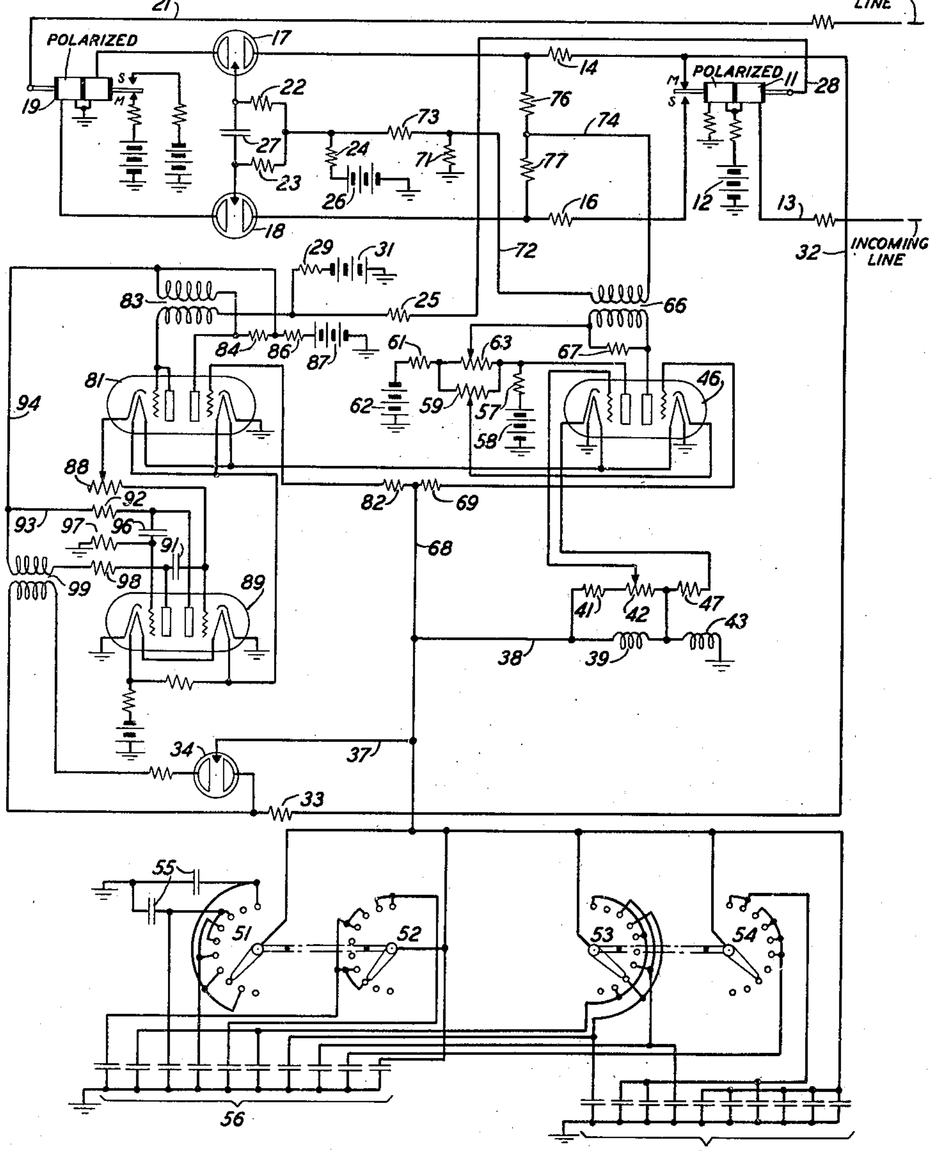
Nov. 8, 1949 | W. T. REA | 2,487,181

REGENERATIVE TELEGRAPH REPEATER UTILIZING AN IMPULSE GENERATOR

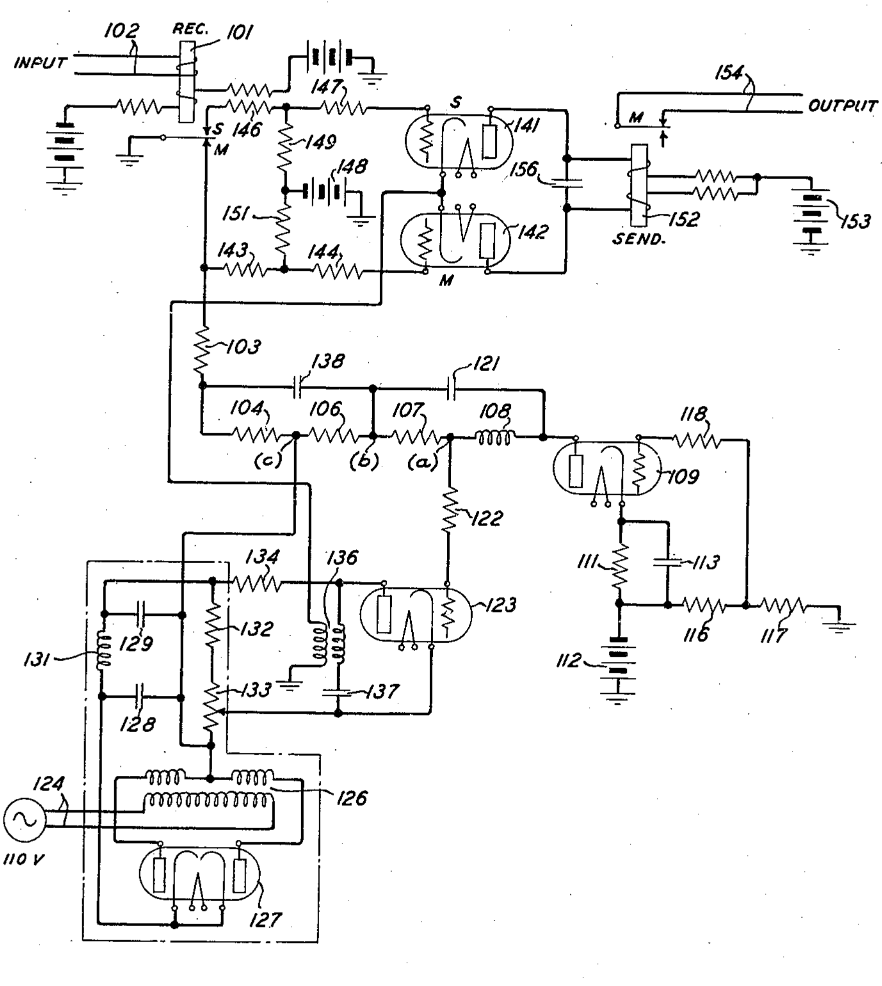
Filed June 3, 1947 | 3 Sheets-Sheet 1

FIG. 1



INVENTOR
W. T. REA
BY R. C. Terry
ATTORNEY

FIG.2



INVENTOR
W. T. REA
BY R. C. Terry
ATTORNEY

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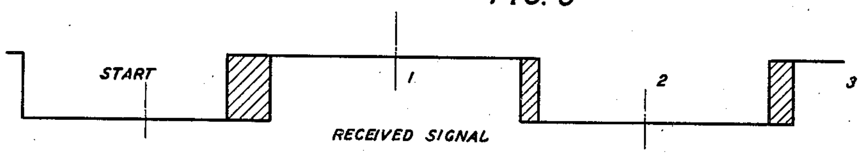
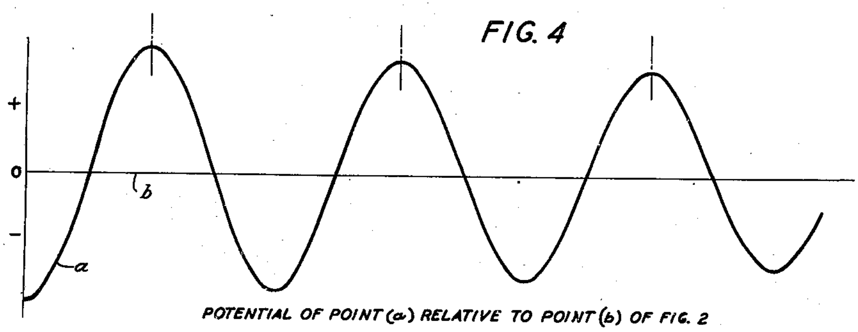
FIG. 3



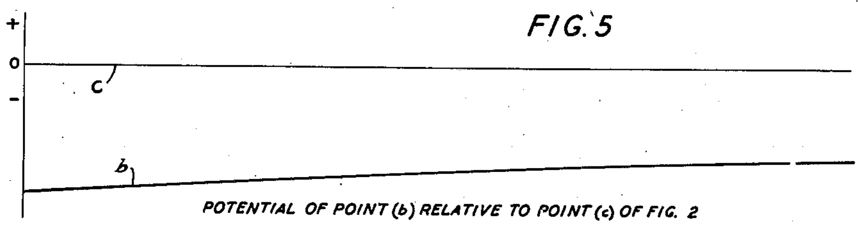
RECEIVED SIGNAL

FIG. 4



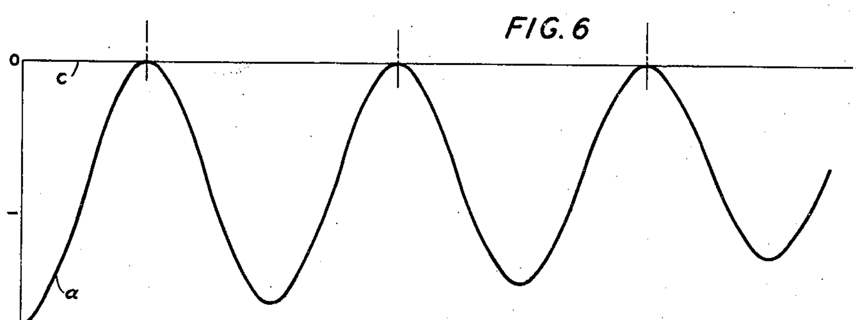
POTENTIAL OF POINT (a) RELATIVE TO POINT (b) OF FIG. 2

FIG. 5



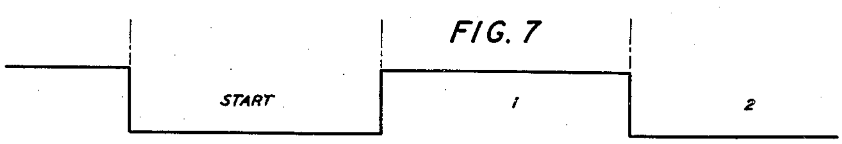
POTENTIAL OF POINT (b) RELATIVE TO POINT (c) OF FIG. 2

FIG. 6



POTENTIAL OF POINT (a) RELATIVE TO POINT (c) OF FIG. 2

FIG. 7



RETRANSMITTED SIGNAL

INVENTOR
W. T. REA
BY R. C. Terry
ATTORNEY

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UNITED STATES PATENT OFFICE

2,487,181

REGENERATIVE TELEGRAPH REPEATER UTILIZING AN IMPULSE GENERATOR

Wilton T. Rea, Manhasset, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Continuation of abandoned application Serial No. 545,781, July 20, 1944. This application June 3, 1947, Serial No. 752,248

9 Claims. (Cl. 178—70)

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

This application is a continuation of copending application Serial No. 545,781, filed July 20, 1944, now abandoned, which in turn is a continuation in part of copending application Serial No. 460,948, filed October 6, 1942, now Patent 2,454,089, by W. T. Rea and J. R. Wilkerson.

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 initiate and terminate the cycles of signal regeneration by electronic discharge tube means, thus dispensing with electromagnetic relays to perform this function.

One embodiment of the invention features a hot cathode gas-filled electron discharge tube for initiating cycles of signal regeneration.

Another embodiment of the invention features a cold cathode gas-filled electron discharge tube for initiating and terminating cycles of signal regeneration.

In accordance with both embodiments of the invention a signal receiving relay deactivates a normally operative electron discharge device which sets in operation an oscillatory circuit. The oscillatory circuit generates alternating current and the successive cycles of alternating current produce impulses at intervals equal to the telegraph impulse intervals of perfectly timed telegraph signals. 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 newly activated electron discharge device.

In accordance with one embodiment of the invention impulses generated by the oscillator and rectified are 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 conductive, which reactivates the

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

In accordance with another embodiment of the invention a condenser is associated with a resistor included in the anode-cathode circuit of the electron discharge tube initially deactivated by the receiving relay. This tube is a hot cathode gas-filled electron discharge tube and the condenser places a negative potential on the grid of this tube with respect to the cathode so that upon the deactivation of the tube the grid will prevent the immediate reactivation of the tube. The resistor associated with the condenser has a sufficiently high resistive value that the discharging of the condenser to a potential at which the grid of the tube can reactivate the tube will require an interval equal to the length of the signaling code upon which the system is operable. Upon being discharged to this potential the condenser permits the grid to reactivate the tube which in turn deactivates the oscillator, thus restoring the system to normal condition.

In the first described embodiment of the invention the normally conductive oscillator controlling tube which is deactivated by the receiving relay in response to a signal, is a cold cathode gas-filled electron discharge tube and the timing circuit which controls its reactivation is arranged to impress a potential difference between the control anode and the cathode of sufficient magnitude to break down the control gap and thereby ionize the tube. In the second described embodiment of the invention the tube which controls the activation and deactivation of the oscillator is a hot cathode gas-filled electron discharge tube controlled by a grid and the timing circuit comprising the condenser and resistor is arranged to permit the grid to approach the potential of the cathode and the limit of this approach is equality between the potentials of the grid and the cathode. The tube will be reactivated when or slightly before this condition of equality is reached.

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 cold cathode gas-filled electron discharge tube for activating and deactivating the oscillator;

Fig. 2 is a schematic circuit diagram showing the alternative embodiment of the regenerative repeater which employs a hot cathode gas-filled electron discharge tube for activating and deactivating the oscillator;

Fig. 3 is a diagrammatic representation of a portion of a received permutation code telegraph signal having distortion;

Fig. 4 is a diagrammatic representation of the voltage across a resistor in the timing oscillatory circuit of Fig. 2 during oscillation;

Fig. 5 is a diagrammatic representation of the voltage produced by condenser discharge across a resistor of Fig. 2 connected to the oscillatory circuit;

Fig. 6 is a diagrammatic representation of the combined effect or algebraic summation of the voltages represented in Figs. 4 and 5; and

Fig. 7 is a diagrammatic representation of the retransmitted signal.

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 nonconducting 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 2,370,685, patented March 6, 1945, by W. T. Rea and J. R. Wilkerson, 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 26, 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 supply a positive potential difference of the control anode with respect to the cathode of a few volts, 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 but 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.

With further and more detailed reference to the circuit of batteries 26 and 31, the resistor 71 is common to their return paths to ground. Since these batteries are oppositely connected with respect to resistor 71, they seek to drive current therethrough in opposite directions. The polarity of the potential difference across the resistor 71 will depend upon the relative voltages of batteries 26 and 31 and the resistive potential differences in their individual circuits which join at the resistor 71. With the armature of receiving relay 11 on its marking contact the potential across the control gap of the inactive tube 17 will be less positive than the potential difference across the resistor 71 by the potential difference across resistor 76 due to current flowing from battery 31. The potential difference across the control gap of tube 18 will be substantially equal to the potential difference across resistor 71 because there is no current flowing in resistor 77 except for the possibility of a very small current flowing from the control anode of tube 18 which is conductive at this time. The values of the resistors are such that the potential difference across resistor 76 is only a few volts less than the potential difference across resistor 71, and being opposite in polarity it impresses on the control anode of tube 17 a positive potential of a few volts with respect to the grounded cathode. The potential of the control anode of tube 18 with respect to the cathode is at a value intermediate that on the control gap of tube 17 and the firing potential of these tubes. This potential may be of the order of 50 volts as previously set forth.

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 this voltage opposed and reduced by the voltage across resistor 77 produced by current from 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 nonconductive 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 right-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 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 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.

In the embodiment of the invention shown in Fig. 2, the receiving relay 101 has its operating winding connected to the receiving line 102 and, in the idle condition, the operating winding is energized and holds the armature on the marking contact. The biasing winding of relay 101 has battery connection of the proper polarity to operate the armature to spacing when the line 102 is interrupted at the transmitting station. The marking contact of relay 101 is connected through resistors 103, 104, 106, 107 and inductance 108 all in series to the anode of a hot cathode, gas-filled, grid controlled, electron discharge tube 109. The armature of relay 101 is connected to ground and the cathode of tube 109 is connected through resistor 111 to the negative terminal of battery 112, the positive terminal of which is grounded. Thus the resistors 103, 104, 106, 107 and 111 and the inductance 108 are included in the anode-cathode current path of tube 109.

Cathode resistor 111 of tube 109 is shunted by a condenser 113 which is charged to the potential difference across the cathode resistor when tube 109 is conductive, which is the normal idle condition. A potential divider comprising resistors 116 and 117 is connected between the negative terminal of battery 112 and ground and the grid of tube 109 is connected through grid current limiting resistor 118 to the junction of resistors 116 and 117. The grid of tube 109 is at all times more positive than the negative terminal of battery 112 by the potential difference across resistor 116, but the cathode of tube 109 is more positive than the negative terminal of battery 112 by the potential difference across resistor 111 when tube 109 is conductive and the resistors are of such relative values that the grid of tube 109 is less positive than the cathode by an amount at least equal to the cut-off value of the tube, so that the grid would render the tube non-conductive except for the fact that the tube is gas-filled and the conductivity of the tube is not responsive to the negative potential of the grid once the tube has been rendered conductive. The condenser 113 in combination with the cathode resistor 111 serves to perform a character timing operation as will be described later.

The resistor 107 and inductance 108 connected in series are shunted by a condenser 121 and the junction *a* of the resistor and inductance is connected through grid current limiting resistor 122 to the grid of a hot cathode, gas-filled, grid controlled, electron discharge tube 123. The network comprising resistor 107, inductance 108 and condenser 121 is an oscillatory circuit for controlling the conductivity of tube 123. Power for operating tube 123 is supplied from alternating current power line conductors 124 through primary and center tapped secondary windings of transformer 126, full wave rectifier tube 127, smoothing filter comprising condensers 128 and 129 and choke oil 131, and output potential divider comprising resistors 132 and 133 in series.

The anode of tube 123 is connected through load resistor 134 to the upper end of resistor 132 which is the positive terminal of the power supply and the cathode of tube 123 is connected to an adjustable contactor associated with resistor 133. The primary winding of a transformer 136 is connected in series with a condenser 137 between the anode and cathode of tube 123. Instead of the power supply comprising an alternating current rectifier and smoothing filter, a battery could be employed for supplying operating power for tube 123. It will be noted that neither the positive nor the negative terminal of the power supply is grounded. The reason for this is that a floating source of potential is required for tube 123 as will be more fully described later and if a battery should be substituted for the power supply, it cannot be the battery 112 or any other battery supplying power to other parts of the circuit but must be a separate battery in order that neither of its terminals shall be grounded.

Resistors 104 and 106 in series are shunted by a condenser 138 and this network comprises an aperiodic circuit with condenser 138 charged to the potential across resistors 104 and 106 in series when tube 109 is conductive. The junction *c* of resistors 104 and 106 is connected to the negative terminal of the power supply for tube 123 and this connection is the cathode return for the grid of tube 123. With tube 109 conductive the grid of tube 123 is negative with respect to the cathode by the potential difference across the resistors 107 and 106 plus the potential difference across that portion of resistor 123 between its lower end and the cathode contactor, this latter potential difference being in the same polar sense or direction as the potential difference across resistors 107 and 106 and therefore being added to the potential difference across resistors 107 and 106. The grid of tube 123 is biased by the sum of these potential differences to a sufficiently negative value to hold tube 123 non-conductive and in the idle condition the tube is non-conductive.

The signal repeating circuit is associated with the marking and spacing contacts of receiving relay 101. It includes a pair of hot cathode, gas-filled, grid controlled electron discharge tubes 141 and 142 in a commutating circuit. The marking contact is connected through resistors 143 and 144 to the grid of tube 142 and the spacing contact is connected through resistors 146 and 147 to the grid of tube 141. Negative potential is supplied from battery 148, the positive terminal of which is grounded, through resistor 149 to the junction of resistors 146 and 147 and through resistor 151 to the junction of resistors 143 and 144. The cathodes of tubes 141 and 142 are connected through the secondary winding of transformer 136 to ground. The anodes of tubes 141 and 142 are connected through the oppositely poled windings of a polar sending relay 152 to the positive terminal of battery 153, the negative terminal of which is grounded.

The armature and marking contact of relay 153 are connected to the two conductors of an outgoing telegraph line 154. A tube quenching condenser 156 is connected between the anodes of tubes 141 and 142. In the idle condition tube 142 is conductive and current flowing in the lower winding of relay 152 operates the armature of the relay to the marking contact. Tube 141 is non-conductive.

Assume that the normal idle condition exists with tubes 109 and 142 conductive and tubes 123 and 141 non-conductive, and that the start impulse of a permutation code combination is received. As the armature of receiving relay 101 leaves the marking contact it interrupts the anode circuit of tube 109 thus cutting off current in the tube and this tube deionizes. Due to the charge on condenser 113, the potential difference across cathode resistor 111, which is of relatively high resistive value, decreases slowly as condenser 113 discharges through resistor 111, and the potential of the cathode will not be brought down to a value at which grid of tube 109 can refire the tube until about the time that the stop impulse at the end of the code combination should be received. In this way condenser 113 and resistor 111 time the refiring of tube 109 to a character interval.

Another result of the departure of the armature of receiving relay 101 from the marking contact is that a circuit from battery 148 through resistors 151 and 143 to ground is interrupted, terminating the flow of current through resistor 151 and making the grid of tube 142 more negative with respect to the cathode than it previously was by the amount of the potential difference which previously existed across resistor 151. This change in the potential of the grid of tube 142 will not cause tube 142 to be cut off because the tube is gas-filled and the grid can not perform this operation.

Upon arrival of the armature of receiving relay 101 at the spacing contact, a circuit is established from battery 148 through resistors 149 and 146, the armature and spacing contact of relay 101 to ground. The junction of resistors 149 and 146 is made less negative than it previously was by the amount of potential difference across resistor 149 resulting from the flow of current established in the circuit just traced. The cathode of tube 141 is substantially at ground potential due to its connection to ground through the secondary of transformer 136. Even with current flowing in resistor 149, the grid of tube 141 is not thereby brought to such potential that it can render tube 141 conductive.

With the flow of anode current of tube 109 through resistors 104, 106 and 107 and the inductance 108 interrupted, the network comprising resistor 107, inductance 108 and condenser 121 breaks into oscillation. The values of inductance 108 and condenser 121 are such that the circuit oscillates at the rate of one cycle per impulse interval of correctly timed permutation code signals, which is sometimes referred to as a frequency twice that of the signaling frequency, considering a marking and a spacing pulse each of a duration of one impulse interval as a signaling cycle. Due to the fact that there is no provision for feeding energy back into the oscillatory circuit to compensate for resistive energy losses within the circuit, the oscillator circuit will oscillate decrementally by which is meant that the amplitude of oscillation decreases throughout successive half cycles. The grid of tube 123 is connected to the right hand end of resistor 107, which is the junction *a* and the voltage across this resistor, starting at a negative maximum at its right hand end performs a damped oscillation, as shown in Fig. 4, alternately rising above and falling below the potential at the junction *b* of resistors 106 and 107 as a reference point.

At the same time that the oscillatory circuit breaks into oscillation, condenser 138 begins to discharge through resistors 104 and 106. The potential difference across resistor 106 is a maximum just before condenser 138 begins to discharge, with the junction *b* of resistors 106 and 107 negative with respect to the junction *c* of resistors 104 and 106, and this potential difference decreases, with the right hand end of resistor 106 becoming less negative with respect to the junction *c* of resistors 104 and 106 which is connected to the cathode of the tube 123 through a portion of resistor 133. The constants of the aperiodic network comprising resistors 104 and 106 and condenser 138 are so chosen that the curve representing the potential of the right hand end of resistor 106 with respect to the left hand end as time elapses, shown in Fig. 5, coincides with the envelope of the oscillatory current across resistor 107 which envelope is the curve of the decreasing amplitudes of successive cycles of the oscillatory potential across resistor 107. During the half cycle of oscillation in which the right hand end of resistor 107 is positive with respect to the left hand end, the potential difference across resistor 107 is opposed by the potential difference across resistor 106 and during the remaining half cycles the potential difference across resistor 106 is in series aiding relation to the potential difference across resistor 107. The algebraic sum of these potentials is impressed between the grid and the cathode of tube 123. Considering the junction *c* as a zero reference point, the result of the algebraic addition of the oscillatory potential in the oscillatory circuit and of the decaying potential in the aperiodic circuit is to shift upwardly the zero axis relative to potentials applied to the grid of the tube. By proportioning the two circuits so that the initial amplitude of the potential across resistor 106 in the aperiodic circuit is equal to the initial amplitude of the potential across resistor 107 in the oscillatory circuit, and so that the time constant of the discharge of the condenser in the aperiodic circuit is identical with the time constant of the envelope of the oscillatory current, the peak voltages in the positive half cycles of oscillatory operation are brought into coincidence with the shifted zero axis as shown in Fig. 6 which is the zero reference potential of junction *c*. From this it follows that the potential of the grid rises to a value that is negative with respect to that of the cathode only by the potential difference across that portion of the resistor 133 between the lower and the movable contactor once in each cycle of the oscillatory circuit and at all other times is more negative with respect to the cathode.

When the grid of tube 123 reaches a predetermined potential near that of the cathode, tube 123 is rendered conductive. The tube, upon firing, completes an oscillatory circuit through the primary of transformer 136 and condenser 137. The current in this circuit rises to a peak and then falls to zero tending to reverse. The current results from the discharging of condenser 137 and induces potentials in the primary of transformer 136. When the sum of the potentials across the transformer primary and the condenser becomes less than the discharge sustaining potential, the discharge in the tube is quenched and in the meantime the grid of the tube has been carried sufficiently negative with respect to the cathode by the oscillatory circuit that the tube is prevented from refiring and deionizes and remains non-conductive until the grid approaches cathode potential in the next cycle of the oscillator.

The rise and fall of current in the primary winding of transformer 136 generates an impulse in the secondary which is connected between ground and the cathodes of tubes 141 and 142.

At one phase in the generation of potentials in the secondary of transformer 136 the potential generated is positive toward ground and negative towards the cathode of tubes 141 and 142. This reduces the potential of the cathodes with respect to their grids. With the armature of receiving relay 101 engaging the spacing contact in response to the start impulse, the grid of tube 141 is less negative than the grid of tube 142 as previously described. The cathode of tube 141 is brought toward negative by the impulse generated in the secondary of transformer 136 to an extent with respect to the grid that permits tube 141 to become conductive. The discharge current flows in the upper winding of relay 152 and at the same time a negative pulse is impressed through condenser 156 on the anode of tube 142 reducing the anode-cathode potential in that tube below the discharge sustaining potential and quenching the tube. At the time tube 142 is quenched, the grid of the tube is more negative with respect to the cathode than is the grid of tube 141 even though the cathodes may at that instant be at the reduced potential resulting from the generation of the impulse of the secondary of transformer 136 so that the grid will not cause tube 142 to be refired and the tube will deionize. With current interrupted in the lower winding of relay 152, and flowing in the upper winding, the armature of the relay will be operated to spacing, opening the outgoing telegraph line and retransmitting the start impulse of spacing nature.

In the next cycle of the oscillatory circuit when tube 123 is rendered conductive momentarily, another impulse will be generated in the secondary of transformer 136 momentarily reducing or rendering less positive the potential of the cathodes of tubes 141 and 142. If the armature of relay 101 is then on the spacing contact indicative of the fact that the first significant impulse of the code combination to be repeated is spacing, tube 142 will not be rendered conductive because the potential of the cathode will not be lowered sufficiently to overcome the negative bias on the grid and tube 141 will remain conductive without interruption, the armature of transmitting relay 152 remaining on the spacing contact. If, however, the first significant impulse of the code combination is marking and the armature of relay 101 has returned to the marking contact, tube 142 will be conditioned to be fired by the armature of the receiving relay 101 and will be fired when the pulse of the proper polarity is generated in the secondary of transformer 136 and tube 142 in firing will quench tube 141 thereby operating transmitting relay 152 to restore the armature to the marking contact.

Fig. 3 represents a received signal that is to be regenerated and retransmitted. The shaded areas represent possible conditions of distortion. Specifically, the first shaded area represents the condition of marking bias, the second shaded area represents the condition of marking end distortion and the third shaded area represents the condition of spacing bias. As indicated by Figs. 4 and 6, the junction *a* and therefore the grid of tube 123 reaches its most positive potential, and therefore its minimum negative potential with respect to junction *c* and the cathode of tube 123 one-half impulse interval after reception of the beginning of the start impulse and at successive impulse intervals thereafter since bias and end distortion advance or retard various transitions relative to the beginning of the start impulse, they do not affect the middle portions of signals unless the signals have become so multilated as to be unintelligible. Accordingly, by causing tube 123 to fire at the middle of the received start impulse and at unit impulse intervals thereafter, the armature of receiving relay 101 is most certain to have reached a steady condition representing the impulse to be repeated. Since the firing of tube 123 determines the beginning of each retransmitted impulse, the retransmitted signal is delayed one-half impulse interval with respect to the received signal, and the start impulse and each selective impulse is of full duration, as represented in Fig. 7.

As the successive significant impulses of a telegraph code combination are received, the tubes 141 and 142 are alternatively conditioned to be fired in accordance with the spacing or marking nature of the impulses received by receiving relay 101 and the tube 123 controlled by the oscillatory circuit times the firing of these tubes. In this way the length of each retransmitted impulse is determined by the oscillatory circuit and a full impulse interval is allotted to each impulse, which constitutes regeneration of the signal and elimination of distortion.

About the time of the seventh activation of tube 123, for five unit code permutation code signals comprising a start impulse, five significant impulses and a stop impulse, or of the eighth activation of tube 123, for six unit code permutation code signals comprising a start impulse, six significant code impulses and a stop impulse, condenser 113 has become discharged and reduced the positive potential of the cathode of tube 109 relative to the grid to the firing potential of the tube. At this time the receiving relay 101 should be responding to the stop impulse of marking nature and the armature of the relay should be on the marking contact. Also, the seventh activation of tube 123 should have occurred and should have activated tube 142 for the retransmission of the stop impulse. Upon being reactivated the tube 109 causes a flow of steady current through resistors 103, 104, 106, 107, 111 and inductance 108. This steady current stops the flow of oscillatory current in the oscillatory circuit and reestablishes a steady current condition in inductance 108 associated with that network. It also recharges condenser 133 to the previous initial value. Resistors 103 and 111 which are in series with but are outside the oscillatory and aperiodic networks have such values that the oscillatory network and the aperiodic network return to the initial steady state condition in the shortest possible time. The apparatus will remain in this condition until the start impulse of the next code combination is received.

It was previously mentioned that the power supply for tube 123 is an ungrounded and therefore floating power supply. This is necessary because in response to each marking signal, the grounded armature of receiving relay 101 engages the marking contact which is connected to the negative side of the power supply through resistor 103 and resistor 104 of the aperiodic network. If any part of the output of the power supply for tube 123 should be held at ground potential, current might be caused to flow from the power supply through resistor 104 and resistor 103, or the resistor 104 might be short-circuited in the case of the direct grounding of the negative side of the power supply, which would disturb the operation of the aperiodic circuit and change the condenser discharge characteristic of this circuit and this in turn would disturb the grid cathode potentials of tube 123. By providing an ungrounded power supply for tube 123, or as a substitute therefore an ungrounded battery separate from any other battery of the repeater circuit, the changes of potential occurring in the signal regenerating circuit as a result of the receiving armature transit do not disturb the proper control of the tube 123 jointly by the oscillatory network and the aperiodic net work.

In the description of the operation of the oscillatory network and the aperiodic network to control tube 123, reference was made to the effect of that portion of potential divider 133 between the contactor and the lower or negative end of the resistance winding, namely, to provide a minimum negative bias on the grid of tube 123. The zero axis in Fig. 6 represents the potential of the cathode, but the potential at the junction *c*. If the contactor should be moved down to the lower end of potential divider 133, the cathode would have the same potential as the point *c*. The cathode is more positive than the point *c* by an adjustable amount determined by the position of the contactor with respect to the winding of potential divider resistor 133. The potential divider 133 provides for a certain amount of orientation adjustment, taking advantage of the characteristics of grid controlled gas-filled electron discharge tubes that the tube will be rendered conductive when the grid, approaching the potential of the cathode, reaches a predetermined negative voltage with respect to the cathode. It is not necessary for the grid to reach the potential of the cathode or to become positive with respect thereto in order to establish conductivity. For any setting of the contactor of the potential divider resistor 133, when the potential of the grid of tube 123, rising to less negative values, reaches that negative value relative to the cathode which is the characteristic conductivity potential difference of grid to cathode, the tube will be rendered conductive. The earliest possible firing of the tube relative to the cycles of oscillatory current will occur when the contactor of potential divider 133 is moved down to the lower end of the resistance winding because this represents complete removal of the fixed bias on the tube. The latest possible instant of firing of tube 123 relative to the cycles of oscillatory current coincides with the most positive peaks of the oscillatory potentials applied to the grid because this represents the condition of minimum potential difference between the cathode and grid, and firing of the tube at this instant will occur when the fixed bias is so adjusted by means of potential divider 133 that the grid just reaches the minimum negative potential relative to the cathode for firing the tube. If the fixed bias should be increased by moving the contactor of potential divider 133 still farther from the lower end of the resistance winding, tube 123 will not be activated cyclically under the control of the oscillatory network and signals will not be transmitted.

With the potential of the junction *a* arranged to start from extreme negative potential with respect to junction *b*, to rise to extreme positive value, and return to maximum negative, in an interval equal to one telegraph impulse interval and under the control of a received start impulse, the peak positive voltage of junction *a* will occur

one-half impulse interval after the departure of the armature of receiving relay 101 away from the marking contact in response to the start impulse and subsequent peak voltage conditions will occur at successive impulse intervals thereafter. From this it follows that the beginning of retransmission of the start impulse may be delayed a maximum of one-half of a telegraph impulse interval after the start impulse is effective upon receiving relay 101, as shown in Fig. 7, and that the retransmission of the start impulse may be initiated earlier than one-half of a telegraph impulse interval after the receiving relay responds to the start impulse by means of the orientation adjustment described in the preceding paragraph. The initiation of all subsequent impulses within a code combination will occur at unit intervals after the initiation of retransmission of the start impulse.

What is claimed is:

1. 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 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 means a predetermined interval after the deactivation thereof whereby to disable said impulse generator.

2. In a telegraph signal repeater, a signal responsive relay, a normally inactive impulse generator, a normally conductive gas-filled electron discharge tube rendered non-conductive by said signal responsive relay upon reponse 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 gas-filled tube a predetermined interval after the deactivation thereof whereby to disable said impulse generator.

3. In a telegraph signal repeater, a signal responsive relay, a normally conductive gas-filled electron discharge tube having its anode circuit normally completed through the armature and marking contact of said relay and adapted to be deactivated upon response of said relay to a signal, a normally inactive impulse generator adapted to be activated by said electron discharge tube upon the deactivation thereof, 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 gas-filled electron discharge tube a predetermined interval after the deactivation thereof whereby to disable said impulse generator.

4. In a telegraph signal repeater, a signal responsive relay, a signal transmitting relay, and an impulse generator for controlling said transmitting relay jointly with said signal responsive relay, said impulse generator comprising an oscillatory circuit adapted to generate an oscillatory potential having decremental amplitude, an electron discharge tube having an anode, a cathode and a control electrode and having its control electrode connected to said oscillatory circuit, and means connected between said oscillatory circuit and said cathode for causing said control electrode to reach a predetermined

potential with respect to said cathode at the amplitude extremes of alternate half cycles of said oscillatory potential.

5. In a telegraph signal repeater, a signal responsive relay, a signal transmitting relay, and an impulse generator for controlling said transmitting relay jointly with said signal responsive relay, said impulse generator comprising an oscillatory circuit adapted to generate an oscillatory potential having decremental amplitude, an electron discharge tube having an anode, a cathode and a control electrode, and having its control electrode connected to said oscillatory circuit, and a resistor and condenser network connected between said oscillatory circuit and said cathode having a potential difference time characteristic substantially identical with the envelope of said oscillatory potential for causing said control electrode to reach a predetermined potential with respect to said cathode at the amplitude extremes of alternate half cycles of said oscillatory potential.

6. In a telegraph signal repeater, a signal responsive relay, a signal transmitting relay, and an impulse generator for controlling said transmitting relay jointly with said signal responsive relay, said impulse generator comprising an oscillatory circuit adapted to generate an oscillatory potential having decremental amplitude, an electron discharge tube having an anode, a cathode and a control electrode and having its control electrode connected to said oscillatory circuit, and a resistor and condenser network connected between said oscillatory circuit and said cathode having a potential difference time characteristic substantially identical in configuration and magnitude with the envelope of said oscillatory potential for causing said control electrode to reach a predetermined potential with respect to said cathode at the amplitude extremes of alternate half cycles of said oscillatory potential.

7. In a telegraph signal repeater, a signal responsive relay, a normally activated electron discharge tube adapted to be deactivated by said signal responsive relay upon response thereof to a signal, a signal transmitting relay, a normally inactive impulse generator rendered active by said electron discharge tube upon the deactivation of said tube for controlling said transmitting relay jointly with said signal responsive relay, said impulse generator comprising an oscillatory circuit connected in the discharge circuit of said tube adapted upon activation to generate an oscillatory potential having decremental amplitude, a normally non-conductive electron discharge tube having an anode, a cathode and a control electrode and having its control electrode connected to said oscillatory circuit, a resistor and condenser network also connected in the discharge path of said first-mentioned tube and connected to the cathode of said second-mentioned tube and having a potential difference time characteristic substantially identical in configuration and magnitude with the envelope of said oscillatory potential for causing said control

electrode to reach a predetermined potential with respect to said cathode at the amplitude extremes of alternate half cycles of said oscillatory potential, and means for activating said first-mentioned tube a predetermined interval after the deactivation thereof whereby to deactivate said impulse generator.

8. In a telegraph signal repeater for regeneratively repeating start-stop telegraph signals, a signal responsive relay, a normally activated electron discharge tube adapted to be deactivated by said relay upon response thereof to a start impulse of a telegraph signal, a signal transmitting relay, a normally inactive impulse generator rendered active by said electron discharge tube upon the deactivation of said tube for controlling said transmitting relay jointly with said signal responsive relay, said impulse generator comprising an oscillatory circuit connected in the discharge circuit of said tube and adapted upon activation to generate an oscillatory potential having decremental amplitude, a normally non-conductive electron discharge tube having an anode, a cathode and a control electrode and having its control electrode connected to said oscillatory circuit, a resistor and condenser network also connected in the discharge path of said first-mentioned tube and connected to the cathode of said second-mentioned tube and having a potential difference time characteristic substantially identical in configuration and magnitude with the envelope of said oscillatory potential for causing said control electrode to reach a predetermined potential with respect to said cathode at the amplitude extremes of alternate half cycles of said oscillatory potential, and timing means for activating said first-mentioned tube during reception by said signal responsive relay of the stop impulse of a telegraph signal whereby to deactivate said impulse generator.

9. 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 upon the reception of a start signal impulse by the relay, a signal transmitting relay, means controlled jointly by said signal responsive relay and said impulse generator for operating said transmitting relay, and means operative when a predetermined number of impulses have been generated by said impulse generator for conditioning said electron discharge means in a manner to cause said impulse generator to restart its pulsing cycle upon the reception of the next start signal impulse by said signal responsive relay.

WILTON T. REA.

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