May 5, 1936. E. T. BURTON 2,039,629

TELEGRAPH REPEATER

Filed Oct. 23, 1930 3 Sheets-Sheet 1

FIG. 1

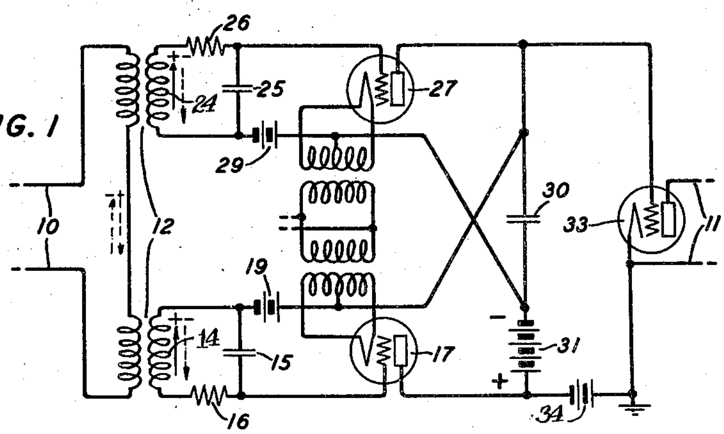

FIG. 2

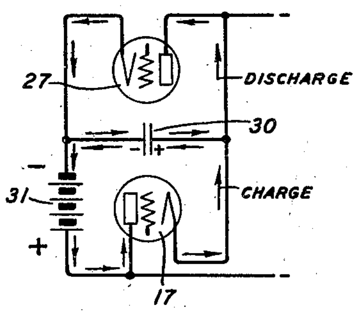

FIG. 11

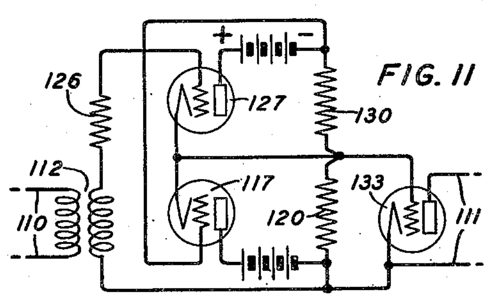

FIG. 3

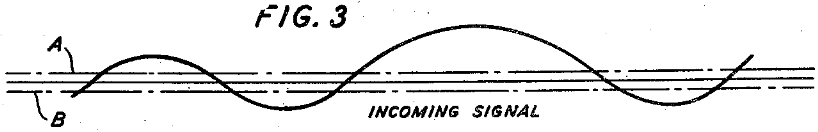

FIG. 4

FIG. 5

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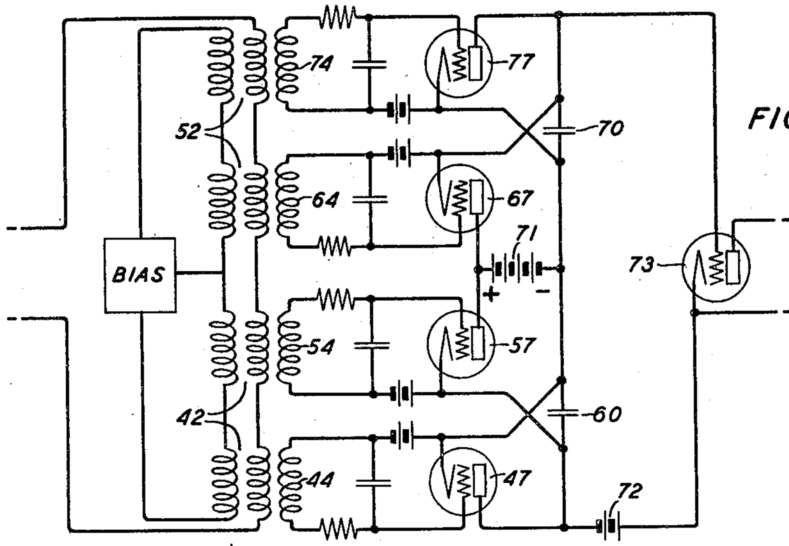


FIG. 6

FIG. 7

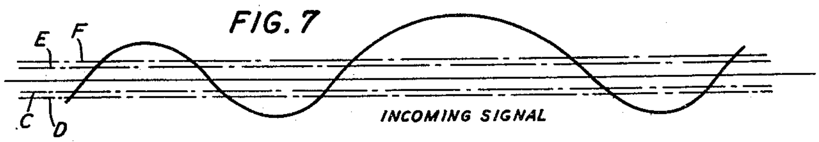


FIG. 8

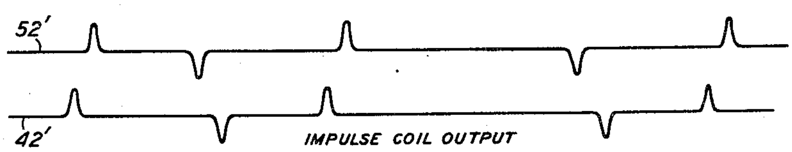


FIG. 9

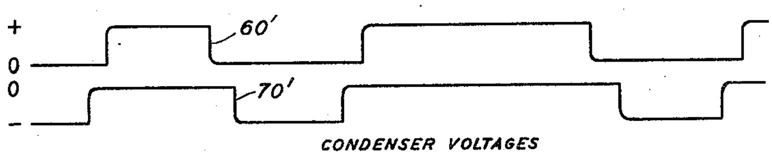
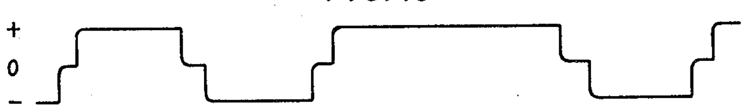


FIG. 10



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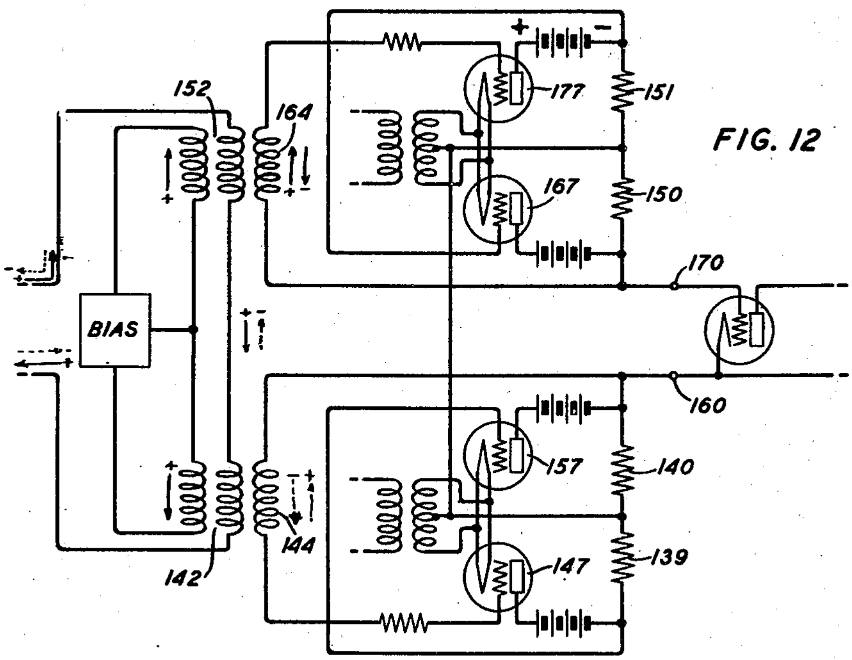

FIG. 12

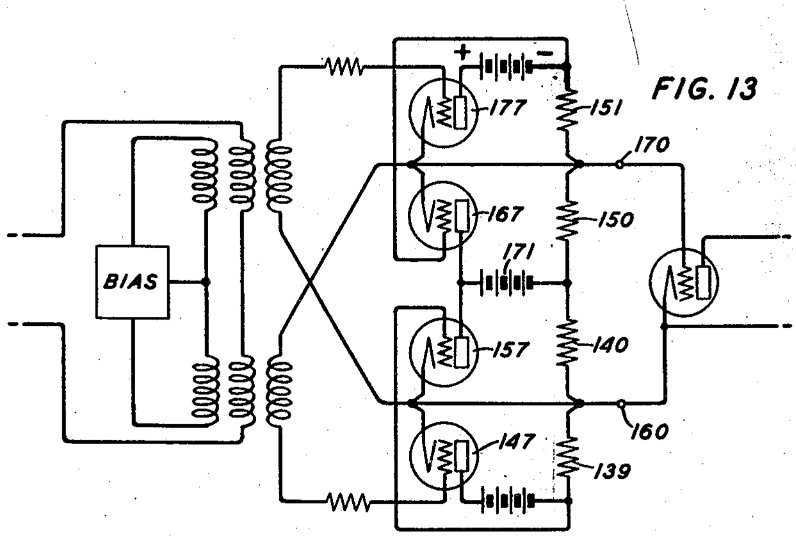

FIG. 13

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UNITED STATES PATENT OFFICE

2,039,629

TELEGRAPH REPEATER

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Application October 23, 1930, Serial No. 490,585

20 Claims. (Cl. 178—70)

This invention relates to telegraph systems and more particularly to repeaters for regenerating impulses for further transmission in telegraph and similar impulse transmission systems such as picture transmission and television systems.

An object of this invention is to reduce distortion in telegraph signals.

Another object is to reshape attenuated and distorted signals of irregular amplitude into corresponding signals having a substantially flat-topped wave of uniform amplitude.

Heretofore, two general types of repeaters have been employed, i. e., electromagnetic relays and thermionic or vacuum tube amplifiers. Electromagnetic relays have been commonly used for reproducing square-topped waves such as are used in telegraphy, while vacuum tube amplifiers have been preferred for reproducing without distortion, waves of varying intensity.

However, a repeating circuit for telegraph signals has been proposed which utilizes vacuum tubes in place of electromagnetic relays and which may produce in its output circuit a substantially square-topped wave. United States patent to Krause 1,537,682, May 12, 1925 discloses such a system in which flat-topped waves are produced in the output circuit of a vacuum tube whenever the input voltage exceeds a certain value. Negative grid voltages in excess of that value produce no further change in the output voltage because the space current is completely blocked. On the other hand, positive grid voltages in excess of that value produce no further change in the output current because of filament saturation. A disadvantage of that arrangement is that disturbing currents of small value are amplified greater proportionally than the signal impulses.

It is, therefore, a further object of this invention to eliminate, by means of a thermionic repeater, disturbing currents of less than a predetermined amplitude.

A still further object of this invention is to provide a thermionic repeater in which the polarity of the repeated impulses is independent of the characteristics of the thermionic or vacuum tubes, and dependent only upon the establishment of definite values of voltage of the received signals.

In accordance with the above stated objects, signaling impulses are received in the form of a wave of somewhat slowly varying current intensity, and converted, as a first step, into a succession of sharp discrete impulses. The waves may be reshaped by employing high permeability inductance coils, commonly known as impulse coils, in which a greatly overloaded magnetic circuit is utilized. The impulses or "kicks" may be selected to occur within any desired range of intensity of current upon the rise and fall of current intensity. This method is described more fully in U. S. Patent 1,936,153, granted to E. T. Burton on November 21, 1933. As a next step, these sharp discrete impulses are lengthened by means of a vacuum tube arrangement which reproduces waves corresponding to the incoming line signals in polarity, but having a substantially flat top. The impulse coils serve as mutual impedances in the input circuits of said vacuum tube arrangement.

Another object of this invention is to provide a repeater of the type described which is capable of operating at a high speed. In the present invention, mechanical relays, which are subject to chattering at high speeds, are rendered unnecessary.

The arrangement for lengthening the impulses may be embodied in any one of several forms. According to one embodiment, the output circuit of the impulse coil is connected to the grid circuits of two thermionic devices, such as vacuum tubes, wherein are provided condensers for storing the signals. The thermionic devices may be described as rectifying or unidirectionally conducting devices. Each condenser becomes charged to one polarity on the receipt of an impulse from the impulse coil and maintains a charge upon the grid until a change of signal polarity occurs, at which time the condenser is discharged. A feature of this arrangement resides in means for reproducing three-element signals, that is, signals consisting of positive, negative and zero impulses.

According to another embodiment of this invention, two three-electrode devices, such as vacuum tubes, are arranged so that the grid circuit of each tube is coupled to the plate circuit of the other, whereby an increase of current in the plate circuit of one tube is effective to decrease the plate current in the other tube until the latter plate current is blocked. This system is stable in two positions, in which there is a steady plate current in one tube or the other, depending on the polarity of the last received impulse. The three-electrode devices may also be described as rectifying or unidirectionally conducting devices.

Other objects and features of this invention will appear more clearly from the following description taken in connection with the accompanying drawings and appended claims.

Fig. 1 of the accompanying drawing shows schematically a circuit including a storing condenser and embodying the present invention;

Fig. 2 is a simplified diagram showing the connections to the storing condenser of Fig. 1;

Fig. 3 illustrates a signaling wave received by the repeater circuit of Fig. 1;

Fig. 4 shows the current in the secondary transformer windings of the circuit of Fig. 1;

Fig. 5 shows the condenser voltage for corresponding points on the incoming signal curve shown in Fig. 3;

Fig. 6 is a modification of the circuit of Fig. 1, which constitutes a three-element relay;

Figs. 7 to 10 inclusive, illustrate a repeated signal at different stages in its retransmission by the circuit of Fig. 6;

Fig. 7 shows an incoming signal;

Fig. 8 shows the output voltages of two windings of the transformer;

Fig. 9 shows the voltages of the two respective condensers;

Fig. 10 shows the voltage of the two condensers in series;

Fig. 11 is a schematic diagram of another modification of the present invention and shows a regenerative locking repeater; and

Figs. 12 and 13 are still further modifications which embody the features of the circuit shown in Fig. 11.

Referring to Fig. 1, a repeater is connected to retransmit signals received from the incoming line 10, to the outgoing line 11. Connected to the incoming line 10 is the primary winding of a transformer 12. The transformer is of a type having a high permeability core which becomes saturated at a very low magnetizing force. A transformer of this type is commonly referred to as an impulse coil, and is described in U. S. Patent 1,936,153, supra. The impulse coil 12 has two secondary windings 14 and 24. The winding 14 is connected serially with a condenser 15 and resistance 16, while the winding 24 is similarly connected in a series circuit with a condenser 25 and a resistance 26. Two space discharge devices such as vacuum tubes 17 and 27 each have their grid circuits connected in parallel with the condensers 15 and 25, respectively. The grid circuits contain C batteries 19 and 29 respectively. The plate circuits of these vacuum tubes are arranged so that the condenser 30 is in series with each plate circuit. A B battery 31 is interposed in the plate circuit of vacuum tube 17. The output voltage of the above described vacuum tube arrangement is supplied from the plate and filament respectively of vacuum tube 17, and is impressed on the grid circuit of amplifier tube 33 whose plate circuit is connected to the outgoing line 11. The C batteries 19 and 29 are desirably of sufficient voltage to block the plate current to zero when a plate voltage equal to that of battery 31 is applied to either tube.

The function of the condenser 30 can best be understood by reference to Fig. 2. When the grid of vacuum tube 17 is positive and the grid of 27 negative, the current flows through the plate circuit of vacuum tube 17 to charge the condenser 30 to the voltage of the B battery 31. The capacity of the condenser 30 is small and, therefore, the condenser becomes charged to the full battery voltage almost immediately. When the grid of vacuum tube 27 becomes positive and that of 17 becomes negative, a discharge path for the condenser is established through the plate circuit of vacuum tube 27. The condenser voltage is reduced almost instantly to zero and remains at this value until the grid of vacuum tube 17 again becomes positive. The grid circuit of vacuum tube 33 is connected in series with condenser 30 and the B battery 31. It follows that the grid voltage of vacuum tube 33 is equal to the voltage of battery 31 minus the sum of the condenser voltage and any "C" battery voltage that may be employed. When the condenser is fully charged, the condenser voltage neutralizes the voltage of the "B" battery 31 and the grid voltage of the amplifier tube 33 becomes equivalent to the voltage of the "C" battery alone. When the condenser is discharged the grid voltage is equal to that of battery 31 minus the "C" battery voltage.

The manner in which a received signal is transferred from the incoming line 10 to the outgoing line 11 will now be explained. In Fig. 3 is illustrated the wave form of a somewhat distorted signal made up of one positive, one negative, two positive and one negative impulses. The two lines A and B in Fig. 3 represent the current values at which the transformer becomes saturated. It is apparent that the only time any current is induced in the secondary winding of the transformer or impulse coil 12 occurs when the current strength of the received signal lies between the values B and A. It will be seen that only a short time elapses during the change in current strength from B to A or vice versa. The electromotive force induced in the secondary windings of the impulse coil is shown diagrammatically in Fig. 4. The secondary windings of the impulse coil induce discrete impulses of short duration which are of one polarity when the incoming signal passes from the value B to A, and of the opposite polarity when the incoming signal changes from A to B.

As explained above, the grid circuit of amplifier tube 33 has a potential at any time of either one of two values, depending upon whether the condenser 30 be charged or discharged. If it be assumed that the grid of vacuum tube 17 becomes positive when the incoming signaling current changes from minus to plus (B to A), the condenser 30 begins charging and therefore becomes fully charged whenever the incoming current is positive and above the saturation point. The condenser is discharged during the time that the incoming impulse is correspondingly negative. The outgoing signal in the line 11 has a shape corresponding to the signal shown in Fig. 5. It will be observed that the signal of Fig. 5 is square-topped as contrasted with irregular signal shown in Fig. 3. The square-topped effect is due to the fact that the voltage of the condenser 30 has but two alternative values and quickly changes from one value to the other whenever the received signal current passes between the values A and B.

The circuit of Fig. 1 may be modified as shown in Fig. 6 to make a three-element relay. The impulse coils 42 and 52 of Fig. 6 each replace the impulse coil 12 of Fig. 1 and are oppositely biased. The impulse coil 42 has a pair of secondary windings 44 and 54 corresponding in function to the secondary windings 14 and 24 of Fig. 1. The impulse coil 52 has a similar pair of secondary windings 64 and 74. The secondary windings are connected to the grid circuits of vacuum tubes 47, 57, 67 and 77, respectively, which are connected to the windings in a similar manner to the corresponding elements in the circuit of Fig. 1. A condenser 60 similar to the condenser 30 of Fig. 1 is connected in series with the plate circuit of either tube 47 or 57. Similarly, condenser 70 is connected in series with the plate circuit of either tube 67 or 77. The condensers 60 and 70 are connected in series with each other and with a battery 72 and the grid circuit of an amplifier tube 73. The vacuum tubes or similar triodes 47, 57, 67 and 77 are supplied with plate voltage by the common B battery 71 which connects the plates of tubes 57 and 67 to condensers 60 and 70.

The operation of the circuit shown in Fig. 6 can best be understood by reference to the curves shown in Figs. 7 to 10 inclusive. The incoming signal wave, as before, is shown in Fig. 7 as consisting of a positive, negative, two positive and one negative impulses. The impulse coil 42 is biased so that it is saturated for any current value below the line D or above the line C. The impulse coil 52 is biased in the opposite direction and this impulse coil is saturated at current values below the line E or above the line F.

As shown in Fig. 8 (see curve 42′) an electromotive force of high amplitude and short duration is induced in the secondary windings of impulse coil 42 when the received current strength passes between the values C and D; and an electromotive force is induced in the secondary windings of impulse coil 52 (see curve 52′) when the incoming signal passes between the values E and F. The polarity of the induced electromotive force is, of course, determined by whether the signaling current is increasing or decreasing as it passes between the values C and D, and E and F, respectively.

Fig. 9 shows the voltages of the condensers 60 and 70, respectively. The curve 60′ corresponding to the condenser 60 resembles somewhat the curve shown in Fig. 5. The condenser 60 is charged in the same manner as the condeser 30 of Fig. 1, but on account of the bias of the impulse coil 42 the zero voltages are of longer duration than the positive voltages. The curve 70′ corresponding to condenser 70 shows two voltage values, one of which is zero and the other negative. The condenser 70 is connected to the battery 71 in a different manner from the condenser 60 and, in response to the incoming signal of Fig. 3, the negative voltage conditions in condenser 70 are of shorter duration than the zero voltages.

The total voltage of condensers 60 and 70 connected in series is as shown in Fig. 10. Comparing the output voltage shown in Fig. 10 with the input current or voltage of Fig. 7, it will be seen that the device of Fig. 6, like the circuit of Fig. 1 produces flat-topped signals. Furthermore, it will be noted that the incoming signal in passing between the current value E and the value C produces a zero voltage in the output circuit. The advantage of converting the current strengths between the values E and C into zero voltage is that signals between these values are too weak to be dependable. It often occurs that due to interference the signaling wave crosses the zero line several times without obtaining a current strength equal to that caused by a transmitted signal. The device of Fig. 6 avoids the possibility of transmitting stray or interfering disturbances, by suppressing all signals not sufficiently strong to reach the value C or E.

A type of two-element thermionic tube relay employing the regenerative locking principle is illustrated in Fig. 11. A pair of three-electrode devices such as vacuum tubes are provided and the polarity of the repeated signal is determined by the tube which is supplying current through its plate circuit.

Referring more particularly to Fig. 11, the incoming line 110 is connected to the primary winding of a high permeability transformer or impulse coil 112 adapted to become saturated at a comparatively low current value. Connected to the secondary transformer winding in a manner to be described presently, are a pair of vacuum tubes 117 and 127. A pair of resistances 120 and 130 are connected in series with each other, the resistances forming a part of the plate circuits of the vacuum tubes 117 and 127 respectively.

The grid circuits of the vacuum tubes 117 and 127 respectively are connected so that when space current flows in the plate circuit of either tube, the grid of the other tube is blocked to a negative polarity by the potential drop through the resistance 120 or 130 in the plate circuit of the first tube. The grid circuit of vacuum tube 117 is connected across resistance 130, while the grid circuit of the tube 127 is connected to form a closed series circuit with resistance 120, secondary winding of transformer 112 and grid leak resistance 126.

The input circuit of the amplifier tube 133 which is connected to the output line 111, is supplied with the potential drop across resistance 120, although, as an alternative arrangement, this grid circuit may be connected across the resistance 130.

The circuit shown in Fig. 11 has only two points of stability. In one stable condition, current flows through the resistance 120 and not through resistance 130, while in the other stable condition current flows through resistance 130 and not through 120. The repeater of Fig. 11 remains in one or the other stable condition until the grid voltages are reversed by an impulse from the transformer 112. By employing a transformer delivering a very short high amplitude impulse, the time of signal crossover—or reversal of polarity—in the output circuit of the repeater may be reduced almost to zero. When such a transformer is employed the crossover point on the incoming wave, at which the repeater changes from one stable condition to another, is independent of the characteristics of the vacuum tubes and dependent upon the permeability and saturation points of the transformer.

A three-element relay operating on the same principle as the two-element relay of Fig. 11 is shown in Fig. 12. Essentially the circuit of Fig. 12 comprises two circuits similar to that of Fig. 11 with their outputs connected in series. A pair of biased impulse coils 142 and 152 are used to operate the relay, each impulse coil controlling the operation of the repeater for one polarity of the incoming signal. Assuming an incoming wave of the shape shown in Fig. 7, the impulse voltages of the secondary windings 144 and 164 of the impulse coils 142 and 152 respectively will be as indicated by the curves 42′ and 52′ respectively of Fig. 8 and their directions are indicated by arrows shown adjacent to their respective windings in Fig. 12. The vacuum tubes 147 and 157 respond to the impulses received from impulse coil 142 and cooperate in a mutually locking arrangement similar to that of Fig. 11, to control the voltage across resistance 140. Similarly vacuum tubes 167 and 177 control the voltage across resistance 150. The resistances 140 and 150 are connected in series, and the output terminals 160 and 170 are selected to obtain the combined voltage drop across both resistances. It will be noted that vacuum tubes 147 and 157 are connected to the secondary winding 144 in opposite relation to the connection of vacuum tubes 177 and 167 to the secondary winding 164. In other words vacuum tubes 147 and 157 are connected to the lower end of winding 144 whereas the vacuum tubes 177 and 167 are connected to the upper end of winding 164. Therefore, a polarity of an impulse shown in curve 42' will have, when impressed on the grid of vacuum tube 147, the opposite effect to an impulse of similar polarity, shown in curve 52', when the latter impulse is impressed on vacuum tube 177.

For the purpose of starting the description of operation of the circuit arrangement shown in Fig. 12 it is assumed that the circuit is in operation and that the first impulse (positive) shown in curve 42' of Fig. 8, is occurring in secondary winding 144 due to the incoming signal wave shown in Fig. 7, passing through the range of intensities between lines C and D. This positive impulse causes the grid of vacuum tube 147 to become negative, thereby blocking the space current in tube 147 and causing space current to flow in vacuum tube 157. The space current in tube 157 produces a voltage drop across resistance 140. This voltage counteracts an equal drop across resistance 150 produced by the previous impulse in secondary winding 164. The effect therefore of the voltage drop across resistance 140 is that terminal 170 goes from negative to zero potential as indicated by the first zero section in the curve shown in Fig. 10.

When the incoming signal wave rises to the positive side and passes through the values between the lines E and F (Fig. 7), a positive impulse occurs in secondary winding 164 to impress a positive potential on the grid of tube 177. This results in changing the stable condition of tubes 177 and 167 established by the previous impulse in winding 164, so that space current now flows in tube 177 causing a voltage drop across resistance 151, and the space current in tube 167 is blocked. At this time the stable condition of tubes 147 and 157 is such that a voltage drop exists across resistance 140 due to the first impulse shown in curve 42' of Fig. 8, and no voltage drop exists across resistance 139. The effect of simultaneous voltage drops across resistances 151 and 140 and of no voltage drop across resistance 150 is to impress a positive potential on terminal 170 and the output voltage of the circuit goes from zero to positive as indicated by the first positive section of the curve shown in Fig. 10.

When the incoming signal wave decreases in intensity and returns through the values between the lines F and E (Fig. 7), a negative impulse occurs in secondary winding 164 impressing a negative potential on the grid of tube 177. The stable condition of tubes 177 and 167 due to the first impulse shown in curve 52' of Fig. 8, is again changed so that the space current in the tube 177 is now blocked and space current flows in tube 167 producing a voltage drop across resistance 150. At this time the stable condition of tubes 147 and 157 is the same as stated in the previous paragraph, that is, a voltage drop exists across resistance 140. The effect of simultaneous voltage drops across resistances 150 and 140 is to restore the potential on terminal 170 to zero and the output voltage of the circuit goes from positive to zero as indicated by the second zero section of the curve shown in Fig. 10.

When the incoming signal wave further decreases in intensity, becomes negative and passes through the values between lines C and D (Fig. 7), a negative impulse occurs in secondary winding 144 to impress a positive potential on the grid of tube 147. The positive potential on the grid changes the stable condition of tubes 147 and 157 so that space current now flows in tube 147 and the space current in tube 157 is blocked. The space current in tube 147 produces a voltage drop across resistance 139 and no voltage drop now exists across resistance 140. At this time the stable condition of tubes 177 and 167 is such that a voltage drop exists across resistance 150 and no voltage drop exists across resistance 151. The effect of simultaneous voltage drops across resistances 139 and 150 is to impress a negative potential on terminal 170 and the output voltage of the circuit goes from zero to negative as indicated by the second negative section of the curve shown in Fig. 10.

It will be noted from the description above that when the incoming signal wave (Fig. 7) is passing through intensities between lines D and F, the potential difference between terminals 170 and 160 is zero. When the intensity is above line F, the potential at terminal 170, with respect to terminal 160, is positive and when below line D the potential at terminal 170 is negative.

The output voltages across terminals 160 and 170 are of a shape similar to that of the curve shown in Fig. 10 that is, of positive, negative and zero polarity and constitute a three-element signal wave. The reproduced signals are flat-topped, and those impulses which have a lesser strength than E or C are not retransmitted.

In Fig. 13 is shown a slight modification of the relay of Fig. 12. The former operates under the same basic principle as the relay of Fig. 12, but dispenses with one of the B batteries. In Fig. 13 a single B battery 171 supplies the plate circuits of both vacuum tubes 157 and 167. The four resistances 139, 140, 150 and 151 are connected in series with each other in the order mentioned. The resistances 140 and 150 are in the grid circuits of both tubes 147 and 177.

The following features of the relays of Figs. 11, 12 and 13 are instrumental in effecting reliability of operation:

In the first place, the input voltages supplied to the grid circuits are obtained from impulse coils rather than directly from the incoming line. By means of the impulse coils the value of incoming current strength, below which a signal is suppressed, can be predetermined with accuracy by simply varying the biasing current in the impulse coils. When the current value crosses a predetermined line the impulse coils produce a sharp impulse or "kick" which instantly changes the vacuum tube plate circuits from a stable condition of one polarity to one of another polarity. Thus the time taken for the outgoing signal to change from one polarity to another is very small and is furthermore independent of any variations in the characteristics of the vacuum tubes. If the grid circuits of the vacuum tubes were connected directly to the incoming line without the interposition of impulse coils, the response to a change in polarity or strength of the received signal would be neither as rapid nor as regular as if the grids were responding to sharp kicks from impulse coils. The response of the grid circuits to incoming signals received directly would vary with the characteristics of the vacuum tubes.

When, on the other hand, impulse coils are employed the relay may operate indefinitely without requiring adjustment of the vacuum tubes.

The plate impedance of the vacuum tubes of Figs. 11, 12 and 13 is comparatively low when the grid is locked to the positive polarity for the reason that no grid biasing batteries are used. Thus the plate circuit resistance and the B battery voltage become the chief factors in determining the output voltage. The output being taken from two of the four plate resistances only, at most two B battery units are instrumental in determining the output voltage. In the circuit of Fig. 13, the question of battery matching is eliminated since a single B battery unit furnishes both output polarities. When a grid is locked to the negative polarity the voltage is sufficient to reduce the corresponding space current to zero.

It will be understood that in certain cases, gas filled, glow discharge tubes may be utilized in place of the more common high vacuum tubes without substantially altering the mode of operation of circuits in accordance with the present invention.

The subject matter claimed herein is in part disclosed in applicant's copending application Serial No. 448,480 filed April 30, 1930 (now Patent 1,836,574 granted December 15, 1931), the claims of which relate to an invention different and divisible from that claimed herein.

What is claimed is:

1. In a repeater for signal impulses, an incoming and an outgoing line, instrumentalities connected to the incoming line for producing a succession of short, sharp, discrete impulses in response to the establishment of definite magnitudes of voltage of each incoming signal impulse, space discharge devices responsive to said discrete impulses, a plate circuit for each of said devices, a single space discharge device interconnecting said plate circuits and the outgoing line, and impedance means in one of said plate circuits for controlling the output voltage in the other of said plate circuits.

2. In a repeater for signal impulses, an incoming circuit, two space discharge devices each having a cathode and a control element connected to its input circuit, anode-cathode output circuits, an outgoing line to which impulses from an incoming line are to be repeated, polarizing sources for equally and symmetrically polarizing each control electrode with respect to its associated cathode, said control electrodes being coupled by equal mutual impedances, but oppositely, to said incoming circuit, and a potential storing device connected in common to said anode-cathode circuits and having impedance equally and oppositely coupled to said anode-cathode circuits, said device being also coupled to said outgoing line.

3. In a communication circuit, a signal repeater comprising instrumentalities for producing in response to each received signal impulse, a succession of short, sharp, discrete impulses of opposite polarities, mutually locking devices adapted to change from one stable condition to another in response to each of said discrete impulses, and a space discharge device adapted to remain stable in one of a plurality of conditions and solely responsive to said discrete impulses for changing from one of its conditions to another.

4. In a signaling system, a repeater comprising a plurality of space discharge devices, a plate circuit for each of said devices, a condenser connected in series in each of said plate circuits, an instrumentality responsive to a received impulse of one polarity and arranged to cooperate with one of said devices in charging said condenser, another instrumentality responsive to a received impulse of the other polarity and arranged to cooperate with another of said devices in discharging said condenser, and a space discharge amplifying device for transmitting signals of a polarity determined by the voltage of said condenser.

5. In a signaling system, a repeater comprising a condenser, means responsive to a received impulse of one polarity for charging the condenser, means responsive to an impulse of another polarity for discharging the condenser, said discharging means comprising a space discharge device having a control electrode responsive to received signals, and means for transmitting signals of a polarity determined by the polarity of the voltage of the condenser.

6. In a signaling system, a repeater comprising a condenser, means responsive to a received impulse of one polarity for charging the condenser, means responsive to a received impulse of another polarity for discharging the condenser, and means for transmitting signals comprising a thermionic amplifier having a control electrode connected to the condenser, whereby to prevent rapid discharge of the condenser through the transmitting means.

7. In the operation of a signaling system, a method of reshaping incoming distorted signal impulses which comprises converting each of the distorted signal impulses into a plurality of impulses of short duration and of opposite polarity, and subjecting each of said impulses of short duration to a relatively high impedance to produce a voltage sustained until the next succeeding short impulse is produced, to form a two-element square topped wave.

8. In the operation of a signaling system, a method of reshaping incoming distorted signal impulses of positive and negative polarity which comprises converting each of the distorted impulses into a plurality of impulses of short duration and of positive and negative polarities, subjecting alternate pairs of said short impulses of opposite polarities to a relatively high impedance to produce a voltage sustained until the next succeeding short impulse alone and of the opposite polarity is produced, subjecting other alternate pairs of said short impulses of opposite polarities at different intervals from those of the first mentioned alternate pairs whereby the voltage produced by one of the impulses of said other alternate pairs is sustained until the next succeeding short impulse of said other alternate pairs is produced, and combining the sustained voltages in their time relation to form a three-element square topped wave.

9. In a signaling system a circuit arrangement for reshaping distorted signals comprising electromagnetic devices for converting each of the distorted signal impulses into a plurality of voltage impulses of short duration and of positive and negative polarities, unidirectionally conducting means for selecting certain of said voltage impulses to produce sustained voltages of a polarity dependent upon the polarities of the voltage impulses of short duration, impedance means for further sustaining the voltages of the output of said unidirectionally conducting means, and means for repeating the further sustained voltages as undistorted signal impulses corresponding to those received by said electromagnetic

devices, the repeated signal impulses having a polarity determined solely by the polarity of the corresponding sustained voltages.

10. In a communication system, a signal repeater comprising two space discharge devices, a condenser, a charging circuit for said condenser including one space discharge device and a discharge circuit for the condenser including the other space discharge device, each space discharge device having control means for successively blocking and permitting space current in response to received signals.

11. In a communication system, a signal repeater comprising two triodes, each having an anode, a cathode and a control electrode, a condenser, a charging circuit for the condenser including the anode and cathode of one triode, a discharge circuit for the condenser including the anode and cathode of the other triode, inductive circuits including the control electrodes for controlling the current through the triodes in response to received signals, and a space discharge device for transmitting repeated signals having a polarity determined by the charge of the condenser.

12. In a signal transmission system, a repeater for suppressing signals having less than a predetermined magnitude, comprising a first impedance element, mutually locking devices responsive to incoming signals for maintaining in approximately constant potential difference across said impedance element only while the incoming signal strength exceeds a predetermined positive value, a second impedance element in series with the first impedance element, other mutually locking devices for maintaining an approximately constant potential difference across said second impedance element only while the incoming signal strength exceeds in negative polarity a predetermined value, the potential differences across the two impedance elements being opposite in polarity, and a transmitting device connected in series with both impedance elements.

13. In a signal transmission system arranged to receive two element signal waves, a repeater for suppressing signals having less than a predetermined magnitude, comprising a condenser, means responsive to incoming signals for successively charging and discharging the condenser in response to the establishment and disestablishment respectively of a predetermined positive value of signal strength, a second condenser in series with the first condenser, means for successively charging and discharging the second condenser in response to the establishment and disestablishment respectively of a predetermined negative value of signal strength, the charges on the two condensers being opposite, and a transmitting device connected in series with both condensers for repeating the two-element wave as a three-element wave.

14. In a communication system, a signal repeater comprising a pair of amplifiers each having an output circuit, and an input circuit connected to the output circuit of the other amplifier and so poled that current in one amplifier is effective to block current in the other amplifier, inductive devices for controlling the input circuits of the amplifiers, said devices being adapted to produce short, sharp, discrete impulses in response to the establishment of definite magnitudes of voltage of the incoming signals.

15. In a signaling system, a repeater comprising a pair of thermionic amplifiers, each having an output circuit comprising an impedance element and an input circuit supplied with voltage from the output impedance element of the other thermionic amplifier, the input circuits being so poled that output current from one amplifier blocks output current in the other amplifier, inductive devices responsive to signals received from a line for controlling the input circuits of the thermionic amplifiers, and a transmitter for repeating the incoming impulses, said transmitter being connected to the two output impedance elements in series.

16. In a signal transmission system arranged to receive two element signal waves, a repeater comprising oppositely biased inductive devices arranged to effect the suppression of signal intensities of a positive polarity and of a negative polarity except those within a predetermined range and to convert the rising and falling portions of a signal wave within said range into short, sharp, discrete impulses of opposite polarity, a plurality of mutually locking space discharge devices responsive to said short impulses, a pair of impedance elements respectively connected in the output circuit of each of said locking devices whereby each pair of short impulses of opposite polarities produces potential differences across said impedance elements alternately, a transmitting device connected in series with the pairs of impedance elements whereby each of the short impulses is effective to cause said transmitting device to transmit or repeat an impulse of positive, negative or zero voltage to form a three-element signal wave.

17. In a repeater for signal impulses, an incoming and an outgoing circuit, devices for receiving from said incoming circuit signal wave impulses of slowly varying intensities and for producing a succession of short, sharp, discrete impulses in response to the establishment of definite magnitudes of voltage in each incoming signal wave impulse, a pair of thermionic valves, each having a cathode, anode and an impedance control element, circuit means conecting the anode of one valve and the impedance control element of the other valve to said devices, and additional circuit means interconnecting the input and output circuits of said valves and said outgoing repeater circuit whereby said valves assume two stable conditions alternately in response to said discrete impulses.

18. In a repeater for signal impulses, according to claim 17, said additional circuit means comprising a connecting lead between the impedance control element of said other valve to the plate circuit of said one valve, completing circuit means whereby an electrical impulse of one polarity applied to the impedance control element of either valve causes a change of plate circuit current in that valve whereby the plate current of one valve is reduced and that of the other valve increased until one of said stable conditions is attained and maintained until an applied impulse of opposite polarity reverses the process actuating said valves to assume the other and opposite stable condition.

19. In a system for communication of intelligence a repeater having incoming and outgoing circuits, means in said incoming circuit and responsive to incoming distorted signal waves for producing a succession of short discrete impulses in response to changes of magnitude of voltage of said waves through a fixed range of magnitudes, the polarity of said discrete impulses being determined by the direction of the change of said volt-

age through said fixed range, thermionic discharge means alternately and oppositely responsive to impulses of positive and negative polarity, an impedance element connected in common to said thermionic discharge means and arranged to cooperate therewith in producing for each pair of short discrete impulses of positive or negative polarity by themselves, a sustained voltage wave of square topped shape and equal in duration to intervals between the impulses of the corresponding pairs, and another thermionic discharge device connected to said outgoing circuit for amplifying said sustained voltages for retransmission.

20. In a repeater for signal impulses, an incoming circuit connected to a source of signal impulses, two space discharge devices each having a cathode and a control element connected to its input circuit, and an anode-cathode output circuit, an outgoing line to which the impulses from an incoming l'ne are to be repeated, a path common to both anode-cathode output circuits and in shunt to said outgoing line, and electrostatic means arranged in said common path to cooperate with said two space discharge devices for producing in said outgoing line a two-element wave of square topped shape in response to the alternate operation of said space discharge devices.

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