenser D1 may be controlled by the capacity of said condenser which, for this invention, may be and is computed to be such that the full positive potential ultimately built up at the cathode of tube T1 is not applied to the control anode of tube T2 during the first positive impulse. All other condensers D2 . . . D9 are, of course, designed to have the same capacity as condenser D1.

The application of the above positive potential to the control anode of tube T2 will not, however, effect a breakdown of this tube. For although negative potential from battery —BT is applied to the cathode of tube T2 via resistor B2, yet the difference of potential between the potential available at the control anode and the potential applied to the cathode is not equal to the breakdown potential. This difference will need the additional positive potential produced by the next positive impulse to raise it to the required breakdown value.

The negative half cycle produced in the tertiary winding T of transformer TR and applied to the control electrode of tube T2 through condensor IM2 will have no effect on tube T2 inasmuch as its only consequence will be to reduce, for the duration of the half cycle, the net available positive potential on the control anode thereof. Since the potential thereat, before the negative half cycle, is insufficient to produce the breakdown of the tube, lowering this potential will not, of course, alter the unoperated condition thereof.

The succeeding positive or third half cycle will produce the same effect as the first positive half cycle. The positive potential produced by the third half cycle or pulse will be added to the positive potential already applied to the control anode of tube T2 consequent to the firing of tube T1, and the total positive potential thereon is now sufficient to establish the necessary difference of potential required to break down the control gap of tube T2 and, thereafter, the main gap thereof. In the same way that a priming positive potential was applied to the control anode of tube T2 as a result of the firing of tube T1, the operation of tube T2 will cause the application of slightly less than breakdown potential to the control anode of tube T3 so that the next positive impulse applied to the control anode of this tube through condenser IM3, will cause the breakdown of the tube. In this way, the counting tubes T1—T0 are fired in accordance with the number of full cycles produced by the start-stop oscillator until the tube is reached which has its cathode connected to conductor S which, in the drawing, is shown connected to the cathode of tube T5 indicating that five full alternations of the signal current are to be produced and transmitted.

When, on the fifth current alternation, tube T5 is operated, the potential at the cathode thereof (due to the current drawn through resistor B5) becomes more positive, and this potential is applied through conductor S and the switching apparatus to the control anode of tube STOP1. Since a negative potential is applied to the cathode of this tube from negative battery STPB over resistor SP, a breakdown potential difference is established between the two electrodes which will cause the tube to become ionized, first through its control gap and then through its main gap, the latter breakdown being caused by the positive potential applied to its anode over the primary winding P of transformer STOPT, No. 1 contacts of relay STOP, to positive battery +BT. When tube STOP1 becomes conductive, however, the rise in current through the primary winding P of transformer STOPT produces a breakdown potential across the terminals of the secondary winding S which is applied to the cathode and control anode of tube STOP2, causing the breakdown of the latter tube through the control gap thereof, the ionization immediately spreading to the main gap and establishing therethrough a circuit for relay STOP which extends from positive battery +BT, No. 1 contacts of relay STOP, winding of said relay, anode-cathode path of the tube STOP2, winding of coil OL to ground, causing the operation of said relay. This relay has a slow-release characteristic in order to prevent any hesitation of operation due to the lowering of the negative potential at the cathode of tube STOP2 when coil OL is passing through a negative half cycle. The relay is also adjusted so that its No. 2 contacts close before its No. 1 contacts open, and is further provided with a fast-operate characteristic. The reason for this latter provision is due to the fact that when the No. 2 contacts of the relay close, negative battery through resistor DP is applied to the grid of oscillator tube O which is thereby dampened very quickly to prevent the production of any further cycles of the current wave beyond the one which operated tube T5 connected to conductor S.

When the No. 1 contacts of relay STOP open, positive battery +BT is disconnected from the anodes of the counting tubes T1 . . . T0 to cause those which have been rendered conductive to be quenched and restored to normal. The circuit of relay STOP is also opened and positive battery +BT is disconnected from tubes STOP1 and STOP2, causing the relay to release and the tubes to quench. Relay STOP, having slow-release characteristics, releases after an interval, said interval being sufficient to cause the switching apparatus (if provided) to function and connect conductor S to the cathode of whichever counting tube marks the last impulse of the group of pulses next to be counted, after which, upon the release of relay STOP, the circuit is reestablished to count the next train of impulses.

Referring, now, to Fig. 2, it has been shown that the first positive impulse produced by the start-stop oscillator and transmitted over the transmission medium to the receiver effected the operation of tube RL therein and the production on that account of a positive impulse in the output winding of transformer RTR. Since the control anode of the first counting tube R1 is held by the potentiometer PR—E1 to a positive potential which is slightly less than that required to break down the tube, the additional positive potential produced by the impulse and applied to said control anode via conductor RIM and condenser K1, raises the resultant potential to the breakdown value in consequence of which tube R1 is fired and rendered conductive. After a delay controlled by the value of the capacity of condenser L1 the potential at the cathode of this tube is raised to a more positive value. This positive potential is now applied to the control anode of the second counting tube R2 via resistor E2 and, also, to the control anode of marking tube M1 through resistor G1. The cathode of this marking tube, as well as the cathodes of all other tubes M—, is negatively biased over a resistor H— from negative battery source —BR. The positive potential applied to the control anode of tube M1 via resistor G1 and the negative potential applied to its cathode via resistor H1 establishes a breakdown difference of potential which causes said tube to break down and become conducting, the conductivity being maintained, after the impulse voltage is dissipated, over the cathode-anode path to positive battery +BR via the winding of relay SO and the contacts thereof. Tube M1, by its operation, registers the reception of the impulse.

As with the counting chain of the transmitter, the negative half cycle of the pulse will produce no effect on the counting chain of the receiver since the only result of the application of such a pulse is to cause negative potential to be applied to the control anode of tube R2 via condenser K2.

Succeeding positive cycles of the incoming wave will cause succeeding tubes R2 . . . R0 of the counting chain and corresponding tubes

M1 . . . M0

of the marking chain to operate in the manner above described. After an interval which is longer than that necessary to send ten impulses but shorter than the releasing time of relay STOP, relay SO operates through the circuit completed via the main gaps of tubes M1 . . . M0 which have been rendered conductive. The last tube of the marking chain fired indicates the digit which has been transmitted. It is clear, however, that, by inserting a relay in the main gaps of each tube of the marking chain or by other means, the digit transmitted may, if desired, be rendered for other uses, and by means of a steering circuit similar to the one alluded to in the earlier part of this specification for the counting chain of the transmitter, the counting tubes of the receiver may be connected to successive groups of marking tubes to record the reception of a corresponding succession of digits.

When relay SO operates, positive battery +BR is removed from the main gaps of both the counting tubes and marking tubes. Upon the release of relay SO subsequent to the quenching of the operated marking tubes, the circuit is restored to normal in preparation for receiving the next train of pulses.

What is claimed is:

1. An alternating current signaling system comprising in combination an oscillator adapted to produce a continuous train of sinusoidal current cycles beginning from the steady state and in which the first cycle is substantially identical with succeeding cycles, means responsive to the operation of said oscillator for counting a variable number of said cycles within and including a maximum number thereof beginning with the first cycle, said means including other means for stopping the operation of said oscillator when said number of cycles have been counted, a registering circuit operative in response to each cycle for the registration thereof, and means effective subsequent to the time required by said oscillator to produce said maximum number of cycles for restoring said registering circuit to normal.

2. An alternating current signaling system comprising in combination an oscillator adapted to produce a continuous train of sinusoidal current cycles beginning from the steady state and in which the first cycle is substantially identical with succeeding cycles, a first chain of gas-filled tubes, a second chain of gas-filled tubes, means for initiating the operation of said oscillator, means responsive to the positive half of each cycle beginning with the positive half of the first cycle for operating a tube in each of said chains, means responsive to the operation of a predetermined number of tubes beginning with the first tube in one of said chains for stopping the operation of said oscillator and restoring the tubes of said chain to their unoperated condition, and means responsive to a predetermined interval subsequent to the restoration of said tubes in said one chain for restoring the operated tubes in the other of said chains to their unoperated condition.

3. An alternating current signaling system comprising in combination means for producing a predetermined number of cycles of a substantially sinusoidal current wave, means for controlling said first-mentioned means to produce less than said predetermined number of cycles, a register circuit responsive to each cycle in said wave, and means effective subsequent to the time required for producing said predetermined number of cycles for restoring said register circuit to normal when the number of cycles produced is less than said predetermined number.

4. An alternating current signaling system comprising in combination an oscillator adapted to produce a continuous train of sinusoidal current cycles from the steady state with the first cycle substantially identical with succeeding cycles, a transmission medium, a first gas-filled tube counting chain associated with said transmission medium at one end thereof, a second gas-filled tube counting chain associated with said transmission medium at the other end thereof, means for connecting the output of said oscillator to one end of said transmission medium and to said first gas-filled tube counting chain, means for initiating the operation of said oscillator, means responsive to the positive half of each cycle for producing a first impulse for operating a tube in said first gas-filled tube counting chain and a second concurrent impulse for operating a tube in said second gas-filled tube counting chain, means responsive to the operation of a predetermined number of tubes in said first counting chain for stopping the operation of said oscillator and for restoring the operated tubes of said chain to their unoperated condition, and means responsive a predetermined interval subsequent to the restoration of said tubes for restoring the operated tubes in said second counting chain.

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