Nov. 16, 1948. W. T. REA ET AL 2,454,089

REGENERATIVE REPEATER

Filed Oct. 6, 1942 2 Sheets-Sheet 1

FIG. 1

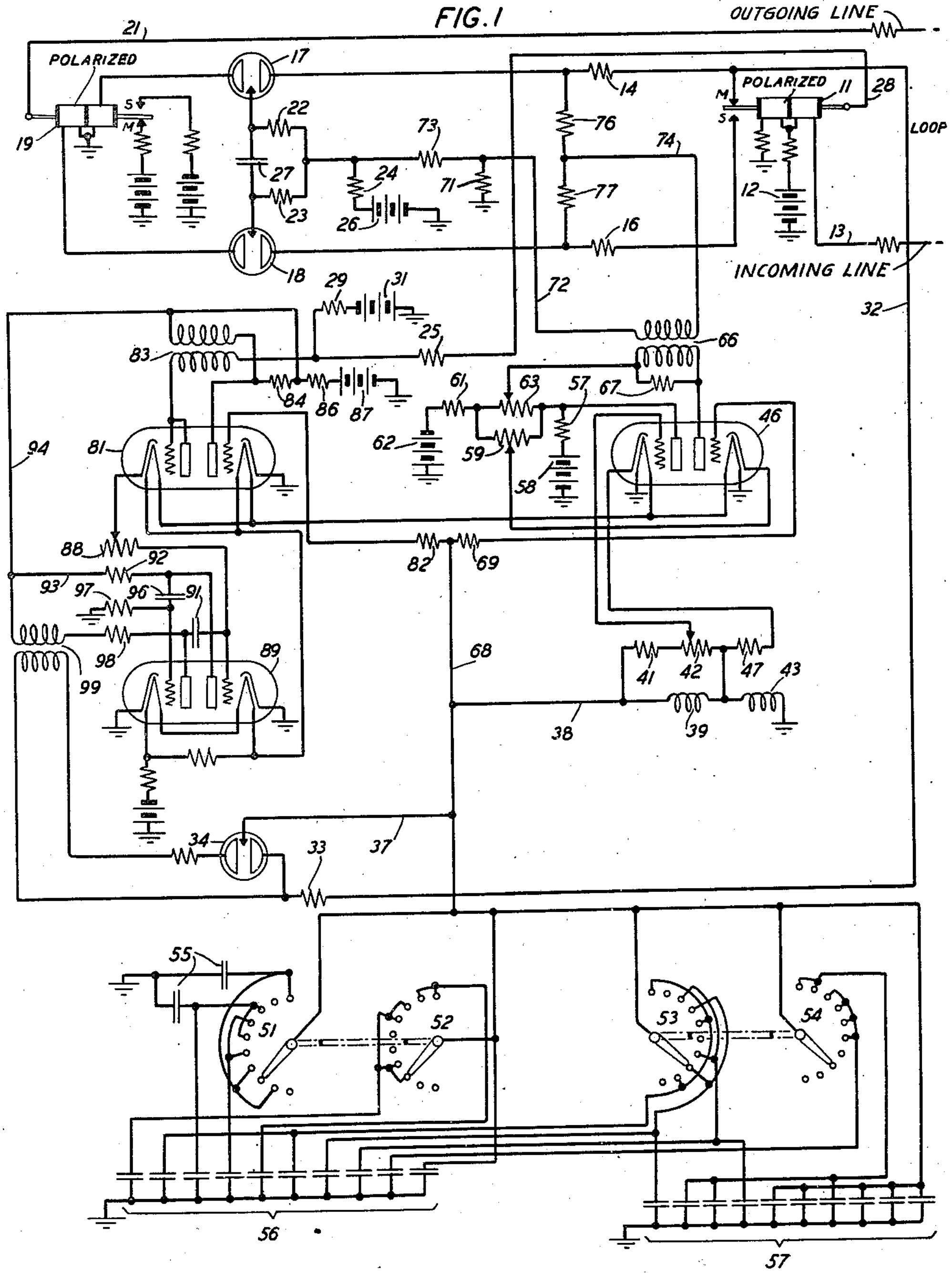

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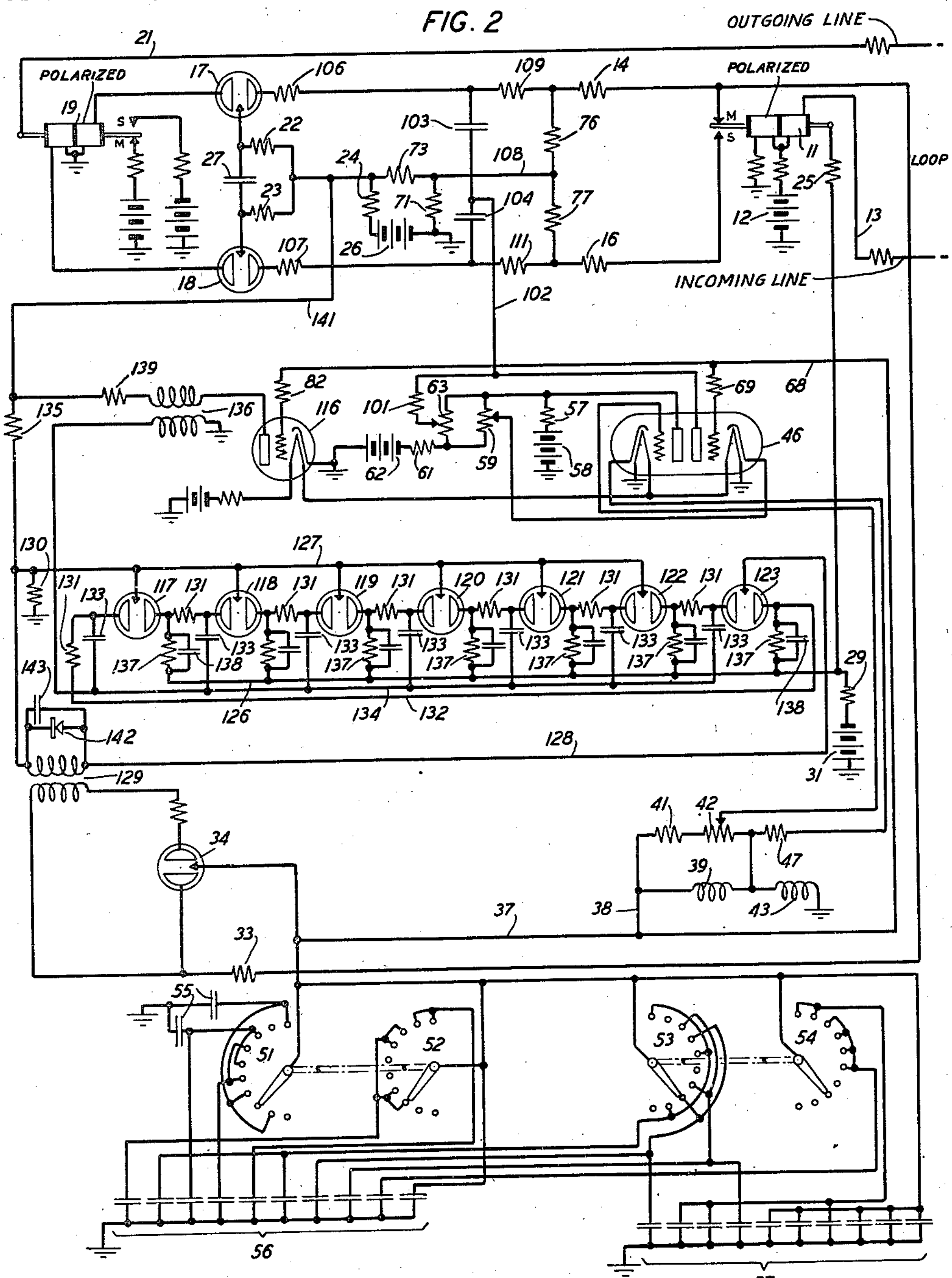
FIG. 2



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REGENERATIVE REPEATER

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Application October 6, 1942, Serial No. 460,948

26 Claims. (Cl. 178—70)

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This invention relates to telegraph apparatus and systems and particularly to regenerative telegraph signal repeaters.

An object of the invention is to time the retransmission of telegraph impulses by electronic discharge tube means thus dispensing with mechanical distributors.

Another object of the invention is to time the interval allotted to the reception and transmission of a permutation code signal combination by a single electron discharge tube controlled by an impulse accumulating circuit.

Another object of the invention is to time the interval allotted to the reception and transmission of a permutation code signal combination by a counting chain of electron discharge tubes.

Another object of the invention is to provide an impulse generator for actuating the impulse accumulating circuit for the electron discharge tube chain circuit.

The invention features a cold cathode electron discharge tube for initiating cycles of signal regeneration.

The invention also features electron discharge tubes in a commutating circuit controlled jointly by received signaling impulses and by the impulse generating means for controlling the retransmission of signaling impulses.

In accordance with one embodiment of the invention a signal receiving relay deactivates a normally operative electron discharge device which deactivation sets in operation an electron discharge tube oscillator. The oscillator is activated at full amplitude without transients and the successive cycles of alternating current thus generated are rectified to produce direct current impulses. These impulses seek to activate the deactivated one of two electron discharge devices, one or the other of which is always conductive, and the receiving relay, which is under the control of received signals, determines whether or not the then deactivated electron discharge device shall be activated. Each of the electron discharge devices upon being so activated quenches the other, and a signal transmitting relay is controlled in accordance with the activation of the particular electron discharge device.

Impulses generated by the oscillator are rectified and impressed upon a condenser which controls the grid of an electron discharge tube and when the condenser has received impulses equal to the number of impulses contained in the signaling code upon which the system is operable, the condenser is charged sufficiently to render the associated grid controlled electron discharge tube

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conductive, which reactivates the electron discharge tube initially deactivated by the receiving relay, which in turn deactivates the oscillator, thus restoring the system to normal condition.

In accordance with an alternative embodiment of the invention, a counting chain of electron discharge tubes is employed instead of the condenser charging and grid controlled tube timing circuit. One tube of the chain is normally conductive and upon the starting of the oscillator in response to operation of the signal receiving relay a tube in the chain which had been prepared for activation by the normally conductive tube is activated and in turn quenches the normally conductive tube. Each tube in the chain prepares the next tube to be activated and the activation of the tube is caused by successive rectified impulses from the oscillator. When the normally conductive tube in the chain is reached, that tube is reactivated under the control of a rectified impulse derived from the oscillator and that tube deactivates the oscillator.

For a complete understanding of the invention reference may be had to the following detailed description to be interpreted in the light of the accompanying drawings wherein:

Fig. 1 is a schematic circuit diagram showing that embodiment of the regenerative repeater which employs a condenser charging and grid controlled electron discharge tube timing system, and

Fig. 2 is a schematic circuit diagram showing the alternative embodiment of the regenerative repeater which employs a timing chain of electron discharge tubes.

Referring now to the drawings, and particularly to Fig. 1, the reference numeral 11 designates a polarized receiving relay which has operating and biasing windings. The operating winding has one terminal connected to grounded battery 12 and the other terminal connected to receiving telegraph line 13. The biasing winding of relay 11 has one terminal connected to grounded battery 12 and the other terminal connected to ground. The operation of relay 11 is such that when line 13 is in the marking condition the armature of the relay engages the upper or marking contact which has been designated M and when line 13 is in spacing condition the armature engages the lower or spacing contact which has been designated S.

The marking and spacing contacts of relay 11 are connected through resistors 14 and 16, respectively, to the control anodes of cold cathode gas-filled electron discharge tubes 17 and 18, respectively. The cathode of tube 17 is connected to one terminal of the right-hand winding of a transmitting relay 19, the other terminal of which is connected to ground and this winding, when energized, causes the armature of the relay to engage the upper or spacing contact which has been designated S. The cathode of discharge tube 18 is connected to one terminal of the left-hand winding of transmitting relay 19 and this winding when energized operates the armature of the relay to the lower or marking contact which has been designated M. From this it will be apparent that tube 17 operates relay 19 to drive its armature to spacing and tube 17 may be designated as the spacing control tube whereas tube 18 when conductive drives the armature of relay 19 to marking and may be designated as the marking control tube. The marking and spacing contacts of relay 19 are connected to positive and negative batteries, respectively, and the armature of the relay is connected to transmitting line conductor 21.

The main anodes of tubes 17 and 18 are connected through individual resistors 22 and 23, respectively, and through common protective resistor 24 to the positive terminal of battery 26, the negative terminal of which is grounded. Also, a condenser 27 is connected directly between the main anodes of discharge tubes 17 and 18. The manner in which tubes 17 and 18 control transmitting relay 19 will be described later.

The armature of receiving relay 11 is connected by conductor 28 through dropping resistor 25 and protective resistor 29 to the negative terminal of battery 31, the positive terminal of which is connected to ground. A conductor 32 extends from the marking contact of receiving relay 11 through resistor 33 to the cathode of a cold cathode gas-filled electron discharge tube 34. The main anode of discharge tube 34 is connected through conductors 37 and 38, left-hand inductance winding 39 and in parallel therewith through the series of resistors 41 and 42, and finally through the right-hand inductance winding 43 to ground, which is at the same potential as the positive end of battery 31. When the system is in the idle condition as shown with the armature of receiving relay 11 on the marking contact, electron current flows from the negative terminal of battery 31 over the circuit previously traced to the cathode of tube 34, through the discharge path to the anode of tube 34, and over the circuits just traced to ground on the right-hand inductance winding 43 and to the positive terminal of battery 31.

Resistor 42 is employed as a potentiometer and its movable contact is connected to the grid of the left-hand triode of a twin triode discharge tube 46. The cathode of the left-hand triode is connected through resistor 47 to the point of interconnection of inductance windings 39 and 43. Thus a portion of the voltage appearing across the winding 39 of the inductance is applied to the grid of the left-hand triode of tube 46. The flow of plate current in resistor 47 applies a positive potential to the cathode of this triode. Due to the low resistance of the inductance coil, the flow of current in tube 34, passing through the inductance, causes only a small negative voltage to appear on the grid of the left-hand triode of tube 46. This is insufficient to cut off the flow of steady plate current.

Connected to conductor 37 and thus to the left-hand end of inductance winding 39 are the contact arms of four multiple contact switches

51, 52, 53 and 54. The contact arms of switches 51 and 52 are ganged for concurrent operation and the contact arm switches 53 and 54 are ganged for concurrent operation. The contacts of switches 51, 52, 53 and 54 are connected in various combinations to one side of capacitances in groups 55, 56 and 57 and the other side of each of the capacitances in the three groups is connected to ground. By the manipulation of switches 51, 52, 53 and 54 various combinations of capacitances may be connected in parallel between conductor 37 and ground to provide a single resultant capacitance value, and the condensers are so arranged with reference to switches 51, 52, 53 and 54 that switches 53 and 54 provide coarse or relatively important changes in the resulting capacitance value and switches 51 and 52 provide fine or minor changes in the resulting capacitance value. Since various combinations of parallelly connected condensers are connected between conductor 37 and ground under the control of the switches and since inductance windings 39 and 43 are connected between conductor 37 and ground, the condensers are in parallel with the inductances, which establishes an oscillatory circuit. Furthermore, since the grid of the left-hand triode of tube 46 is connected to one end of this oscillatory circuit through resistor 41 and potentiometer 42 and since the cathode of the left-hand triode is connected to a point intermediate the ends of the inductive branch of the circuit through resistor 47, the system comprises an electron discharge tube oscillator which will generate oscillatory current, as long as tube 34 is non-conducting, at a frequency determined by the adjustment of switches 51, 52, 53 and 54. These switches are in practice adjusted so that the frequency of oscillations generated is twice the signaling frequency and each cycle of oscillation is of the same duration as a normal signaling impulse of the code upon which the system is operable. The anode of the left-hand triode of tube 46 is connected through resistor 57 to the positive terminal of battery 58 the negative terminal of which is connected to ground. The positive terminal of battery 58 is also connected through potentiometer 59 and resistor 61 to the negative terminal of battery 62, the positive terminal of which is grounded. A potentiometer 63 is connected in parallel with potentiometer 59. The constants of the oscillator are so adjusted that the circuit performs undamped oscillations and the configuration of the circuit is such that the oscillations have no starting transients and, accordingly, the first and all succeeding cycles are developed at full amplitude. The operating characteristics of an oscillator of the type shown herein are fully disclosed in copending application Serial No. 432,823, filed February 28, 1942, now Patent No. 2,370,685, granted March 6, 1945, by W. T. Rea et al., and the disclosure of this copending application is incorporated herein by reference as part of the present specification.

The cathode voltage for the right-hand triode section of tube 46 is derived from the adjustable contact of potentiometer 59 and the plate voltage for this triode section is derived from the adjustable contact of potentiometer 63. The anode circuit of the right-hand triode of tube 46 includes the primary winding of a transformer 66 which is shunted by a resistor 67. The voltage with reference to ground which appears at the left-hand end of inductance winding 39 is connected through conductors 38 and 68, and resistor 69 to the grid of the right-hand triode of tube 46. Thus the grid of the right-hand triode of tube 46 is controlled in accordance with the potentials developed across the oscillatory circuit and the plate circuit of the right-hand triode becomes conductive whenever the voltage applied to the grid becomes more positive than that of the cathode and becomes non-conducting whenever the voltage applied to the grid becomes more negative than the cathode. Each time the anode circuit of the right-hand triode passes from the conductive to the non-conductive condition a positive impulse is applied to the secondary of transformer 66. The potentiometers 59 and 63 from which the cathode and anode potentials for the right-hand triode of tube 46 are derived provide for varying the cathode potential with respect to ground without changing the plate-to-cathode potential. This provides for orientation of the positive pulses generated in the secondary of transformer 66 with respect to the oscillatory cycles generated by the discharge tube oscillator, by which is meant that the time of occurrence of the positive impulse in the secondary of transformer 66 relative to each cycle of oscillation of the oscillator may be varied.

The terminal of the secondary of transformer 66 which is negative when the right-hand triode of tube 46 passes from conductive to non-conductive condition is connected through conductor 72, resistor 73 and resistor 24 to the positive terminal of battery 26 and through resistor 71 to ground. The other terminal of the secondary of transformer 66 is connected by conductor 74 to branching circuits through resistors 76 and 77 to the control anodes of cold cathode gas-filled discharge tubes 17 and 18, respectively.

Referring again to the system for controlling transmitting relay 19, it will be noted that a potential difference is applied by battery 26 across the control gaps of the tubes 17 and 18 and the circuits for the application of these potentials are from the positive terminal of battery 26 through resistor 24, resistor 73, conductor 72, secondary of transformer 66, conductor 74, resistor 76, control anode and cathode of tube 17 and right-hand winding of relay 19 to ground, which is at the potential of the negative terminal of battery 24, and through resistor 77, control anode and cathode of tube 18 and left-hand winding of relay 19 to ground. In the case of tube 17, with the armature of relay 11 on the marking contact a reverse voltage is applied from the negative terminal of battery 31 through resistors 29 and 25, conductor 28, armature and marking contact of relay 11, resistor 14, control anode and cathode of tube 17 and right-hand winding of relay 19 to ground, which is at the potential of the positive terminal of battery 31. The voltage across the control gap of tube 17 is thus seen to be the difference between the voltages supplied by batteries 26 and 31, and this difference may be zero so that there is no potential across the control gap of tube 17, or battery 26 may be of slightly higher voltage than battery 31, so as to apply a positive potential difference of a few volts to the control anode with respect to the cathode, provided such potential difference is well below the firing potential of the control gap. Since, with the armature of relay 11 engaging the marking contact, battery 31 is disconnected from the control anode of tube 18, the potential of battery 26, reduced by the voltage divider comprising resistors 73 and 71, is applied across the control gap of tube 18, with the positive potential applied to the control anode. This potential should be well below the firing potential of the control gap of the tube and may, for example, be of the order of fifty volts. One or the other of the tubes 17 and 18 must be conducting, as will be described later, and since the armature of relay 11 is shown in engagement with the marking contact for the idle condition of the apparatus it will be assumed that tube 18 which controls the transmission of marking impulses is conducting. It is to be noted that the control anode of this tube is connected to the spacing contact of receiving relay 11 and the reason for this arrangement will appear later.

Upon the movement of the armature of relay 11 into engagement with the spacing contact in response to the start signal, battery 31 is disconnected from the control anode of tube 17 and becomes connected to the control anode of tube 18. Thus the voltage of battery 26 reduced by the potentiometer comprising resistors 73 and 71 is applied across the control gap of tube 17 and the opposing voltage of battery 31 is applied across the control gap of tube 18. These conditions do not of themselves change the operative condition of tubes 17 and 18 because the voltage applied across the control gap of tube 17, assumed to be of the order of fifty volts, is insufficient to fire that control gap and the reduction in voltage across the control gap of tube 18 to a few volts or to zero cannot deactivate the tube. The first cycle of oscillatory current generated by the oscillator as a result of reception of the start signal results in the production of a voltage across the secondary of transformer 66 at a timed instant just before or just after the middle of the cycle of oscillatory current as determined by potentiometers 59 and 63. The voltage developed across the secondary of transformer 66 aids the potential difference across the control gap of tube 17 applied by battery 26, as may be observed by tracing the circuit from the positive terminal of battery 26, through resistors 24 and 73, conductor 72, winding of the secondary of transformer 66 from negative to positive end, conductor 74, resistor 76, control anode and cathode of tube 17 and right-hand winding of relay 19 to ground. The aiding voltage in the secondary of transformer 66 is also applied through resistor 77 and across the control gap of tube 18 through the left-hand winding of relay 19 to ground but the voltage of battery 26 aided by the voltage in the secondary of transformer 66 and opposed by the voltage of battery 31 is below the firing potential of tube 18. This is of no immediate consequence as tube 18 has been assumed to be conductive at this time. The voltage supplied by battery 26, assumed to be of the order of fifty volts, aided by the voltage of transformer 66, which will also be assumed to be of the order of fifty volts, produces a potential difference across the control gap of tube 17 of the order of one hundred volts which is sufficient to fire the control gap and, accordingly, the main gap between the main anode and the cathode of tube 17 becomes conductive and the right-hand winding of relay 19 is energized. The firing of the main gap of tube 17 results in the production of an impulse through condenser 27 to the main anode of tube 18 which reduces the potential of the anode relative to the cathode below the discharge sustaining potential. Accordingly, the main gap of tube 18 from main anode to cathode is rendered non-conductive and the left-hand winding of relay 19 is deenergized. The right-hand winding therefore assumes control of the armature and moves the armature to the spacing contact, thus impressing a spacing impulse on transmitting line 21.

Assuming that the voltage developed across the secondary of transformer 66 should persist after the main gap of tube 18 has been quenched, the control gap will not be fired, due to the fact that the voltage across this gap resulting from the battery 26 aided by the voltage in the secondary of transformer 66 but opposed by the voltage of battery 31 is below the control gap firing potential. It is to avoid the undesired refiring of tube 18 that the voltage developed across the secondary of transformer 66 should be sufficient to fire the control gap of the tube 17 or tube 18 with the aid of battery 26 only when unopposed by the battery 31 but should not be sufficient to accomplish this when opposed by the battery 31.

When the armature of relay 11 is again restored to marking in response to a marking signal in the received code combination the opposing effect of battery 31 will be removed from tube 18 and will be applied to tube 17. The firing of tube 18 will await the production of the impulse of the proper polarity in the secondary of transformer 66 under the control of the oscillator, and when the impulse is generated the control gap and then the main gap of tube 18 will be fired and the main gap of tube 17 will be quenched, whereupon the left-hand winding of relay 19 will move the armature to the marking contact. From the foregoing it will be apparent that relay 19 is operated by the commutating tubes 17 and 18 under the control of relay 11 as to marking and spacing conditions and at timed intervals as determined by the oscillator. Thus the oscillator determines the several instants at which relay 19 shall move its armature from one contact to the other and signaling impulses received in weak or distorted condition will be retransmitted as full length and full strength impulses. The orientation feature afforded by the potentiometers 59 and 63 enables the right-hand triode of tube 46 to effect the operation of tube 17 or tube 18 when the most effective part of each signaling impulse is being received by the relay 11 so that the armature of the receiving relay will have arrived at its proper selective position when the impulse for firing one of the commutating tubes 17 and 18 is generated. When two successive impulses in a code combination are alike, the armature of relay 11 is in the same position when the positive impulse is generated in the secondary of transformer 66 for each of the two signaling impulses, so that the control gap of the same one of the tubes 17 or 18 is refired in response to the second impulse. Since the main gap of the refired tube is already conducting, the refiring of the control gap has no effect.

At the same time that the grid of the right-hand triode section of tube 46 is made positive with respect to ground through the resistor 69 under the control of the oscillatory circuit the grid of the right-hand triode section of a tube 81 is made positive with respect to its grounded cathode under the same control through a resistor 82. The anode of the right-hand triode section of tube 81 is connected through the primary of transformer 83, which is shunted by resistor 84, and through resistor 86 to the positive terminal of grounded battery 87. The right-hand triode of tube 81 is thus rendered conductive once for each cycle of the oscillator and when current rises in its anode circuit an impulse is generated in the secondary of transformer 83, one terminal of which is connected through resistor 29 to the negative terminal of grounded battery 31 and the other terminal of which is connected to the grid and anode of the left-hand triode section of tube 81 which, having its grid and anode connected together, operates as a diode. The impulse generated in the secondary of transformer 83 as current rises in the anode section of the right-hand triode is positive toward the anode and grid of the left-hand triode section and negative toward the battery 31. The voltage developed across the secondary of transformer 83 is sufficient to overcome the negative voltage applied by battery 31 so that the interconnected anode and grid are made sufficiently positive for the tube to be conductive. The voltage of opposite polarity which is generated in the secondary of transformer 83 when the grid of the right-hand triode section of tube 81 is restored to negative with respect to the cathode and current is cut off in the right-hand triode section, has no effect on the diode-connected left-hand section of tube 81 since that section is conductive in only one direction.

The cathode of the left-hand section of tube 81 is connected through a variable resistor 88 to the grid of the right-hand triode section of a twin triode electron discharge tube 89 and is also connected to one side of a condenser 91 the other side of which is connected to the anode of the left-hand triode section of tube 89. Each time that the left-hand section of tube 81 is conductive the flow of cathode current causes a charge to be impressed upon condenser 91 which is positive on the side of the condenser connected to the grid of the right-hand triode section of tube 89. The circuit is so adjusted that when a full permutation code signal has been received, which, in the case of a code having five selecting impulses is sometimes called a seven-unit code if the start and stop impulses are each of one unit impulse length, or a seven and one-half unit code in case the start impulse is of one code impulse unit length and the stop pulse is of substantially one and one-half code impulse unit length, the condenser 91 will have received seven charging impulses under the control of the seven cycles of oscillatory current generated by the oscillator and the seven accumulated impulses raise the potential of the grid sufficiently with respect to the grounded cathode to render the right-hand section of tube 89 conductive. The anode of the right-hand section of tube 89 is connected through resistor 92, conductors 93 and 94 and resistor 86 to the positive terminal of grounded battery 87. The anode of the right-hand section of tube 89 is also connected to one side of a condenser 96 the other side of which is connected to the grid of the left-hand triode section of tube 89 and is also connected through resistor 97 to ground. Due to the flow of anode current in the right-hand section of tube 89 the potential of the anode becomes less positive, which causes condenser 96 to discharge, thus producing a flow of current through resistor 97 and driving the grid of the left-hand section of tube 89 more negative than the ground potential which it had when no current was flowing through resistor 97. The left-hand triode section of tube 89 is normally conductive and when the potential of the grid is made negative with respect to the grounded cathode, current in the left-hand triode section is cut off. The anode of the left-hand section of tube 89 is connected through resistor 98 and primary winding of transformer 99 to conductor 94 and thus to the positive terminal of battery 87. The right-hand end of the secondary winding of transformer 99 is connected to the control anode of discharge tube 34 and the left-hand end of the secondary winding is connected to the cathode of that tube. The impulse generated in the secondary of transformer 99 when current in the left-hand section of tube 89 is cut off is positive toward the control anode of discharge tube 34 and negative toward the cathode and is of sufficient voltage to fire the control gap of tube 34. If receiving relay 11 is at this time in marking position which it should be in response to the stop impulse, battery 31 is connected to the cathode of tube 34 so that the main gap of the tube will be fired. Since at this time the oscillator has produced seven complete cycles, and since its decrement is substantially zero, current and voltage conditions in the oscillatory circuit have returned to their initial values. The firing of tube 34 therefore merely holds the oscillator and no stopping transient results. If, however, the decrement is other than zero, the final amplitude will differ from the initial amplitude. To take care of this condition, the values of resistances 25 and 33 are so chosen that the circuit returns to its initial condition in critically damped manner and the stopping transient is of the shortest possible duration. Thus the production of timing impulses is suspended and the system awaits the reception of the next start impulse.

When the anode current was cut off in the left-hand section of tube 89 the anode potential was made more positive which, through condenser 91, makes the grid of the right-hand triode section of tube 89 more positive. Not only does the right-hand triode section of tube 89 continue to be conductive after anode current in the left-hand section has been cut off, but due to the positive potential of the grid it draws current thus charging condenser 91. After a short while condenser 96 charges through resistor 97 thus bringing the grid of the left-hand section of tube 89 to ground potential and reactivating the left-hand section of the tube. With the restoration of anode current in the left-hand section of tube 89 the anode potential of that section is made less positive by virtue of the flow of current in resistor 98, and through condenser 91 the grid of the right-hand triode section is driven to negative potential with respect to the grounded cathode thus cutting off anode current in the right-hand section of the tube and restoring the system to normal.

Had the received signal combination been so distorted that the stop signal was not being received at the time the voltage developed across the secondary of transformer 99 fired the control gap of tube 34, the main gap of tube 34 would not have been fired because of the absence of negative battery connection for the cathode of tube 34 at the marking contact of relay 11 since presumably the armature of relay 11 might not have returned to marking position. Under these circumstances the oscillator would not be stopped but would continue to produce timing cycles of oscillatory current from which impulses would be derived for charging condenser 91 and when seven cycles of oscillatory current had been generated the right-hand triode of tube 89 would again be activated and the control gap of tube 34 would again be fired seeking to reestablish the main gap discharge in the tube 34 under the control of the armature of receiving relay 11. It should be noted that when the left-hand triode section of tube 89 is restored to conductive condition under

the control of the right-hand triode section, an impulse is generated in the secondary of transformer 99 of the opposite polarity to that which refired the control gap of tube 34. Since the main gap of the tube has already been rendered conductive, the application of the reverse voltage across the control gap will have no effect.

Fig. 2 shows a regenerative repeater similar to that shown in Fig. 1 but differing in two principal respects, namely, the provision of a counting chain of electron discharge tubes instead of the impulse accumulating condenser system for counting the oscillator cycles to determine when the oscillator shall be stopped and the provision of a capacity coupling instead of transformer coupling for the timing control of the firing of the control gaps of the commutating tubes which control the transmitting relay. The oscillator circuit and the circuit for controlling its operation are identical with those shown in Fig. 1 and the same reference numerals have been applied thereto. The tube circuit for deriving impulses from the oscillator circuit for supplying the timing pulses for the commutating tubes is also identical except for the capacity coupling. Corresponding elements of the signal receiving mechanism and of the signal transmitting mechanism including the signal transmitting relay, the commutating tubes and controlling circuits also carry the same reference numerals. In Fig. 2 all circuit elements which do not appear in Fig. 1 whether they represent substitutions for elements appearing in Fig. 1 or additional elements, are identified by reference numerals above 100.

In the system shown in Fig. 2, when the receiving relay 11 responds to the start signal its armature disconnects battery 31 from the cathode of tube 34 thereby quenching the main gap discharge in the tube and permitting the oscillator to start generating cycles of oscillatory current. Pulses derived from the oscillatory circuit are applied through conductor 68 and resistor 69 to the grid of the right-hand triode section of tube 46 to render the tube alternately conductive and non-conductive. The anode circuit of the right-hand triode section of tube 46 instead of including the primary of a transformer as in Fig. 1 includes a resistor 101 between the anode and the movable contact of potentiometer 63. The anode of the right-hand triode section of tube 46 is also connected by conductor 102 to one side of each of the condensers 103 and 104. The other side of condenser 103 is connected to the control anode of tube 17 through resistor 106 and the other side of condenser 104 is connected to the control anode of tube 18 through resistor 107. In view of the elimination of the transformer, the conductors 72 and 74 which included the secondary of the transformer are replaced by conductor 108 which extends directly from the right-hand end of resistor 73 to the point of interconnection of resistors 76 and 77.

The conditioning voltage for the control gaps of tubes 17 and 18 is supplied directly to the control anodes of those tubes from the positive terminal of battery 26 through resistors 24 and 73, conductor 108 and branching through resistor 76, through a resistor 109 which is connected between the upper end of resistor 76 and the upper side of condenser 103, and through the resistor 106 to the control anode of tube 17 and in the other branch through resistor 77, a resistor 111 connected between the lower end of resistor 77 and the lower side of condenser 104, and through resistor 107 to the control anode of tube 18. The conditioning voltage is opposed on the side which is engaged by the armature of relay 11, by the voltage supplied by battery 31.

With the right-hand triode of tube 46 non-conductive, condensers 103 and 104 are charged by the voltage appearing at the point of contact of the movable contact of potentiometer 63 with the potentiometer winding through a circuit including resistor 101, conductor 102 and in one branch through condenser 103, resistor 109, resistor 76, conductor 108, and resistor 71 to ground and in the other branch through condenser 104, resistor 111, resistor 77, conductor 108 and resistor 71 to ground. When the right-hand triode of tube 46 is rendered conductive, the potential of its anode is reduced, thus partially discharging condensers 103 and 104 and thereby making the upper plate of condenser 103 and the lower plate of condenser 104 less positive. These potentials are in opposition to the voltages applied across the control gaps of tubes 17 and 18 supplied by battery 26 so that the voltage across the control gaps of tubes 17 and 18 is reduced while condensers 103 and 104 are discharging but the voltages are restored to normal value when the condensers reach a steady state during the period that the right-hand triode of tube 46 is conductive. When current is cut off in the right-hand triode of tube 46 the potential of the anode rises to its original value thus recharging the condensers 103 and 104. The potentials on the upper plate of condenser 103 and on the lower plate of condenser 104 increase and these potentials are applied to the control anodes of tubes 17 and 18 in aiding relation to those supplied by battery 26 so that the tube from which the opposing effect of battery 31 was removed, namely, the tube 17, since the armature of relay 11 has been assumed to have moved to spacing in response to the start signal, becomes conductive in its control gap and thereupon immediately in its main gap. From this it will be apparent that tube 17 or tube 18 is rendered conductive upon the cessation of current in the right-hand triode of tube 46 as in the arrangement shown in Fig. 1, with the difference that the firing potentials are applied across the control gaps of the tubes by means of condensers in aiding relation to battery 26 instead of by transformer coupling.

For counting the cycles of oscillatory current generated by the oscillator, there is a triode tube 116 which controls a counting chain of cold cathode gas-filled electron discharge tubes of which tube 117 corresponds to the start pulse, tubes 118 to 122, inclusive, correspond to the five selecting impulses of a permutation code and tube 123 corresponds to the stop pulse. In each of the tubes 117 to 123, inclusive, the left-hand electrode is the control anode, the right-hand electrode is the cathode, and the uppermost electrode is the main anode. The cathode of each of the seven tubes is connected through an individual resistor 137, which is shunted by a condenser 138, to conductor 126 which extends through resistor 29 to the negative terminal of battery 31, the positive terminal of which is grounded. The main anode of each of the tubes 117 to 122, inclusive, is connected to a conductor 127, which is connected to a voltage divider comprising resistors 130 and 135, bridged between battery 26 and ground. The main anode of tube 123 is connected by conductor 128 through the primary of a transformer 129 to the same voltage divider. A varistor 142 shunted by a condenser 143 is connected in parallel with the primary of transformer 129. The characteristic of varistor 142 is that it exhibits relatively low impedance to flow of current in one direction and exhibits extremely high impedance to flow of current in the opposite direction. The purpose in providing varistor 142 is to provide a low resistance path for quickly dissipating the energy of the voltage developed in the primary of the transformer when current therethrough is cut off, thereby to prevent the induction of a voltage across the secondary, and to prevent the rapid dissipation of the energy of the voltage developed when current rises in the primary, thereby permitting a voltage to be induced across the secondary.

The cathode of each tube is connected to the control anode of the next tube in the series by a resistor 131 and the cathode of the last tube 123 in the series is connected to the control anode of the first tube 117 through conductor 132 and a similar resistor 131. A condenser 133 is connected between the control anode of each of the tubes 117 to 123, inclusive, and a conductor 134 which extends through the secondary winding of a transformer 136 to ground.

During idle intervals tube 123 is conducting in a circuit from the negative terminal of battery 31, through conductor 126, cathode resistor 137 associated with the cathode of tube 123, cathode to anode space discharge path of the tube, conductor 128, primary of transformer 129 and resistor 135 to battery 26. Due to the flow of current through the cathode resistor 137 of tube 123, a voltage drop exists across this resistor and across the condenser 138 in parallel with it, the polarity of which is negative toward conductor 126 and positive toward conductor 132. Since conductor 126 is connected through the cathode resistor associated with tube 117 to the cathode of that tube and conductor 132 is connected through the resistor 131 associated with tube 117 to the control anode of that tube, the voltage across the cathode resistor 137 associated with tube 123 is impressed across the control gap of tube 117 with the left-hand or control anode positive with respect to the cathode which is the right-hand electrode. It may be noted that the cathodes of all of the other tubes 118 to 122, inclusive, are at the same potential as conductor 126 but only the control anode of tube 117 is at a potential more positive than these cathode potentials because the cathode potential of the conducting tube 123 is applied to the control anode of tube 117 only. This potential is insufficient to fire the control gap of tube 117.

Upon the production of the first cycle of oscillatory current by the oscillator in response to the start signal, the potential of the grid of triode tube 116 with respect to the grounded cathode is raised by a pulse applied through resistor 82 and tube 116 is rendered conductive. The anode circuit of tube 116 extends through the primary of transformer 136, resistor 139, conductor 141, resistor 24 to the positive terminal of battery 26, the negative terminal of which is grounded. The rise of anode current in the primary of transformer 136 induces a voltage across the secondary which applies an impulse through the condensers 133 associated with the control anodes of all of the tubes 117 to 123, inclusive. The polarity of the impulse is such as to make the control anodes of all of the tubes more positive with respect to the cathodes and in the case of tube 117 the control anode of which has already been made more positive than the cathode as previously explained, the control gap is fired, whereupon the main gap becomes conductive. None of the tubes 118 to 122, inclusive, also becomes conductive because conditioning voltages had not been applied across their control gaps and the voltage supplied by the secondary of transformer 136 is insufficient to fire the control gaps of these tubes.

At the instant that the main gap of tube 117 fires, the potential difference between the main anode and the cathode which, when the tube is non-conductive is higher than the discharge sustaining potential but is insufficient to directly fire the tube through the main gap, decreases to the discharge sustaining potential. This decrease occurs before the discharge current has flowed into condenser 138 associated with the cathode of tube 117 sufficiently long to develop a voltage across the condenser. Tube 123 has been conducting up to this time and the discharge sustaining potential difference has existed between its main anode and the cathode. An additional potential difference has existed across the cathode-resistor 137 and condenser 138 associated with tube 123 due to the flow of the discharge current. However, upon the firing of the main gap of tube 117 and before discharge current has begun to flow in resistor 137 associated with tube 117, the potential difference between the main anode and the cathode of tube 117, which is the discharge sustaining potential and is lower than the potential difference appearing across those electrodes when the tube was non-conductive, appears directly between conductors 127 and 126 due to the fact that there is no voltage drop in the resistor 137 associated with tube 117. The anode of tube 123 is connected to conductor 127 through conductor 128 and the primary winding of transformer 129 and the resistor 137 associated with the cathode of tube 123 is connected to conductor 126 so that the potential difference between the main anode and the cathode of tube 123 plus the potential difference acros the associated resistor 137 and condenser 138 is reduced to a value equal to the discharge sustaining potential between the main anode and the cathode of tube 117. Since a portion of this reduced potential difference appears across resistor 137 and condenser 138 associated with tube 123, it follows that the potential difference between the main anode and cathode of tube 123 has been reduced below the discharge sustaining potential and, accordingly, current through the main gap of tube 123 is cut off. Thus the firing of tube 117 results in the quenching of tube 123, and by virtue of the fact that the main anodes of all of the tubes are connected directly to a common supply circuit, the firing of any one of the tubes will result in the quenching of any other of the tubes that has been conducting.

With the cutting off of current in tube 123, cathode current in the resistor 137 associated therewith ceases and thereupon condenser 138 gradually discharges through resistor 137, thereby sustaining for a short while the positive potential on the cathode of tube 123. This affords time for tube 123 to become thoroughly deionized before the normal potential supplied from the negative terminal of battery 31 is reapplied to the cathode of tube 123. Were this time for deionization of the tube not afforded the tube 123 might refire directly through its main gap. Since the anode circuit of tube 123 includes the primary of transformer 129, the dying out of current in this circuit would produce a voltage across the secondary of the transformer were it not for the fact that varistor 142 shunted by condenser 143 is connected across the primary of transformer 129 with its direction of low impedance conductivity so related to the voltage developed that the primary of the transformer is practically short-circuited and is ineffective to develop a voltage across the secondary due to the dying out of the anode current. The secondary of transformer 129 is connected across the control gap of tube 34 the same as the secondary of transformer 99 in Fig. 1 and thus the firing of the control gap of that tube is not accomplished by the quenching of tube 123.

With the development of a voltage across resistor 137 and condenser 138 associated with tube 117, the potential of the control anode of tube 118 with respect to the cathode is made more positive in the same manner that the control gap of tube 117 was conditioned by tube 123 and, accordingly, tube 118 is prepared to be rendered conductive. Under the control of the second cycle of oscillatory current generated by the oscillator, triode tube 116 is rendered conductive mementarily and a voltage is developed across the secondary of transformer 136 which, through condenser 133 associated with the control anode of tube 118, further raises the potential of the control anode and the control gap of the tube is fired, followed immediately by the firing of the main gap. Since the main anode of tube 118 is connected to the main anode of tube 117, the reduction in voltage across the main gap of tube 118 to the discharge sustaining potential, which occurs before current flows through resistor 137 associated with tube 118, results in the reduction of the potential of the main anode of tube 117 with respect to its cathode so that the potential difference between the main anode and the cathode is less than the discharge sustaining potential and tube 117 is accordingly quenched in the same manner that that tube, when it was rendered conductive, quenched the tube 123.

In this manner, successive cycles of the oscillator effect the firing of successive ones of the tubes in the counting chain and each tube upon being fired quenches the tube ahead of it. In response to the end of the seventh cycle of the oscillator which occurs during the stop impulse of the received signal, tube 123, which was conditioned by tube 122, becomes conductive and in turn quenches tube 122. The rise in anode current for tube 123 through the primary of transformer 129 results in the production of a voltage across the secondary of the transformer without hindrance by the varistor 142 and the voltage developed is positive with respect to the control anode of tube 34 and negative with respect to the cathode. The control gap of tube 34 is thus rendered conductive and if the armature of receiving relay 11 is at this time in marking condition, which it should be if the received signals are not so badly distorted that the stop signal is not being received, the main gap of tube 34 will be fired and the oscillator will be stopped. In this way the apparatus will be restored to the initial condition with discharge tubes 18, 34 and 123 conductive and all others non-conductive.

It is to be noted that a varistor was not provided in shunt with the primary of transformer 99 in Fig. 1 whereas it is provided in shunt with the primary of transformer 129. The reason for this is that there is a different interval between the starting and stopping of current through the primary of transformer 99 than there is between the starting and stopping of current in the primary of transformer 129. In the case of the transformer 99 current normally is flowing in the primary because the left-hand triode section of tube 89 is normally conductive. It is rendered non-conductive, to fire tube 34, and is almost immediately restored to conductivity under the control of the right-hand triode section of tube 89 so that the reversed impulse in the secondary of the transformer follows the control gap firing impulse almost immediately and has no effect on tube 34. In the case of the transformer 129 no current is flowing in the primary during the reception of a code combination due to the fact that tube 123 is quenched. Tube 123 is fired under the control of the seventh cycle of the oscillator to produce an impulse in the secondary of transformer 129 which fires the control gap of tube 34. Thereafter upon the reception of the start impulse of the next signal combination the main gap of tube 34 is quenched, the oscillator is started and produces its first cycle, the end of which causes the firing of tube 117 which, in turn, quenches tube 123. The stopping of anode current for tube 123 through the primary of transformer 129 would produce a voltage across the secondary of transformer 129, were it not for the provision of varistor 142, which voltage would be negative toward the control anode of tube 34 and positive toward the cathode. It is a characteristic of some types of gas-filled cold cathode tubes that the control anode and the cathode are identical and may be employed interchangeably. Thus the failure to suppress the reverse firing of the control gap of tube 34 in response to quenching of tube 123 might result in firing of the main gap of tube 34 and stopping of the oscillator whereby the retransmission of the received signal combination would be disturbed and a garbled or incorrect signal would be transmitted.

Although certain specific embodiments of the invention have been shown in the drawings and described in the foregoing specification, it will be understood that the invention is not limited to such specific embodiments but is capable of modification and rearrangement without departing from the spirit of the invention and within the scope of the appended claims.

What is claimed is:

1. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means for counting the impulses generated by said impulse generator, and means operated by said counting means upon counting a predetermined number of impulses for stopping said generator.

2. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, electron discharge means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means for counting the impulses generated by said impulse generator, and means operated by said counting means upon counting a predetermined number of impulses for stopping said generator.

3. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, normally conductive electron discharge means rendered non-conductive by said signal responsive relay upon response of said relay to a signal for activating said impulse generator, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means for counting the impulses generated by said impulse generator, and means operated by said counting means upon counting a predetermined number of impulses for rendering said electron discharge means conductive whereby to disable said generator.

4. In a telegraph signal repeater, a signal responsive relay, a normally inactive electronic generator of oscillatory current, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled by said generator for deriving impulses at the rate of at least one impulse per cycle of oscillatory current, means controlled jointly by said signal responsive relay and said impulse deriving means for operating said transmitting relay, means for counting the cycles of oscillatory current generated by said generator, and means operated by said counting means upon counting a predetermined number of cycles for stopping said generator.

5. In a telegraph signal repeater, a signal responsive relay, a normally inactive electronic oscillator for generating oscillatory current, means controlled by said relay for setting said oscillator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said oscillator for operating said transmitting relay, means for deriving impulses from said oscillator at the rate of one impulse per cycle of oscillatory current, means for counting said impulses, and means operated by said counting means upon counting a predetermined number of impulses for stopping said oscillator.

6. In a telegraph signal repeater, a signal responsive relay, a normally inactive electronic oscillator for generating oscillatory current, means controlled by said relay for setting said oscillator in operation, a signal transmitting relay, a first impulse deriving means for deriving impulses from said oscillator at the rate of one impulse per cycle of oscillatory current, means controlled jointly by said signal responsive relay and said first impulse deriving means for operating said transmitting relay, a second impulse deriving means for deriving impulses from said oscillator at the same rate as said first impulse deriving means, means for counting the impulses derived by said second impulse deriving means, and means operated by said counting means upon counting a predetermined number of derived impulses for stopping said oscillator.

7. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, an electron discharge device having a control grid, a condenser associated with said grid, means for deriving impulses from said generator and for impressing charges on said condenser cumulatively to render said electron discharge device conductive after the accumulation of a predetermined number of charges, and means controlled by said electron discharge device upon being rendered conductive for stopping said generator.

8. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means for deriving impulses from said generator, a normally non-conductive electron discharge device having a control grid and a condenser associated with said grid, means controlled by said impulse deriving means for cumulatively charging said condenser according to the number of impulses derived from said generator for raising the potential of said control grid step by step to ultimately render said electron discharge device conductive, means controlled by said electron discharge device upon being rendered conductive for stopping said generator, and means for discharging said condenser whereby to restore said electron discharge device to non-conductive condition.

9. In a relay system, a controlling relay, a pair of cold cathode electron discharge tubes having main and control discharge paths, means for applying across the control paths of both tubes a potential difference less than the firing voltage of said control paths, means for cyclically applying across the control paths of both of said tubes a potential difference in additive relation to said first-mentioned potential difference, the aggregate of which exceeds the firing potential of said control paths, and means controlled by said relay for selectively applying across the control path of one of said tubes a potential difference in subtractive relation to the other potential differences whereby to maintain the potential difference across the control path of said one tube below the firing voltage.

10. In a relay system, a controlling relay, a pair of cold cathode electron discharge tubes having main and control discharge paths, one of said tubes being normally conductive through its main discharge path, means for continuously applying across the control paths of both tubes a potential difference less than the firing voltage of said control paths, means for cyclically applying across the control paths of both of said tubes a potential difference in additive relation to said first-mentioned potential difference, the aggregate of which exceeds the firing voltage of said control paths, means controlled by said relay for selectively applying across the control path of either of said tubes, a potential difference in subtractive relation to the other potential differences whereby to maintain the potential difference across the control path of the selected tube below the firing voltage, and means effective upon the firing of the main discharge path of either tube under the control of its control discharge path for quenching the discharge through the main discharge path of the other tube.

11. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, a series of electron discharge devices operable successively by said impulse generator and means controlled by the last electron discharge device in said series for deactivating said impulse generator.

12. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, a closed ring of electron discharge devices having a predetermined one of said electron discharge devices normally conductive and the remainder non-conductive, means controlled by said impulse generator for rendering said non-conductive electron discharge devices conductive in succession, means effective upon any one of said electron discharge devices becoming conductive for rendering non-conductive any other of said electron discharge devices which is then conductive, and means controlled by said predetermined one of said electron discharge devices upon being again rendered conductive for deactivating said impulse generator.

13. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, a plurality of electron discharge devices arranged in a closed ring circuit, a predetermined one of said electron discharge devices being normally conductive and the remainder being normally non-conductive, means intervening said electron devices in said circuit whereby each tube upon being rendered conductive prepares the next tube to be rendered conductive, means controlled by said impulse generator for impressing tube firing impulses on said ring circuit whereby said tubes are fired in succession as prepared, means effective upon each of said tubes becoming conductive for rendering non-conductive any tube which is then conductive, and means controlled by said predetermined one of said tubes upon being again rendered conductive for deactivating said impulse generator.

14. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, a normally conductive electron discharge device rendered non-conductive by said signal responsive relay upon response of said relay to a signal for activating said impulse generator, a series of electron discharge devices one of which is normally conductive and the remainder of which are normally non-conductive, means controlled by said impulse generator for rendering the tubes in said series conductive in succession by successive impulses generated by said impulse generator, means effective upon any of the tubes of said series being rendered conductive for rendering non-conductive any other tube in said series which is then conductive, and means controlled by said predetermined one of said tubes upon again becoming conductive for rendering the first-mentioned electron discharge device conductive, whereby to deactivate said impulse generator.

15. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, a normally non-conductive cold cathode electron discharge tube rendered non-conductive by said signal responsive relay upon response of said relay to a signal for activating said impulse generator, said tube having a pair of spaced electrodes defining a non-polar control gap, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means comprising a closed ring circuit of cold

cathode electron discharge tubes for counting the impulses generated by said impulse generator, said ring circuit having one of the electron discharge tubes normally conductive, means associated with the anode circuit of said one tube for applying a potential difference between the electrodes defining the control gap of the first-mentioned electron discharge tube, and means for causing said potential difference to be impressed on said electrodes only upon the firing of the normally conductive tube in said ring circuit.

16. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, a normally conductive cold cathode electron discharge tube rendered non-conductive by said signal responsive relay upon response of said relay to a signal for activating said impulse generator, said tube having a pair of spaced electrodes defining a non-directional control gap, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, a plurality of cold cathode electron discharge tubes arranged in a ring circuit for counting the impulses generated by said impulse generator, said ring circuit having a predetermined one of the tubes contained therein normally conductive, a transformer having its primary winding in the anode circuit of the normally conductive tube of said ring circuit and having its secondary winding connected to the control gap electrodes of the first-mentioned electron discharge tube, and means connected in shunt relation to the primary of said transformer having unilateral conductivity for estopping the generation of a potential difference in the secondary of said transformer upon the cessation of anode current in the normally conductive tube of said ring circuit.

17. In a telegraph signal repeater, a signal responsive relay having an armature operable between two contacts, a signal generating relay having an armature operable between two contacts, individual means of which one or the other is always operated for operating the armature of said signal generating relay in each direction between its contacts, means effective at the beginning of each transit of the armature of said signal responsive relay for conditioning the unoperated one of said operating means to be operated and effective at the end of each transit for conditioning the other operating means to be deactivated, and timing means for operating the unoperated one of said operating means, said unoperated means, upon being operated, causing the other operating means to be deactivated.

18. In a telegraph signal repeater, a signal responsive relay having an armature operable between two contacts, a pair of electron discharge devices having their control electrodes connected to said contacts, a signal generating relay operable in opposite directions by said electron discharge devices, a source of potential of effective polarity but ineffective voltage also connected to the control electrodes of said discharge devices, a source of potential of opposite polarity connected to the armature of said signal responsive relay for opposing the potential applied to the control electrode of one or the other of said discharge devices only during engagement by said armature with one or the other of its contacts, means for producing timed impulses, and means controlled by said timing means for impressing a potential on the control electrodes of said discharge devices of the same polarity as the first-mentioned source of potential whereby to activate the discharge device from the control electrode of which the armature of said signal responsive relay has disconnected the opposing source of potential.

19. In a telegraph signal responsive device, a signal responsive relay, normally inactive means activated by said relay for generating oscillatory current, means for deriving impulses from said oscillatory current, means for varying the time relation of said impulses to the cycles of said current, and second means for deriving impulses from said current in fixed time relation to the cycles thereof.

20. In a telegraph signal responsive device, a signal responsive relay, normally inactive means activated by said relay for generating oscillatory current, means for deriving impulses from said oscillatory current, means for varying the time relation of said impulses to the cycles of said oscillatory current, means controlled by said impulses for registering the signal responsive operation of said relay, second means for deriving impulses from said current in fixed time relation to the cycles thereof, and impulse counting means controlled by said second impulse deriving means.

21. In a telegraph signal responsive device, a signal responsive relay, normally inactive means activated by said relay for generating oscillatory current, means for deriving impulses from said oscillatory current, means for varying the time relation of said impulses to the cycles of said oscillatory current, means controlled by said impulses for registering the signal responsive operation of said relay, second means for deriving impulses from said current in fixed time relation to the cycles thereof, impulse counting means controlled by said second impulse driving means, and means controlled by said counting means upon counting a predetermined number of impulses for deactivating said current generating means.

22. In a start-stop telegraph signal responsive device, means for generating oscillatory current adapted to be started by one of a series of received impulses, and thereafter to generate cycles in approximate synchronism with said impulses and to be stopped at the end of said series, means for deriving timing impulses from said cycles, means for varying the time relation of said timing impulses to said cycles, means controlled by said timing impulses for registering said received impulses, second means for deriving timing impulses from said cycles in fixed time relation thereto, impulse counting means controlled by said second impulse deriving means, and means controlled by said counting means upon counting a predetermined number of said fixed time relation impulses for stopping said current generating means.

23. In a start-stop telegraph signal repeater, a signal responsive relay, means for generating oscillatory current adapted to be started by one of a series of signaling impulses received by said relay, and thereafter to generate cycles in approximate synchronism with the remaining impulses in said series and to be stopped at the end of said series, means for deriving timing impulses from said cycles, means for varying the time relation of said timing impulses to said cycles, a signal generating relay controlled jointly by said signal responsive relay and said impulse deriving means, second means for deriving timing impulses from said cycles in fixed time relation thereto, impulse counting means

controlled by said second impulse deriving means, and means controlled by said counting means upon counting a predetermined number of said fixed time relation impulses for stopping said oscillatory current generating means.

24. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, a normally conductive cold cathode electron discharge tube rendered non-conductive by said signal responsive relay upon response thereof to a signal for activating said impulse generator, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for controlling said transmitting relay, and means for reactivating said electron discharge tube a predetermined interval after the deactivation thereof whereby to disable said impulse generator.

25. In a regenerative repeater for the retransmission of received telegraph signals, a repeating device, means for preparing said device for operation in accordance with the marking and spacing character of the received signals, and means including a counting ring circuit comprising a plurality of electron discharge tubes corresponding in number to the impulse units in the signals to be retransmitted for accurately timing in a predetermined manner the operation of said repeating device.

26. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, electron discharge means controlled by said relay for setting said generator in operation, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, means for counting the impulses generated by said impulse generator, and means operated by said counting means upon counting a predetermined number of impulses for conditioning said electron discharge means in a manner to cause said impulse generator to restart its pulsing cycle upon the reception of a start signal impulse by said signal responsive relay.

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