Aug. 8, 1950 J. A. KRECEK 2,518,027

TELEGRAPH REPEATER

Filed May 18, 1946 2 Sheets-Sheet 1

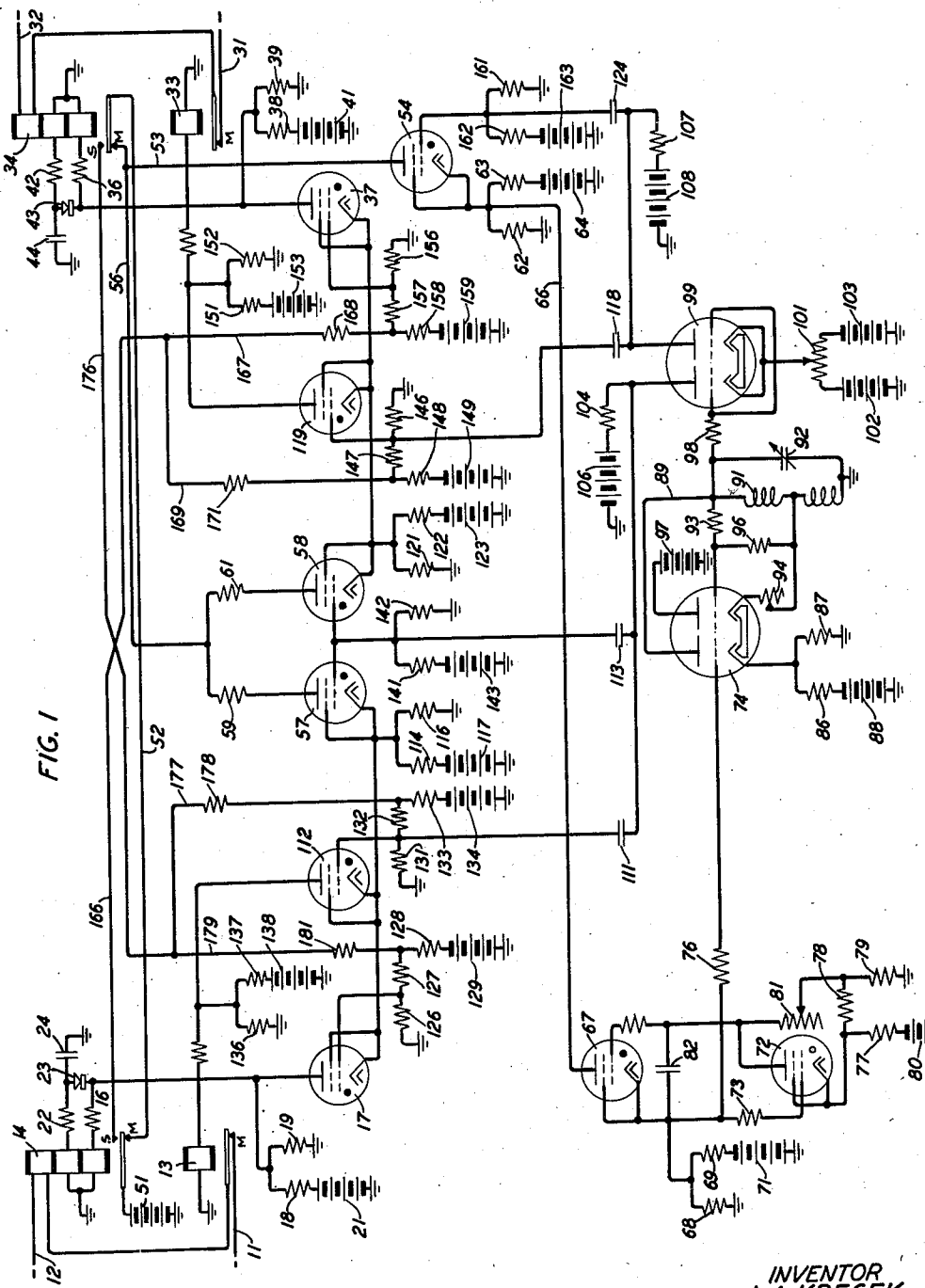

FIG. 1

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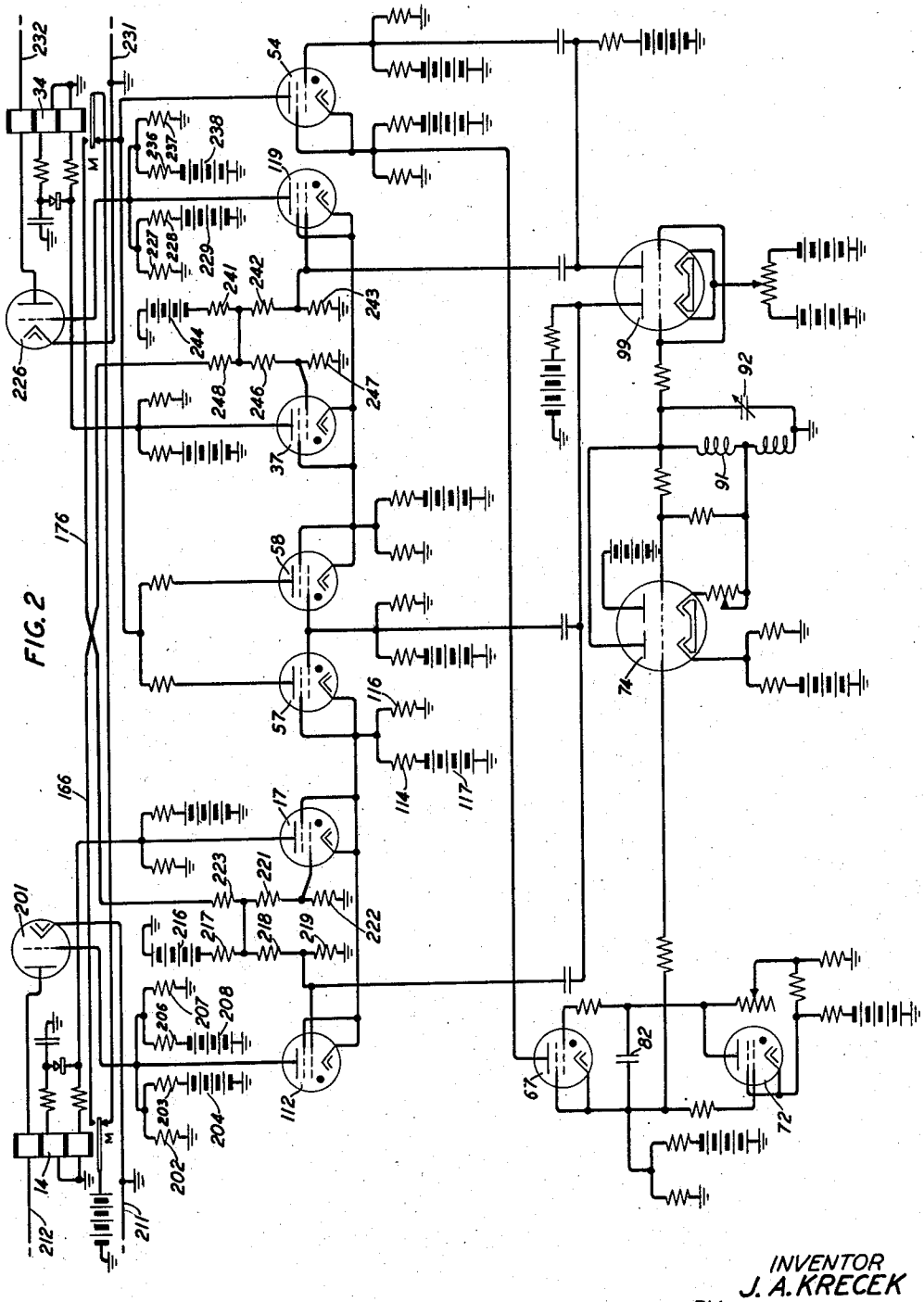

FIG. 2

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TELEGRAPH REPEATER

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11 Claims. (Cl. 178—71)

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This invention relates to telegraph repeaters and particularly to electronic regenerative repeaters.

An object of the invention is to minimize the number of electromagnetic relays required to repeat telegraph signals regeneratively.

Another object of the invention is to control the regenerative retransmission of signals by means of gas-filled electron discharge tubes.

Another object of the invention is to employ an electron discharge tube as a transmitter of direct current telegraph signals.

The invention features a circuit arrangement in which the current through the winding of a telegraph signal transmitting relay is reversed and thereafter restored to initial direction by virtue of the firing and subsequent quenching of a gas-filled electron discharge tube.

The invention is contemplated in two embodiments. Each of the embodiments of the invention is a two-way half-duplex electronic regenerative repeater by which is meant that transmission may proceed in either direction through the repeater, one direction at a time. In accordance with one embodiment of the invention each of the two lines to be interconnected by the repeater is terminated in a loop which includes the operating winding of a receiving relay and the armature and marking contact of a transmitting relay. A series circuit from positive battery through the armature and marking contacts of both receiving relays to the anode of an electron discharge tube establishes an anode-cathode discharge path for the tube which, being normally conductive in the idle condition of the repeater with both of the receiving relays in the marking condition, holds inactive a start-stop oscillator. Upon operation of either receiving relay to spacing in response to a spacing signal as, for example, the start impulse of start-stop telegraph signals, the anode circuit of the discharge tube is interrupted, quenching the tube, and either of two parallel paths is completed from the positive battery to potential dividers associated with the grids of individual gas-filled electron discharge tubes having the operating windings of the transmitting relays connected in their anode circuits. The connection of the positive battery to either of the potential dividers provides a preparatory grid biasing

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condition for its associated tube and the relationships are such that either receiving relay, upon operating to spacing, preparatorily biases the grid of the tube associated with the transmitting relay on the opposite side of the repeater.

When the first-mentioned tube becomes deactivated the oscillator breaks into oscillation and oscillates at a frequency of one cycle per impulse interval of correctly timed telegraph signals, and a detector circuit derives timing impulses at the rate of one impulse per cycle. These impulses are applied to the control grids of the electron discharge tubes associated with the operating windings of the transmitting relays. The timing impulse renders conductive whichever of the last-mentioned electron discharge tubes that was preparatorily biased by the receiving relay on the opposite side of the repeater, and the tube, upon becoming conductive, operates its associated transmitting relay to spacing, thereby initiating the retransmission of a spacing signal over the other telegraph line. The impulses applied to the transmitting control tubes by the detector circuit are of momentary duration but since the tubes are gas-filled tubes the activated tube remains conductive and continues the retransmission of the spacing signal.

In addition to the anode circuit for the oscillator control tube, the previously mentioned series circuit from the positive battery to the armature and marking contacts of the receiving relays provides an anode circuit for a pair of gas-filled electron discharge tubes each of which has its cathode connected to the cathode of one of the transmitting control tubes and to a potential divider. In the idle condition of the repeater the pair of tubes connected to the series circuit is normally conductive along with the oscillator control tube, and upon the operation of either receiving relay to spacing they are quenched along with the oscillator control tube. The tubes of the pair are always preparatorily biased and their control grids receive a pulse from the detector circuit at the same time as the transmitting control tubes. However, at the time of activation of either of the transmitting control tubes due to the response of a receiving relay to a spacing signal the tubes of the pair cannot be activated because their common anode circuit is

open at the marking contact of the receiving relay which is operated to spacing.

Upon the application of the next timing pulse to the control grids of the transmitting control tubes and to the grids of the pair of tubes, if the receiving relay which had been operated to spacing has returned to marking in response to a marking signal as, for example, the first significant impulse of a telegraph code combination, the common anode circuit of the pair of tubes will have been reestablished through the series circuit and the preparatory bias will have been removed from the control grid of the transmitting control tube which is then conductive, and the pair of tubes will be reactivated. As a result of the reestablishment of a flow of current through the pair of tubes from the potential divider associated with their cathodes, those cathodes undergo a rise in potential and the cathodes of the transmitting control tubes, being connected to the cathodes of the pair of tubes, undergo a corresponding rise. In the case of the transmitting control tube which is conductive the rise in cathode potential decreases the anode-to-cathode potential difference in that tube below the discharge sustaining potential and thereby quenches the tube, permitting the associated transmitting relay to return marking to retransmit the marking impulse.

If the receiving relay has not returned to marking when the next timing impulse is applied to the pair of tubes, their common anode circuit will be open, they cannot be activated, the potential of the cathode of the transmitting control tube which is conductive will remain unchanged and the tube will remain conductive, continuing the transmission of a spacing impulse, which may be the first significant impulse of a telegraph code combination.

The oscillator control tube has its control grid connected to receive timing pulses from the detector circuit along with the previously mentioned tubes. Its control grid is always preparatorily biased so that each time its control grid receives an impulse and the receiving relays are both in the marking condition, the tube will be reactivated. The control of the oscillator circuit by the oscillator control tube is indirect, there being a timing circuit including electron discharge tubes and a condenser timing circuit interposed between them. Each time the oscillator control tube is reactivated it seeks to cause the timing circuit to stop the oscillator. However, the timing circuit cannot be caused to stop the oscillator until an interval equal to that occupied by a start-stop telegraph signal combination has elapsed following the starting of the oscillator. Accordingly, the timing circuit does not become prepared to cause the stopping of the oscillator until about the time that the stop impulse of a telegraph code combination is received. At the time that the timing circuit does become prepared to stop the oscillator, if the oscillator control tube is then conductive, the oscillator will be stopped. If the oscillator control tube has not yet become conductive and is awaiting the detector impulse pertaining to the stop impulse of the telegraph signal combination at the time that the timing circuit becomes prepared to stop the oscillator, the oscillator will not be affected. Upon the activation of the oscillator control tube in response to the timing pulse pertaining to the stop impulse of the telegraph signals the timing circuit will be caused to stop the oscillator. It will be apparent from the foregoing that the two-way repeater corresponding to this embodiment of the invention includes only four electromagnetic relays, namely, the two receiving relays and the two transmitting relays, and that all timing operations and all selecting operations pertaining to the retransmission of marking and spacing impulses are performed by electron discharge tubes.

In accordance with another embodiment of the invention the electromagnetic transmitting relays are omitted and in their stead vacuum tubes are employed, one in place of each transmitting relay, the telegraph line terminating loop including the operating windings of the receiving relays and the anode-cathode discharge paths of the vacuum tubes. Normally, and in the idle condition of the repeater the vacuum tubes included in the line circuit are biased for conductivity and current flows, representing a marking condition and maintaining the receiving relays operated to their marking contacts. When either receiving relay responds to a spacing signal, such as the start impulse of a telegraph code combination, which is represented by opening of the telegraph line at the remote transmitting station, the receiving relay operates to spacing and the current through the associated vacuum tube which replaces the electromagnetic transmitting relay is cut off.

The impulse selecting, impulse timing and character timing operations are performed by the same arrangement of oscillator, detector, oscillator control tube and character timing circuit and transmitting control tubes as in the previously described embodiment. The spacing transmitting control tubes have their anodes associated with potential dividers and connected to the control grids of the vacuum tubes which have been substituted for the electromagnetic transmitting relay. Upon the activation of either one of the spacing transmitting control tubes, it biases the grid of the associated vacuum tube in the telegraph line terminating loop to cut-off, thereby effecting the transmission of a spacing impulse in all respects comparable with the opening of the loop by the armature of the transmitting relay in the previously described embodiment of the invention. Upon the activation of the pair of tubes having the common series circuit associated with their anodes, they quench whichever of the spacing signal transmitting control tubes that is then conductive, thereby restoring the cut-off vacuum tube to conductive condition and effecting the retransmission of a marking impulse. It will be noted that in this embodiment of the invention only two electromagnetic relays are employed, namely, the receiving relays, all impulse selecting, impulse timing and character timing operations and also the spacing impulse transmitting operations being performed by electron discharge tubes.

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 one embodiment of the invention; and

Fig. 2 is a schematic circuit diagram showing another embodiment of the invention.

Referring now to the drawings and particularly to Fig. 1, a telegraph line comprising conductors 11 and 12 extends to a remote telegraph station (not shown) at which the telegraph signaling battery is located. Conductor 11 of the line terminates in the regenerative repeater at the mark-

ing contact of a transmitting relay 13 and conductor 12 extends through the operating winding of a receiving relay 14 to the armature of transmitting relay 13. When the line comprising conductors 11 and 12 is closed at the remote station through the signaling battery, current in the operating winding of relay 14 holds the armature on the marking contact. The biasing winding of relay 14, which is the lowermost winding, has one terminal connected to ground and the other terminal connected through resistor 16 to the anode of an electron discharge tube 17 and to a potential divider comprising resistors 18 and 19 and battery 21. Tube 17 is preferably a gas-filled tube and in the idle condition of the repeater is cut off. The potential divider under this condition of tube 17 provides a flow of current for the biasing winding of relay 14 seeking to drive the armature to spacing, but the operating winding of the relay dominates and holds the armature on the marking contact. The middle winding of receiving relay 14 is a holding winding and has one terminal connected to ground and the other terminal connected through resistor 22 and varistor or unidirectional conducting device 23 to the anode of tube 17 and to the potential divider comprising resistors 18 and 19, and the junction of resistor 22 and varistor 23 is connected to one terminal of condenser 24, the other terminal of which is grounded.

The opposite line circuit, over which signals received on the line circuit comprising conductors 11 and 12 are adapted to be repeated, comprises conductors 31 and 32 which extend to a remote telegraph station at which the battery for supplying signaling current is located. Conductor 31 terminates in the repeater at the marking contact of transmitting relay 33 and conductor 32 extends through the operating winding of a receiving relay 34 to the armature of transmitting relay 33. The biasing winding, which is the lowermost winding, of relay 34 is connected through resistor 36 to the anode of an electron discharge tube 37, which may be like the tube 17, and to a potential divider comprising resistors 38 and 39 and battery 41. The holding winding of relay 34, which is the middle winding, is connected through resistor 42 and varistor 43 to the anode of tube 37 and to the potential divider comprising resistors 38 and 39, and the junction of resistor 42 and varistor 43 is connected to one terminal of condenser 44, the other terminal of which is connected to ground.

With the repeater in the normal idle condition, relays 14 and 34 being operated to marking, a circuit is traced from the positive terminal of battery 51, armature and marking contact of relay 14, conductor 52, armature and marking contact of relay 34, to branching paths, one of which extends through conductor 53 to the anode of electron discharge tube 54, which is preferably a gas-filled tube and the other of which extends through conductor 56 to the anodes of tubes 57 and 58 through load resistors 59 and 61 respectively. Tubes 57 and 58 are preferably of the same type as tubes 17, 37 and 54. At this time tubes 57, 58 and 54 are conductive. No special importance attaches to the fact that tubes 57 and 58 are conductive but tube 54 maintains the impulse and character timing circuits dormant.

The cathode of tube 54 is connected to a potential divider comprising resistors 62 and 63 and battery 64 which has its positive terminal grounded. It is a characteristic of gas-filled tubes that when they are conductive the cathode

is less positive than the anode by only a small potential difference. The cathode of tube 54 is also connected by conductor 66 to the anode of a gas-filled electron discharge tube 67. Accordingly, the anode of tube 67 is only slightly less positive than the anode of tube 54. The cathode of tube 67, which is conductive at this time, is connected to the junction of resistors 68 and 69 which are connected in series between negative battery 71 and ground. The tube 67 has a low and substantially constant anode to cathode voltage drop when conductive and the values of resistors 68 and 69 are such that the cathode is slightly positive with respect to ground.

The control grid of a tube 72, which is similar to tube 67, is connected to the cathode of tube 67 through resistor 73. The control grid of the left-hand triode section of a twin triode electron discharge tube 74, which is preferably a vacuum tube, is also connected to the cathode of tube 67 through a resistor 76. The cathode of tube 72 is connected to the junction of resistors 77 and 78 connected in series with resistor 79 between negative battery 80 and ground. The anode of tube 72 is connected through variable resistor 81 to the junction of resistors 78 and 79. A condenser 82 is connected between the anode of tube 72 and the cathode of tube 67.

Since the cathode of tube 67 is slightly positive with respect to ground as previously stated, the grid of tube 72 is also slightly positive with respect to ground. The cathode of tube 72 is negative with respect to ground by virtue of the potential divider comprising resistors 77, 78 and 79, so that the control grid of tube 72 is positive with respect to the cathode and the tube is conductive. Resistor 81 is of high value, so that only a very small current is drawn by tube 72. Condenser 82 is charged to the difference in potential between the cathode of tube 67 and the anode of tube 72 and the charge on the condenser is positive on the left-hand plate by virtue of the fact that the cathode of tube 67 is slightly positive with respect to ground and negative on the right-hand plate by virtue of the fact that the anode of tube 72 is negative with respect to ground by the potential difference across resistor 79 and the potential difference across variable resistor 81 due to the anode current through the tube.

The cathode of the left-hand triode section of tube 74 is connected to the junction of resistors 86 and 87, connected in series between negative battery 88 and ground. Accordingly, the cathode of the left-hand triode section of tube 74 is negative with respect to ground. The grid of the left-hand triode section of tube 74 is positive with respect to ground by virtue of its connection to the cathode of tube 67. It follows that the grid to cathode potential is such as to render the left-hand triode section of the tube conducting. The left-hand anode is connected through conductor 89 and winding of tapped inductance 91 to ground. Since the left-hand triode section of tube 74 is conductive, a steady direct current flows in inductance 91. The inductance is shunted by a condenser 92, and the inductance and condenser together form an oscillatory circuit which is held in a non-oscillating condition by the direct current through the inductance winding 91, with a small charge on condenser 92 equal to the ohmic potential difference across inductance 91, and with energy stored in the magnetic field produced by the steady direct current through the inductance winding. The upper terminal of inductance

winding 91 is connected through resistor 93 to the grid of the right-hand triode section of tube 74. The tap terminal of inductance winding 91 is connected through variable resistor 94 to the cathode of the right-hand triode section of tube 74. The grid is also connected to the tap terminal of inductance winding 91 through resistor 96. These elements comprising inductance winding 91, condenser 92 and the right-hand triode section of tube 74, and their interconnections, will be recognized as an electron tube oscillator circuit. The condenser 92 is preferably adjusted so that the frequency of the oscillator is twice the telegraph signaling frequency, from which it follows that the duration of each cycle of the oscillator is equal to the duration of one impulse of correctly timed telegraph signals. The anode of the right-hand triode section of tube 74 is connected to positive battery 97.

The upper terminal of inductance winding 91 is slightly negative with respect to ground by the amount of the steady potential difference across the inductance winding. This negative point is connected through resistor 98 to the grids of both triode sections of a twin triode tube 99 which is preferably a vacuum tube. The cathodes of tube 99 are connected to the movable contactor of the potentiometer 101 connected between positive and negative batteries 102 and 103 respectively. The left-hand anode of tube 99 is connected through resistor 104 to positive battery 106 and the right-hand anode of tube 99 is connected through resistor 107 to positive battery 108. With the grids of tube 99 slightly negative with respect to the cathodes, there may be a small discharge current flowing in both halves of the tube and, therefore, the current flowing through resistors 104 and 107 may cause the anodes of the tube to be slightly less positive than the full potential of batteries 106 and 107. The left-hand anode of tube 99 is connected through condenser 111 to the grid of a gas-filled electron discharge tube 112 which may be similar to the tubes 17, 57, 58, 37, 54, 67 and 72. The same anode is also connected through condenser 113 to the control grid of tubes 57 and 58. The cathodes of tubes 17, 57 and 112 are connected to the junction of resistors 114 and 116 connected in series between negative battery 117 and ground. The right-hand anode of tube 99 is connected through condenser 118 to the control grid of an electron discharge tube 119 which is preferably gas-filled and may be of the same type as the others hereinbefore described. The cathodes of tubes 58, 119 and 37 are connected to the junction of resistors 121 and 122 connected in series between negative battery 123 and ground. The right-hand anode of tube 99 is also connected through condenser 124 to the grid of tube 54.

Biasing potential for tube 17 is supplied at the junction of resistors 126 and 127 connected in series with resistor 128 between negative battery 129 and ground. Biasing potential for tube 112 is supplied from the junction of resistors 131 and 132 connected in series with resistor 133 between negative battery 134 and ground. Anode potential for tube 112 is supplied at the junction of resistors 136 and 137 connected between positive battery 138 and ground. Biasing potential for tubes 57 and 58 is supplied from the junction of resistors 141 and 142 connected in series between negative battery 143 and ground. Biasing potential for tube 119 is supplied from the junction of resistors 146 and 147 connected in series with resistor 148 between negative battery 149 and ground. Anode potential for tube 119 is supplied from the junction of resistors 151 and 152 connected in series between positive battery 153 and ground. Biasing potential for tube 37 is supplied from the junction of resistors 156 and 157 connected in series with resistor 158 between negative battery 159 and ground. Biasing potential for tube 54 is supplied from the junction of resistors 161 and 162 connected in series between negative battery 163 and ground.

In the idle condition of the repeater, the condition of the gas-filled tubes is as follows:

Tube 17—quenched		Tube 67—conductive	
Tube 37—quenched		Tube 72—conductive	
Tube 54—conductive		Tube 112—quenched	
Tube 57—conductive		Tube 119—quenched	
Tube 58—conductive			

It will be assumed that start-stop permutation code signals begin to be received by the repeater from the line circuit comprising conductors 11 and 12 to be repeated in the line circuit comprising conductors 31 and 32. The start impulse of the first permutation code signal combination is of spacing nature and causes the armature of receiving relay 14 to travel from the marking to the spacing contact. The armature, upon leaving the marking contact, disconnects battery 51 from the circuit previously traced over conductor 52, the armature and marking contact of receiving relay 34, conductor 53 to the anode of tube 54 and conductor 56 to the anode of tubes 57 and 58. These tubes, having their anode potential thus disconnected are quenched. With tube 54 quenched, its cathode immediately goes to a more negative potential than it had when the tube was conductive and carries the anode of tube 67 more negative to a value below the discharge sustaining potential of tube 67 and this tube likewise becomes quenched. With tube 67 quenched, the potential of the cathode drops abruptly to that maintained by the potentiometer comprising resistors 68 and 69 and battery 71. The control grid of tube 72 and the grid of the left-hand triode section of tube 74 will undergo a corresponding drop in potential and, in the case of tube 72, the new grid potential is below the firing potential. The abrupt decrease in the potential of the cathode of tube 67 causes a negative pulse to be impressed through condenser 82 on the anode of tube 72, reducing the anode potential below the discharge sustaining potential and thus cutting off this tube. None of the gas-filled tubes is now conducting. In the case of the left-hand triode section of vacuum tube 74, the new grid potential is below the cut-off potential of the tube so that the flow of direct current through the anode-cathode circuit of this tube, which includes inductance winding 91, is interrupted.

Due principally to the energy stored in the magnetic field of inductance 91 and also to a small extent to the charge on condenser 92, this circuit begins to oscillate at a frequency of one cycle per impulse interval of telegraph signals and oscillation at uniform amplitude is maintained by the right-hand triode section of tube 74. The grids of tube 99 are connected to the upper terminal of inductance winding 91 as previously described, and starting from a slightly negative potential with respect to ground these grids will swing positive in the first half-cycle of oscillation of the oscillatory circuit, which is the positive half-cycle and in each succeeding odd half-cycle. As the grids swing positive, the flow of current in both triode sections of tube 99

increases and the anodes become less positive due to the increase in potential difference across resistors 104 and 107. As the anodes swing less positive in potential, negative impulses are applied through condensers 111, 113, 118 and 124 respectively, to the grids of tube 112, tubes 57 and 58, tube 119 and tube 54, thus decreasing the potential of these grids with respect to their cathodes. As the conductivity of the triode sections of tube 99 decreases in the second half of the positive half-cycle of oscillation of the oscillatory circuit the anodes of tube 99 swing more positive in potential and positive pulses are impressed through condensers 111, 113, 118 and 124 on the control grids of tubes 112, 57, 58 119, and 54 momentarily carrying those grids above the firing potential with respect to their cathodes. This occurs once for each cycle of oscillation of the oscillatory circuit.

In the meantime condenser 82, having applied to its left-hand plate the reduced potential of the cathode of tube 67, discharges. The discharging circuit includes high variable resistor 81 so that the discharging of the condenser is slow and is adjustable by means of variable resistor 81. The discharging of condenser 82 is a character timing operation as will be described later.

Returning again to consideration of relay 14, when the armature reaches the spacing contacts it completes a conductive path from battery 51 over conductor 166 to branching paths one extending through conductor 167 and resistor 168 to the junction of resistors 157 and 158 and the other extending through conductor 169 and resistor 171 to the junction of resistors 147 and 148. The connection of positive battery 51 to these potential divider junction points results in raising the potentials of the control grids of tubes 119 and 37 relative to their cathodes. In the case of tube 119 the new potential of the control grid is still below the firing potential, so that tube 119 does not fire. In the case of tube 37, the new potential is above the firing potential and the tube fires. Due to the flow of discharge current through tube 37 from the potential divider comprising resistors 38 and 39, the anode of the tube swings from a positive to a negative potential relative to ground. This reverses the flow of current in the biasing winding of receiving relay 34, changing the bias condition from a spacing to a marking bias. This is in preparation for the operation of transmitting relay 33 which, upon being operated to spacing for the retransmission of the spacing impulse, interrupts the flow of current through the operating winding of relay 34, which would operate its armature to spacing were it not for the reversal of the current through the biasing winding, thereby seeking to repeat back to the line circuit comprising conductors 11 and 12 the spacing impulse received by relay 14 from that line circuit. The relatively negative potential on the anode of tube 37 is at the polarity from the standpoint of varistor 43 which causes it to pass current in its forward direction and this current flows to charge condenser 44 in preparation for energization of the middle or locking winding in the marking direction. As the condenser becomes charged current will also flow through resistor 42 and the middle or locking winding of relay 34 in the marking direction thus aiding the lowermost or biasing winding now conducting current in the marking direction.

When the first positive pulse is impressed on condensers 111, 113, 118 and 124 by tube 99, the grids of tubes 112, 57, 58, 119 and 54 are momentarily made more positive with respect to their cathodes. Tube 112 cannot fire because it has received no preparatory bias through the spacing contact of receiving relay 34. Tubes 54, 57 and 58 cannot fire because their anode circuits are opened at the marking contact of receiving relay 14. Tube 119 is preparatorily biased and it fires. In the same manner that tube 37 reversed the flow of current through the biasing winding of relay 34, tube 119 reverses the flow of current through the winding of transmitting relay 33, causing that relay to move its armature away from the marking contact, thereby opening the terminating loop of the line circuit comprising conductors 31 and 32 and transmitting a spacing impulse.

It will be understood that transmitting relay 33, and also transmitting relay 13, could be a neutral relay instead of a polar relay, or could be a spring biased polar relay. Under these circumstances, and with reference to relay 33, a potentiometer and battery combination adjusted to provide substantially the same potential as that at the anode of tube 119 may be substituted for the ground connection to the relay. Under these circumstances relay 33 would normally be deenergized. Upon the activation of tube 119 accompanied by the swinging of its anode from positive to negative with respect to ground, relay 33 would be energized to disengage its armature from the marking contact, thereby effecting the transmission of a spacing signal.

During the transmission of the spacing impulse, the condition of the gas-filled tubes is as follows:

Tube 17—quenched	Tube 67—quenched
Tube 37—conductive	Tube 72—quenched
Tube 54—quenched	Tube 112—quenched
Tube 57—quenched	Tube 119—conductive
Tube 58—quenched	

It will be assumed that the first significant impulse of the code combination, which is the impulse following the start impulse, is of marking nature. In response to this impulse, receiving relay 14 reoperates its armature from the spacing to the marking contact. As the armature leaves the spacing contact, it removes the preparatory bias from the control grid of tube 119 and the firing bias from the control grid of tube 37. The restoration of these tubes to their previous condition of bias does not affect the conductivity of these tubes because of their characteristics as gas-filled tubes that, having been fired, they are no longer responsive to control by their control grids and, accordingly, they remain conductive and maintain the marking condition of relay 34 and the spacing condition of relay 33. As the armature of receiving relay 14 reengages its marking contact, it reconnects battery 51 to the anodes of tubes 57, 58 and 54. The reconnection of anode potential to these tubes does not change their condition of non-conductivity because their control grids have only the normal bias which, as previously described, is below the firing potential of the control grid.

One cycle of the oscillator circuit after the first positive impulse was impressed on condensers 111, 113, 118 and 124, another positive impulse is impressed upon these condensers. The interval between the two positive impulses is equal to one impulse interval of correctly timed telegraph signals by virtue of the previously described frequency of the oscillator. The positive impulse

through condenser 111 has no effect on tube 112 because this tube is not preparatorily biased. The positive impulse through condenser 118 has no effect on tubes 119 and 37 because they are already conductive. The positive impulse impressed on condenser 113 raises the potential of the control grids of tubes 57 and 58 above the firing potential and these tubes fire. The positive impulse impressed through condenser 124 is momentarily applied to the control grid of tube 54 and this tube fires. By virtue of the low internal voltage drop in a gas-filled tube when conductive, the cathodes of tubes 57 and 58 abruptly rise to more positive potentials. The cathodes of tubes 119 and 37 are connected to the cathode of tube 58 and they undergo a corresponding rise which reduces the anode-to-cathode potential in the tubes 119 and 37 below the discharge sustaining potential quenching them.

With tube 119 quenched, its anode again assumes a positive potential with respect to ground, thereby restoring current in transmitting relay 33 in the marking direction and causing the armature to reengage its marking contact for the retransmission of the marking impulse into the line circuit comprising conductors 31 and 32. With tube 37 quenched, the anode of this tube now swings to a positive potential with respect to ground thereby again reversing current through the biasing winding of receiving relay 34, which is the lowermost winding, and restoring the spacing bias to this relay. Current through varistor 43 is interrupted but condenser 44 now discharges through resistor 42 and the locking winding of receiving relay 34 thereby maintaining a marking hold upon receiving relay 34 for an interval after the spacing bias has been restored in the biasing winding. The locking of the receiving relay 34 in marking condition for this additional interval assures that conditions in the repeater shall become stabilized before the normal sensitivity of relay 34 to spacing impulses is restored. One of the reasons that this precaution is desirable is that the restoration of spacing bias in the receiving relay 34 and the restoration of marking current in the transmitting relay 33 occur substantially simultaneously due to the simultaneous quenching of tubes 119 and 37. Until the relay 33 has actually operated its armature to the marking contact, the relay 34 is solely under the control of its locking and biasing winding and in the absence of the locking winding or in the absence of the condenser 44 to prolong the locking condition, the biasing winding might operate relay 34 to spacing before the transmitting relay 33 had reclosed the loop circuit, thereby quenching tubes 57, 58 and 54 and possibly interfering with the quenching and deionization of tubes 119 and 37.

During the transmission of the marking impulse the condition of the gas-filled tubes is as follows:

Tube 17—quenched	Tube 67—quenched
Tube 37—quenched	Tube 72—quenched
Tube 54—conductive	Tube 112—quenched
Tube 57—conductive	Tube 119—quenched
Tube 58—conductive	

The tube 54 having been refired along with tubes 57 and 58 raises the potential of the anode of tube 67 by virtue of the raising of the potential of the cathode of tube 54 to which the anode of tube 67 is connected. Although the full anode potential is thus restored to tube 67, this tube cannot fire at this time because it is under the control of its grid which is negative with respect to the cathode by virtue of the charge on condenser 82 which is in the process of leaking off through variable resistor 81. The values of condenser 82 and restor 81 are such that the control grid does not reach firing potential relative to the cathode until or, preferably, just before the time that the positive pulse pertaining to the stop impulse at the end of the permutation code combination is impressed on condensers 111, 113, 118 and 124.

The retransmission of the successive significant impulses of the code combination proceeds in the manner hereinbefore described. When any spacing impulse follows a marking impulse, tubes 57, 58 and 54 are quenched under the control of the armature of receiving relay 14, tube 37 is fired as soon as the armature reaches the spacing contact and tube 119 is fired when the positive timing impulse is impressed on condenser 118. When a marking impulse follows a spacing impulse the anode circuits of tubes 57, 58 and 54 are reestablished under the control of the armature of receiving relay 14 and when the positive timing impulse is impressed on condenser 113, tubes 57 and 58 are fired, quenching tubes 119 and 37. At the same time tube 54 is fired by the positive impulse impressed on condenser 124. This is an idle operation at this time, since tube 54 cannot fire tube 67. When a spacing impulse follows another spacing impulse no change in the condition of the repeater occurs as a result of the positive timing impulses impressed on condensers 111, 113, 118 and 124 because the anode circuit of tubes 57, 58 and 54 remains open at the marking contact of receiving relay 14, and since the tubes 57 and 58 cannot be fired under this condition the tubes 119 and 37 remain conductive. When a marking impulse follows another marking impulse no change occurs in the repeater as a result of the positive timing impulse impressed on condensers 111, 113, 118 and 124 because neither of the tubes 119 nor 37 is preparatorily biased for activation and tubes 57, 58 and 54 are already conducting.

About the time that the seventh positive impulse is impressed upon condensers 111, 113, 118 and 124, and preferably just before this time, condenser 82 discharges to a level at which the control grid of tube 67 is at such potential relative to the cathode as to be capable of firing the tube. If the last significant impulse of the code combination was of marking nature, tube 54 is conductive along with tubes 57 and 58, and has applied full positive potential to the anode of tube 67 so that tube 67 will fire as soon as its control grid reaches the proper potential under the control of condenser 82. If the last significant impulse of the code combination has been of spacing nature, tubes 57, 58 and 54 are non-conductive, tubes 119 and 37 are conductive and tube 67 awaits the firing of tube 54 under the control of the seventh positive timing impulse. When tube 99 impresses this impulse upon the condensers 111, 113, 118 and 124, tubes 57 and 58 fire, quenching tubes 119 and 37 thereby initiating the transmission of the stop impulse. Tube 54 fires and from its cathode provides positive potential for the anode of tube 67 which in turn fires. Upon the firing of tube 67 the cathode returns to its initial or steady state potential, slightly positive with respect to ground, and impresses this potential through resistor 76 upon the grid of the left-hand triode section of tube 74 which again becomes conductive, providing a steady flow of cur-

rent through inductance winding 91, thereby stopping oscillation of the oscillatory circuit and suspending the production of timing impulses. The positive potential of the cathode of tube 67 is also applied through resistor 73 to the control grid of tube 72, biasing that tube to firing condition. The positive potential of the cathode of tube 67 impressed on the left-hand side of condenser 82 causes a positive pulse to be transmitted through the condenser to the anode of tube 72 causing that tube to fire. Tube 72 provides a low impedance path by comparison with the impedance of variable resistor 81 for recharging condenser 82 and the condenser quickly recharges to its steady state potential. As soon as the condenser has become recharged the current through tube 72 decreases to its low steady state value. In this way the repeater has been restored to its initial condition with all relays in the marking condition, all gas-filled tubes in the state of conductivity indicated in the first of the three tables, the left-hand triode section of vacuum tube 74 conductive and holding the right-hand oscillator section dormant and the timing impulse generating tube 99 also dormant.

It should be noted that the tube 54, exercising control over the firing of tube 67, assures the production of the seventh positive timing impulse, if such impulse is needed, and it is needed when the last significant impulse of the telegraph signal combination is of spacing nature to fire tubes 57 and 58 for the purpose of quenching tubes 119 and 37 thereby to operate relay 33 to marking for the transmission of the stop impulse. The seventh timing impulse is not especially needed when the last significant impulse of the telegraph signal combination is of marking nature, because transmitting relay 33 will be operated to marking by the quenching of tubes 119 and 37 as a result of the firing of tubes 57 and 58 for the last significant impulse of the code combination, and as no spacing signal normally intervenes the last significant code impulse and the stop impulse, relay 33 will continue in marking condition for transmission of the stop impulse. Were it not for the provision of tube 54 to control tube 67 jointly with condenser 82 it would be necessary to time the discharging of condenser 82 so that it could not bring the grid of tube 67 to activating potential until after the oscillator had produced seven full cycles and tube 99 had produced seven positive timing impulses and the timing of the condenser discharging circuit might thereby be much more critical than is necessary with the dual control over tube 67.

When the transmission of signals is in the opposite direction from the line circuit comprising conductors 31 and 32 to the line circuit comprising conductors 11 and 12 the operation of the repeater is the same with the exception that tubes 17 and 112 are employed for controlling the transmission of spacing signals instead of the tubes 37 and 119. The armature of receiving relay 34 interrupts the anode circuit of tubes 57, 58 and 54 at its marking contact and provides the preparatory grid bias for tube 112 and the firing grid potential for tube 17 through its armature and spacing contact, conductor 176, conductor 177 and resistor 178 to the junction of resistors 132 and 133 in the case of tube 112 and conductor 179 and resistor 131 to the junction of resistors 127 and 128 in the case of tube 17. Tube 17 provides the marking bias through the lowermost winding of relay 14, the charging current for condenser 24 and the marking current through the locking winding of relay 14 and tube 112, when fired under the control of positive timing impulses through condenser 111, operates the relay 13 to spacing. The operation of tubes 54, 67 and 72 starting and stopping the oscillator and timing the duration of the character, the operation of tube 74 as an oscillator and oscillator control and the operation of tube 99 as an impulse generator are the same for either direction of transmission through the repeater.

The repeater accommodates the transmission of break signals in either direction. For example, when permutation code signals are being retransmitted into the line circuit comprising conductors 31 and 32 under the control of transmitting relay 33, a break signal may be transmitted by the station which is receiving the signals by the opening at that station of the line circuit comprising conductors 31 and 32. If the break signal is initiated at an instant that transmitting relay 33 is transmitting a spacing signal, the line circuit comprising conductors 31 and 32 will be open at the marking contact of relay 33, and the opening of the line circuit at the remote station will have no effect on receiving relay 34 which is held to marking by the marking current in the biasing winding. As long as spacing impulses are received by receiving relay 14 transmitting relay 33 will be operated to spacing and the break signal will have no effect. In response to the first marking signal received by relay 14, which may be the stop impulse or one of the significant impulses of the code combination, and upon the generation of the positive timing impulse pertaining to that telegraph signal impulse, relay 33 will be restored to marking and the marking bias on relay 34 will be replaced by a spacing bias. However, relay 34 will not respond to the break signal and operate its armature to spacing until the marking hold effected by the discharging of condenser 44 through the locking winding of relay 34 has been dissipated by the discharging of the condenser. Thereupon, receiving relay 34 will operate its armature to spacing, quench tubes 57, 58 and 54, operate tube 17 to place a marking bias on receiving relay 14, preparatorily bias tube 112, and upon the generation of the next timing impulse tube 112 will fire and repeat the break signal to the line circuit comprising conductors 11 and 12. As long as relay 34 receives the break signal, transmitting relay 13 will remain operated to spacing, tube 54 will be prevented from firing, tube 67 will be prevented from firing, although condenser 82 will undoubtedly time out and bias tube 67 for activation, and the oscillator will continue to operate and cause tube 99 to generate timing impulses. As soon as the break signal is terminated, relay 34 will be restored to marking preparing tubes 57, 58 and 54 for activation and in response to the next positive timing impulse these tubes will be fired, tube 57 will quench tubes 17 and 112 and tube 54 will cause tube 67 to fire which in turn will stop the oscillator and suspend the generation of the timing impulses.

By way of completing the description of the embodiment of the invention shown in Fig. 1, attention is directed to two features. One of these features is that the variable resistor 81 provides for adjustment of the character timing function performed by condenser 82 in cooperation with variable resistor 81. The discharging time of condenser 82 may be increased or decreased by increasing or decreasing the effective resistance of variable resistor 81. By means of

the variable resistor the time interval between the quenching of tubes 67 in response to a start impulse of telegraph signals and the arrival of the control grid of tube 67 at a potential relative to the cathode which represents the activating condition of the tube may be adjusted within close limits. The other feature is the relation of potential divider 101 to the impulse generating tube 99. The potential divider 101 provides an orientation adjustment whereby the time of production of the first positive timing impulse and each succeeding timing impulse may be advanced or delayed relative to the start impulse of received telegraph signals in order to adapt the repeater to various conditions of bias and distortion in received signals, so that the timing impulses shall be produced relative to the received telegraph impulses when the receiving relay is responding to the most effective part of each received telegraph impulse. Since the time of occurrence of each positive timing impulse is the time at which the repeater selects between marking and spacing impulse transmission under the control of the receiving relay, the selecting instants may be adjusted by means of potentiometer 101 to the particular condition of the signals being received.

The embodiment of the invention shown in Fig. 2 differs from that shown in Fig. 1 principally in the termination of the telegraph loop circuit in the repeater and in the resultant signal transmitting arrangement. The oscillator, oscillator control and timing impulse producing circuits in Fig. 2 are identical with those in Fig. 1. Likewise, the start-stop control circuit and character timing circuits are the same in both figures. Gas tubes in like number and function for marking and spacing selection and for receiving relay biasing and locking are employed in both figures. For the sake of simplicity these principal components have been identified by the same reference numerals in Fig. 2 as in Fig. 1. In those instances in which the two figures differ significantly as, for example, in the case of entirely different components and different potential supply arrangements, new and different reference characters have been applied in Fig. 2, and these reference numerals are all in the 200 series.

One of the line circuits entering the repeater comprises the line conductors 211 and 212. Conductor 211 terminates at the cathode of an electron discharge tube 201 which is preferably a vacuum tube. Conductor 211 is also grounded at the repeater for the purpose of providing a reference potential of the cathode to which the control grid of tube 201 may be related to prevent the potential of the cathode from varying with respect to certain operating potentials applied to the grid of the tube. The cathode of the tube being connected to the end of a telegraph line conductor, such variation might result from line leakage resistance and other factors. Line conductor 212 extends through the operating winding of receiving relay 14 and terminates at the anode of vacuum tube 201. Receiving relay 14 is provided with biasing and locking windings associated with the anode of gas-filled tube 17 as in Fig. 1. The control grid of tube 201 is connected to the anode of gas-filled tube 112. The anode of tube 112 is also connected to two potentiometer circuits, one connection being to the junction of resistors 202 and 203 connected in series between positive battery 204 and ground and the other connection being to the junction of resistors 206 and 207 connected in series between negative battery 208 and ground. These potentiometers provide a grid potential for tube 201, in the idle or marking condition of the line circuit comprising conductors 211 and 212, such that current flows in the line circuit to operate receiving relay 14 to its marking contact. As in the foregoing table of conditions of the gas-filled tubes for the idle or marking condition of the repeater, tube 112 is non-conductive, so that the potential of the grid of tube 201 is determined solely by the two potential dividers to which it is connected. It may be assumed that the grid of tube 201 is at or above ground potential to provide the necessary flow of current in tube 201 and accordingly the anode of tube 112 is at the same potential. The potential divider comprising resistors 114 and 116 from which the cathode of tube 112 receives its operating potential has associated therewith the negative battery 117, as previously described, so that the cathode of tube 112 is negative with respect to the anode by a sufficient amount that when, at the proper time, a potential is applied to the grid of tube 112 to cause it to fire, the tube will fire.

The biasing arrangement for tubes 112 and 17 in Fig. 2 is slightly different from that disclosed in Fig. 1. A conductive path is traced from negative battery 216 through resistors 217, 218 and 219 in series to ground and the grid of tube 112 is connected to the junction of resistors 218 and 219. From the junction of resistors 217 and 218, resistors 221 and 222 are connected in series to ground and the grid of tube 17 is connected to the junction of resistors 221 and 222. Conductor 176 which extends from the spacing contact of receiving relay 34 is connected through a single resistor 223 to the junction of resistors 217, 218 and 221 and positive potential is supplied over conductor 176 when the armature of relay 34 operates to spacing and applies to the control grid of tube 17 a potential relative to the cathode of that tube sufficient to fire the tube immediately, and applies to the control grid of the tube 112 a preparatory bias.

At the opposite side of the repeater the incoming line conductor 231 is grounded and terminates at the cathode of a vacuum tube 226. The line conductor 232 extends through the operating winding of receiving relay 34 and terminates at the anode of vacuum tube 226. The grid of the tube is connected to the anode of gas-filled tube 119, to the junction of resistors 227 and 228, connected in series between ground and positive battery 229 and to the junction of resistors 236 and 237 connected in series between negative battery 238 and ground. The biasing arrangement for tubes 37 and 119 is the same as that for tubes 17 and 112 in Fig. 2. Resistors 241, 242 and 243 are connected in series between negative battery 244 and ground and the control grid of tube 119 is connected to the junction of resistors 242 and 243. Resistors 246 and 247 are connected in series between the junction of resistors 241 and 242 and ground, and the control grid of tube 37 is connected to the junction of resistors 246 and 247. The spacing contact of receiving relay 14 is connected through conductor 166 and resistor 248 to the junction of resistors 241, 242 and 246.

In the operation of the repeater to transmit signals received over the line circuit comprising conductors 211 and 212 into the line circuit comprising conductors 231 and 232, the start impulse of a permutation signal code combination is of spacing nature and is represented by opening of

the line circuit at the transmitting station. The effect of this is to open the anode-cathode discharge path of vacuum tube 201 and relay 14 operates its armature to spacing under the control of its biasing winding. In the manner described in connection with Fig. 1, tubes 57, 58, 54, 67 and 72 are quenched and the oscillator is started as a result of departure of the armature of relay 14 from the marking contact. With the armature in engagement with the spacing contact, the grid of tube 37 is immediately brought to firing potential and the tube fires to hold receiving relay 34 in the marking condition. Tube 119 is at the same time preparatorily biased for operation. When tube 99 supplies the first positive timing impulse, tube 119 fires and its anode assumes a less positive potential than it has in the steady state condition, carrying the grid of tube 226 to cut off potential and thereby cutting off current through tube 226. Thus current is cut off in the line circuit comprising conductors 231 and 232 which is the spacing condition of the line. The repeater remains in this condition as long as receiving relay 14 responds to a spacing signal. When the receiving relay 14 is restored to marking condition in response to a marking signal, preparatory bias is removed from the control grid of tube 119, the operating bias is removed from the control grid of tube 37 and the anode circuit of tubes 57, 58 and 54 is reestablished. Upon the production of the next positive timing impulse by tube 99 following the restoration of receiving relay 14 to marking, tubes 57, 58 and 54 are refired. Tube 58 quenches tubes 37 and 119, the former restoring the spacing bias to receiving relay 34 and the latter restoring the grid of tube 226 to its initial value permitting line current to flow in the line circuit comprising conductors 231 and 232. About the time that the stop impulse is received, condenser 82 times out and conditions tube 67 for firing. If tube 54 is then conductive or when it is rendered conductive in response to the stop impulse, tube 67 fires, in turn firing tube 72 and suspending operation of the oscillator through the left-hand triode section of tube 74.

From the foregoing it will be apparent that the principal difference between the embodiment of the invention shown in Fig. 2 and that shown in Fig. 1 is the substitution of vacuum tubes for electromagnetic relays as transmitters of start-stop permutation code signals. All functions and operations are performed by electron discharge instrumentalities with the exception of the signal receiving operations which are performed by electromagnetic relays.

The impulse timing circuit including the oscillator and detector, character timing circuit including the start-stop oscillator control circuit disclosed in identical form in Figs. 1 and 2, are similar to impulse and character timing circuits shown in copending application, Serial No. 556,352, filed September 29, 1944, now Patent 2,476,864, patented July 19, 1949, by R. B. Hearn and J. A. Krecek.

Although 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 regenerative telegraph repeater, a receiving relay, a transmitting relay, a source of timing impulses, a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said receiving relay upon response thereof to a spacing signal for operating said transmitting relay to spacing, and a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said receiving relay upon response thereof to a marking signal and independent of said transmitting relay for quenching said first-mentioned tube to cause said transmitting relay to be restored to marking solely as a result of said quenching.

2. In a regenerative telegraph repeater, a receiving relay, a transmitting relay having a single winding normally energized to transmit a marking signal and reversely energizable to transmit a spacing signal, means including a source of timing impulses, a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said receiving relay upon response thereof to a spacing signal for reversely energizing said transmitting relay to effect transmission of a spacing signal, and a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said receiving relay upon response to a marking signal for quenching said first-mentioned tube to effect reenergization of said transmitting relay for transmission of a marking signal.

3. In a regenerative telegraph repeater, a first telegraph line having a receiving relay and a transmitting relay associated therewith, a second telegraph line having a receiving relay and a transmitting relay associated therewith, a source of timing impulses, a gas-filled electron discharge tube operable jointly by said source of timing impulses and one of said receiving relays upon response thereof to a spacing signal received over its associated line for operating the transmitting relay associated with the other line to spacing condition, and a gas-filled electron discharge tube operable jointly by said one receiving relay upon response thereof to a marking signal and independent of said transmitting relay associated with the other line for quenching the first-mentioned tube to restore the transmitting relay associated with said other line to marking condition solely as a result of said quenching.

4. In a regenerative telegraph repeater, a first telegraph line having a receiving relay and a transmitting relay associated therewith, a second telegraph line having a receiving relay and a transmitting relay associated therewith, a source of timing impulses, a gas-filled electron discharge tube having its anode connected to the transmitting relay associated with one of said lines and operable jointly by said source of timing impulses and the receiving relay associated with the other line for operating the transmitting relay associated with said one line to spacing condition, a gas-filled electron discharge tube having its anode connected to a winding of the receiving relay associated with said one line and operable by the receiving relay associated with said other line for holding the receiving relay associated with said one line in marking condition, and a gas-filled electron discharge tube operable jointly by said source of timing impulses and the receiving relay associated with said other line upon response thereof to a marking signal for quenching said first-mentioned and said second-mentioned electron discharge tubes to restore the transmitting relay associated with said one line to marking condition and to release the marking

hold on the receiving relay associated with the same line.

5. In a regenerative telegraph repeater, a first telegraph line having a receiving relay and a transmitting relay associated therewith, a second line having a receiving relay and a transmitting relay associated therewith, a gas-filled electron discharge tube individual to each transmitting relay and having its anode connected to the operating winding thereof, a source of timing impulses for operating jointly with either of said receiving relays the gas-filled electron discharge tube connected to the transmitting relay associated with the other line to cause operation of that transmitting relay to spacing condition, and a gas-filled electron discharge tube individual to each of said first-mentioned tubes and operable jointly by said source of timing impulses and either of said receiving relays upon restoration thereof to marking condition responsive to a marking signal for quenching the operated one of said first-mentioned tubes to restore its associated transmitting relay to marking condition.

6. In a regenerative telegraph repeater, an incoming line loop including signal receiving means, an outgoing line loop including transmitting means adapted to interrupt said outgoing line loop, a source of timing impulses, a gas-filled electron discharge tube having its anode connected to said transmitting means and operable jointly by said source of timing impulses and said receiving means upon response of the latter to a spacing signal for causing said transmitting means to interrupt said outgoing line loop, and a gas-filled electron discharge tube independent of said transmitting means and operable jointly by said source of timing impulses and said receiving means upon response of the latter to a marking signal for quenching said first-mentioned tube to cause said transmitting means to reclose said outgoing line loop solely as a result of said quenching.

7. In a telegraph repeater, a first line terminating loop including a receiving relay and the anode-cathode discharge path of a normally conductive grid-controlled electron discharge tube, a second line terminating loop including a receiving relay and the anode-cathode discharge path of a normally conductive grid-controlled electron discharge tube, means controlled by either of said receiving relays upon response thereof to a spacing signal for applying a cut-off potential to the grid of the electron discharge tube associated with the other loop to cause the retransmission of a spacing signal and for holding the receiving relay associated with said other loop in marking condition, and means controlled by the same receiving relay upon response thereof to a marking signal for raising the potential of the grid of the tube associated with said other loop to restore said tube to conductivity.

8. In a regenerative telegraph repeater, an incoming line loop including the operating winding of a receiving relay, an outgoing line loop including the anode-cathode discharge path of a normally conductive grid-controlled electron discharge tube, a source of timing impulses, a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said relay upon response thereof to a spacing signal for applying a cut-off potential to the grid of said first-mentioned tube to cause the transmission of a spacing signal over said outgoing line loop, and a gas-filled electron discharge tube controllable jointly by said source of timing impulses and said relay upon response thereof to a marking signal for quenching said second-mentioned tube to restore said first-mentioned tube to conductivity for transmitting a marking signal over said outgoing line loop.

9. In a regenerative telegraph repeater, a first line terminating loop including a receiving relay and the anode-cathode discharge path of a normally conductive grid-controlled electron discharge tube, a second line terminating loop including a receiving relay and the anode-cathode discharge path of a normally conductive grid-controlled electron discharge tube, a source of timing impulses, a gas-filled electron discharge tube individual to and having its anode connected to the grid of each of said line terminating loop tubes and controllable jointly by said source of timing impulses and the receiving relay associated with the other line terminating loop upon response of said relay to a spacing signal for applying a cut-off potential to said grid to cause the retransmission of a spacing signal, and a gas-filled electron discharge tube individual to each of said first-mentioned gas-filled tubes and controllable jointly by said source of timing impulses and said receiving relay upon restoration thereof to marking for quenching their respectively associated ones of the first-mentioned gas-filled tubes to restore the cut-off one of said line terminating loop tubes to conductivity for retransmitting a marking signal.

10. In a regenerative telegraph repeater, a first telegraph line having a receiving relay and a transmitting relay associated therewith, a second telegraph line having a receiving relay and a transmitting relay associated therewith, a source of timing impulses, a gas-filled electron discharge tube having its anode connected to the transmitting relay associated with one of said lines and operable jointly by said source of timing impulses and the receiving relay associated with the other line for operating the transmitting relay associated with said one line to spacing condition, a gas-filled electron discharge tube having its anode connected to a winding of the receiving relay associated with said one line and operable by the receiving relay associated with said other line for holding the receiving relay associated with said one line in marking condition, and a gas-filled electron discharge tube operable jointly by said source of timing impulses and the receiving relay associated with said other line upon each response thereof to a marking signal following a spacing signal for quenching said first-mentioned and said second-mentioned electron discharge tubes to restore the transmitting relay associated with said one line to marking condition and to render the receiving relay associated with the same line responsive to a spacing signal.

11. In a regenerative telegraph repeater, a first telegraph line having a receiving relay and a transmitting relay associated therewith, a second telegraph line having a receiving relay and a transmitting relay associated therewith, a source of timing impulses, a gas-filled electron discharge tube having its anode connected to the transmitting relay associated with one of said lines and operable jointly by said source of timing impulses and the receiving relay associated with the other line for operating the transmitting relay associated with said one line to spacing condition, a gas-filled electron discharge tube having its anode connected to a winding of the receiving relay associated with said one line and

operable directly by the receiving relay associated with said other line for holding the receiving relay associated with said one line in marking condition, and a gas-filled electron discharge tube operable jointly by said source of timing impulses and the receiving relay associated with said other line upon each response thereof to a marking signal for quenching said first-mentioned and said second-mentioned electron discharge tubes to restore the transmitting relay associated with said one line to marking condition and to release the marking hold on the receiving relay associated with the same line.

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