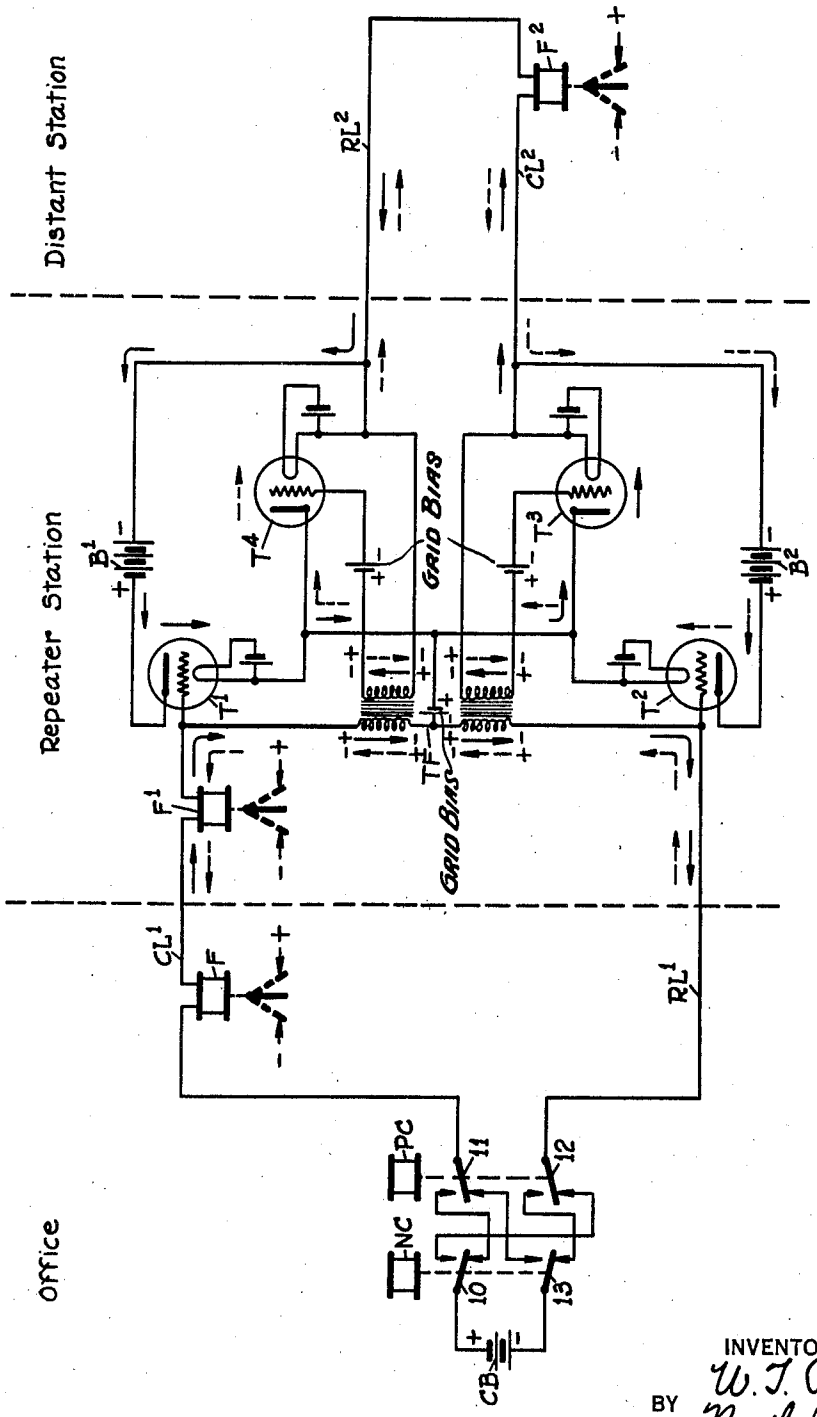
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POLAR IMPULSE REPEATER SYSTEM

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Note 1 — T^1 and T^2 Are tubes in which the Grid maintains Control
Note 2 — T^3 and T^4 Are tubes in which the Grid triggers the tube and the Plate Potential maintains Control

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POLAR IMPULSE REPEATER SYSTEM

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14 Claims. (Cl. 178—70)

This invention relates to remote control systems of the type involving a control station and a plurality of remote or field stations connected by one or more line circuits. One object of this invention is the provision, in a system of this character, of a repeating or relaying station located at a point between the control station and the more remote stations, for the purpose of repeating each code that is sent out from the control office.

A repeating or relaying station is desirable when a remote control system involves line circuits of such length as to introduce a handicap due to line resistance and leakage. In such cases, the repeating station or stations may be located at any point or points where it is convenient to house the equipment associated therewith.

One form of repeating station embodying this invention will be described, after which the novel features of the invention will be pointed out in claims.

The accompanying drawing is a diagrammatic view showing one form of repeating station embodying this invention.

In the present instance, the repeating station is illustrated as applied to a centralized traffic controlling system of the type involving a two-wire line circuit. On the primary side of the repeating station the two-wire line circuit comprises control line conductor CL^1 and return line conductor RL^1. On the secondary side of the repeating station the two-wire line circuit extending to one or more distant stations comprises control line conductor CL^2 and return line conductor RL^2.

In a system of the character contemplated by the present invention the primary line circuit is reversibly connected to a control battery CB in the control office for providing direct current polar impulses in the control line circuit. Current flows from the control office battery through a line relay F in the control office and a line relay F^1 at the repeater station, if a field station is located at the repeater station location. It will be understood that the repeater station may be at a location where no controls are contemplated, therefore no relays at such a location will be provided. The control line conductor CL^1 is connected to the return line conductor RL^1 at the repeater station through the primary windings of a transformer TF which provides a closed path for the primary line circuit.

The secondary line circuit is energized with direct current polar impulses supplied by batteries B^1 and B^2 at the repeater station in accordance with the impulses received in the primary line circuit, in a manner which will be pointed out in detail. It will be understood that one or more field stations, with their line relays such as relays F^2 connected in the secondary line circuit, will be connected to the line circuit extending from the right-hand portion of the repeater station. It will also be understood that additional repeater stations may be provided to meet actual operating conditions.

Since vacuum tubes are used for repeating the polar impulses from the primary line circuit into the secondary line circuit, it will be obvious that no mechanical moving parts are involved so that these impulses are repeated with no lag or loss of time.

One system arranged as specified above is disclosed in an application for United States Letters Patent, Ser. No. 640,062, filed October 28, 1932 by T. J. Judge and C. S. Bushnell, corresponding to British Patent 419,399, for centralized traffic controlling systems. In this pending application the polar impulses are applied to the line circuit in accordance with codes to be transmitted by selectively operating relays PC and NC, which relays are indicated in the left-hand portion of the accompanying drawing and correspond to similar relays in the above-mentioned application.

The system of the present invention employs four vacuum tubes T^1, T^2, T^3 and T^4 at the repeater station. Each of these tubes is of the "triode" type having a cathode emitting electrons when heated and associated with a plate (or anode) for collecting (or attracting) the electrons when it is positively charged, and also having a control electrode (or grid) for controlling the electron emission from the cathode. Although these tubes in the disclosure have been shown as having filament cathodes, it is to be understood that a separate cathode with a heater element may be employed.

Tubes T^1 and T^2 are of the "hard" or high vacuum type in which the grid has continuous control over the electron emission from the cathode. With the plate or anode positively charged and the cathode heated, a negative charge on the grid reduces the electron flow to the plate so that the anode-cathode circuit has a decreased current flow, while a positive charge on the grid increases the electron flow to the plate so that the anode-cathode circuit has an increased current flow. In the present case a sufficient negative charge (or grid bias) is normally placed on the grids of tubes T^1 and T^2 to render their

anode-cathode circuits substantially non-conductive, but when an impulse of a particular polarity is present on the primary line circuit, the negative charge is reduced (or changed to a positive charge) on the grid of one of the tubes T^1 and T^2 to render its anode-cathode circuit conductive.

Tubes T^3 and T^4 are of the gas or vapor content discharge type in which the grid is only employed to control the starting of the current in the anode-cathode circuit. Such a gas filled tube is familiarly known as the Thyratron in which the action of the tube is somewhat different than a tube of the high vacuum type. In the Thyratron tube, a sufficient negative charge on the grid prevents electron flow to the plate so as to maintain a high impedance in the anode-cathode circuit, but when this negative charge on the grid is reduced (or changed to a positive charge) the electron flow from the cathode to the plate reduces the impedance of the tube so that the positive charge on the plate or anode causes current to flow from the anode to the cathode, which current flow or discharge so greatly ionizes the grid of the tube that current continues to flow in the anode-cathode circuit irrespective of the change of potential on the grid. In other words, the grid in this type of tube controls only the starting of the discharge or current flow through the anode-cathode circuit, after which it neither modulates, limits nor extinguishes the discharge irrespective of the positive or negative charge on the grid. The only way that the impedance of this type of tube can be restored to its original value is to remove the potential on its plate or anode so as to stop the current flow in its anode-cathode circuit.

The function required of the repeating station is the receiving of the control codes that are generated in the control office and the transmission of these codes to the field station or stations beyond the repeating station. It will be understood that in a system contemplated by the present invention, indications will be transmitted from the field stations to the control office either by timing the lengths of the impulses in the control line circuits or by making use of a separate indication line circuit, but since this portion of the system is immaterial to an understanding of the present invention it has not been disclosed in the accompanying drawing.

In view of the above, one of the objects of the present invention is to reduce the delay introduced between the application of coded impulses to the primary line circuit and the application of these impulses to the secondary line circuit, which delay is ordinarily introduced in a system which uses mechanically operating or relay type repeaters.

Another object of the present invention is to provide a repeater station which repeats polar impulses from one line circuit into another without the use of any mechanically moving parts.

A further object of the present invention is the provision of a polar impulse repeater of the vacuum tube type which repeats into a secondary line, accurate facsimiles of direct current polar impulses received in a primary line. In other words, each primary polar impulse received over a primary line causes a similar secondary polar impulse to be transmitted over a secondary line, which secondary impulse begins and ends at approximately the same time as the primary polar impulse begins and ends. In this way the secondary impulses not only correspond to the polarity of the primary impulses but they accurately correspond to the duration of the primary impulses. Thus the secondary impulses are referred to as facsimiles of the primary impulses.

Operation

With the system in its normal condition, relays PC and NC in the control office are deenergized so that the primary control line circuit is deenergized, thus effecting the positioning of the polar contacts of the line relays to their neutral positions.

It will be assumed that, under normal conditions, none of the tubes at the repeater station are conducting, this being due to the fact that the grid circuits of these tubes are normally at a negative potential with respect to their filaments by means of grid batteries or the like. It will be obvious that these tubes may be arranged to operate on the portions of their characteristic curves in such a way that it requires a positive grid potential to cause the tube to conduct by way of its plate circuit. In view of the above no current flows in the secondary line circuit under normal conditions.

In order to apply a (+) impulse to the primary control line circuit in the control office, relay PC is energized by means not illustrated in the drawing but which is clearly disclosed in the above-mentioned prior application, Ser. No. 640,062. A (+) impulse energizes the primary control line over a circuit extending from the (+) terminal of battery CB, armature and back contact 10 of relay NC, armature and front contact 11 of relay PC, winding of relay F, control line conductor CL^1, winding of relay F^1 (if provided), through the primary windings of transformer TF, return line conductor RL^1, armature and front contact 12 of relay PC and armature and back contact 13 of relay NC to the (−) terminal of battery CB.

Current flows over the control line circuit in the direction indicated by the full line arrows, which establishes potentials across the primary windings of transformer TF as indicated by the (+) and (−) symbols associated with the full line arrows adjacent these transformer windings.

Upon the rise in current in the primary windings of the transformer TF, a potential is of course produced across the upper primary winding of this transformer in accordance with the impedance of such winding, and after the current assumes a steady value for the remainder of the impulse on the primary line circuit this potential then becomes a steady value in accordance with the potential drop (IR drop) across this winding of the transformer. Both the potential drop and the resistance drop across the upper primary of the transformer TF are positive with respect to the negative bias on the grid of tube T^1 so that its charge is changed to a positive charge which reduces the impedance of the tube T^1 to render it conductive. This change in the impedance of the tube T^1 occurs immediately upon the presence of current in the primary line circuit so that a positive potential from the battery B^1 is placed upon the plates of the tubes T^3 and T^4 in readiness for the triggering of one or the other of these tubes.

It will be seen that the potential drops across the lower winding of the transformer TF are negative with respect to the bias of the tube T^2 so that the charge on the grid of this tube T^2 is maintained negative so as to maintain the high impedance in the anode-cathode circuit of this tube to render it non-conductive.

The sudden rush of current through the primary windings of transformer TF in response to the (+) impulse applied to the primary control line circuit, sets up potentials across the secondary windings of this transformer as indicated by the (+) and (—) symbols associated with the full line arrows adjacent these secondary windings. The momentary potential produced in the upper secondary winding of transformer T^4 is negative with respect to the bias on the grid of this tube so that the charge on such grid is maintained negative and the high impedance of the anode-cathode circuit of this tube is maintained, but the momentary potential in the lower secondary winding of transformer TF is positive with regard to the bias on tube T^3 thus changing the charge on the grid of tube T^3 to a positive value with respect to its cathode. With the positive potential on the plate of the tube T^3 due to the reduction of the impedance of T^1 in accordance with the potential drop across the upper primary winding of transformer TF, the impedance of the anode-cathode circuit of the tube T^3 is reduced so that current can now flow through the anode-cathode circuits of tubes T^1 and T^3 in series.

With tubes T^1 and T^3 rendered conductive, a (+) impulse is applied to the secondary control line over a circuit extending from the (+) terminal of battery B^1, plate filament circuit of tube T^1, plate-filament circuit of tube T^3, control line conductor CL^2, winding of relay F^2 and return line conductor RL^2 to the (—) terminal of battery B^1 in the direction of the full line arrows. This current is in the proper direction to actuate the polar contacts of relay F^2 (and any other similar line relays in the circuit) to their right-hand dotted positions.

It will be understood that the induced potential set up across the lower secondary winding of transformer TF is of momentary duration, since uninterrupted steady current continues to flow through the primary winding of this transformer until the termination of the (+) impulse. However, since tube T^3 is of the trigger type, as above explained, it continues to conduct even after the grid loses its positive potential so that current continues to flow in the direction of the full line arrows through tubes T^1 and T^3 over the secondary control line circuit until the impulse in the primary control line circuit is terminated.

When the impulse in the primary control line circuit is terminated the plate circuit of tube T^1 becomes non-conducting because the potential drop across the upper primary winding of the transformer TF is removed allowing the charge on the grid of the tube T^1 to be made negative by its biasing battery which prevents the flow of electrons from its cathode to the plate thereby preventing the flow of current in its anode-cathode circuit. The restoration of the anode-cathode circuit of the tube T^1 to its normally high value also stops the flow of current through the anode-cathode circuit of tube T^3 so that the grid of this tube T^3 can regain control of the current flowing in its out-put circuit. This is effective to terminate the impulse in the secondary control line circuit by opening the circuit at tube T^1. It will be understood that it requires another positive potential applied to the grid of tube T^3 to again render it conducting.

From the above discussion it will be apparent that the grid of tube T^1 is rendered positive and maintained positive by the IR drop in the upper primary winding of transformer TF as long as positive impulse current flows in the primary line. Furthermore, the grid of tube T^2 is rendered more negative and maintained more negative by the IR drop in the lower primary winding of transformer TF as long as positive impulse current flows in the primary line.

In order to initiate a (—) impulse in the control line circuit at the control office, relay NC is picked up while relay PC remains down for energizing the primary control line circuit over a path extending from the (+) terminal of battery CB, armature and front contact 10 of relay NC, armature and back contact 12 of relay PC, return line conductor RL^1, primary windings of transformer TF, winding of relay F^1 (if provided), control line conductor CL^1, winding of relay F, armature and back contact 11 of relay PC and armature and front contact 13 of relay NC to the (—) terminal of battery CB.

This (—) impuse causes current to flow over the primary control line circuit in the direction indicated by the dotted line arrows, which is effective to position the polar contacts of the F relays in the line circuit to their left-hand dotted positions.

This impulse sets up potentials across the primary windings of transformer TF as indicated by the (+) and (—) symbols associated with the dotted line arrows indicating current flow through these windings. The potential drop across the upper primary winding of transformer TF renders the grid of tube T^1 more negative with respect to its filament as provided by its grid biasing battery while the potential drop across the lower primary winding of transformer TF opposes the bias normally provided on the grid of tube T^2 so that its bias is now made positive with respect to its filament.

Tube T^1 is rendered non-conductive by this (—) impulse and tube T^2 is rendered conductive. The sudden rush of current through the primary windings of transformer TF induces potentials across the secondary windings as indicated by the (+) and (—) symbols associated with the dotted line arrows which are associated with these windings. It will be observed that the grid of tube T^3 is made more negative with respect to its filament while the grid of tube T^4 is made positive with respect to its filament.

Tubes T^2 and T^4 are thus made conductive in response to a (—) impulse applied to the primary control line circuit. This causes the secondary control line circuit to be energized with a (—) impulse over a path extending from the (+) terminal of battery B^2, plate filament circuit of tube T^2, plate filament circuit of tube T^4, return line conductor RL^2, winding of relay F^2 and control line conductor CL^2 to the (—) terminal of battery B^2. Current flows in this circuit in the direction indicated by the dotted line arrows.

In this case tube T^4 continues to pass current in this direction after its grid loses its (+) potential, so that current continues to flow over the above described circuit as long as tube T^2 is rendered conductive by the (—) impulse applied to the primary control line circuit.

When this (—) impulse is terminated the (+) potential is removed from the grid of tube T^2, so that current ceases to flow through its plate circuit and therefore the (—) impulse is terminated in the secondary control line circuit.

From the above discussion it will be apparent that the grid of tube T^2 is rendered positive and maintained positive by the IR drop in the lower primary winding of transformer TF as long as

negative impulse current flows in the primary line. Furthermore, the grid of tube T^1 is rendered more negative and maintained more negative by the IR drop in the upper primary winding of transformer TF as long as negative impulse current flows in the primary line.

From the foregoing it will be observed that a novel repeater for direct current polar impulses has been provided. It will be obvious that this repeater may have an amplification of unity or more, so that impulses in the primary line may be repeated into the secondary line at their received amplitude or they may be increased in amplitude in the secondary line as desired.

It has been mentioned that tubes T^3 and T^4 are of the Thyratron or gas content discharge type. This type tube is inherently of low impedance and high current carrying capacity, which is desirable in the present arrangement because each of these tubes operates in series with one of the "hard" or high vacuum type tubes T^1 and T^2, which tubes are inherently of high impedance and low current carrying capacity.

Having thus described one specific embodiment of an impulse repeater system it is desired to be understood that the particular arrangement illustrated is merely typical of applicant's invention and not intended to show the exact circuit arrangement necessary to carry out the features of the invention, but has been selected to facilitate in the disclosure rather than to limit its scope and it is further to be understood that various modifications may be made and various adaptations and alterations may be applied to the specific form disclosed in order to meet the various problems encountered in practice and that the system may be varied in the amount of apparatus installed, all without in any manner departing from the spirit or scope of the invention except as limited by the appended claims.

What I claim is:—

1. In an impulse repeater, a first circuit and a second circuit, a first grid controlled vacuum tube and a second grid controlled vacuum tube, means for energizing said first circuit, means responsive to the initial energization of said first circuit for controlling the grids of said vacuum tubes whereby said second circuit is energized, means for withdrawing control of the grid of said second vacuum tube and maintaining control of the grid of said first vacuum tube as long as said first circuit is energized, and means including both of said vacuum tubes for maintaining said second circuit energized as long as said first circuit is energized.

2. In combination; a circuit; a first and a second pair of electron discharge devices, each pair comprising a primary and a secondary device, each device comprising an anode, a cathode and a control electrode and each pair of said devices being reversely connected to said circuit; a source of direct current connected to each anode of said primary devices; means including their associated control electrodes for individually controlling said primary devices; and means responsive to the individual control of each of said primary devices for reversely energizing its associated secondary device and said circuit in series from said sources of current.

3. In a direct current impulse repeater, a first line circuit having characteristic sustained direct current impulses applied thereto, a transformer and a vacuum tube amplifier conductively connected to said first line circuit and characteristically energized by said impulses, a second line circuit, and means responsive to the characteristic energization of said transformer and including said amplifier for amplifying and repeating said sustained direct current impulses into said second line circuit.

4. In an impulse repeater; an incoming line; an outgoing line; means for applying primary positive, negative and zero current impulses to said incoming line; a plurality of thermionic relay devices responsive to said primary impulses to transmit corresponding positive, negative and zero secondary impulses over said outgoing line in approximate synchronism with said primary impulses; a portion of said thermionic relay devices being characterized by anode, cathode and control electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit after being started by a momentary critical starting potential applied to the control electrode; and another portion of said thermionic relay devices being characterized by anode, cathode and control electrode elements so constructed and arranged that current continues to flow in the anode-cathode circuit only as long as a critical starting potential continues to be applied to the control electrode.

5. In an impulse repeater; an incoming line; an outgoing line; means for applying primary positive, negative and zero current impulses to said incoming line; low current vacuum tubes conductively connected to said incoming line; high current vacuum tubes; a transformer inductively connecting said incoming line with said high current vacuum tubes; biasing circuits for said low and high current vacuum tubes so arranged that each polar impulse in said incoming line is effective to produce a secondary impulse of corresponding polarity in said outgoing line, said outgoing line being selectively energized by each secondary impulse in series with the output circuits of certain of said low and high current vacuum tubes as selected by the polarity of said primary impulses.

6. In a transmitting apparatus adapted to apply currents of opposite polarity to a line circuit, oppositely poled current generators, a gaseous ionizable arc discharge tube interposed between each generator and the line circuit, a one way current conducting device associated with each arc discharge tube, means including an inductive connection associated with each tube to start current flow in said line circuit, and means including each one way device for controlling the current started in said line circuit.

7. In a signalling system having incoming and outgoing lines, apparatus for repeating code signal impulses between said lines, comprising oppositely poled sources of direct current, a gaseous ionizable arc discharge path interposed between each source and the outgoing line, arc starting means associated with each of said paths, means actuated by current impulses transmitted to said incoming line to generate potentials which actuate said arc starting means, and means actuated by said current impulses and cooperating with said arc starting means selectively controlling said arc discharge paths for sending code impulses of current from one or the other of said sources over said outgoing line to form replicas of the current impulses on said incoming line.

8. In a repeater station having incoming and outgoing lines, means for applying positive and negative time spaced impulses to said incoming line, oppositely poled current generators, a gaseous ionizable arc discharge path interposed be-

tween each generator and the outgoing line, an arc quenching device associated with each of said paths, means actuated by the impulses received over the incoming line to condition one path for operation and to prevent the operation of the other path, and means for controlling each arc quenching device to quench the current impulse in the outgoing line in response to a time space between said impulses.

9. In a signalling system, a first circuit and a second circuit interlinked by an impulse repeater comprising a plurality of thermionic tubes, means to supply primary polar direct current impulses from said first circuit to said repeater, means responsive to primary impulses of one polarity for effecting conductive connection of a first pair of said tubes in series with said second circuit wherey secondary impulses of said one polarity are applied to said second circuit, and means responsive to primary impulses of another polarity for effecting conductive connection of a second pair of said tubes in series with said second circuit whereby secondary impulses of said another polarity are applied to said second circuit.

10. In a line circuit repeating system, a first line circuit, means for selectively applying sustained impulses of direct current to said first line circuit, two electronic tubes arranged to have their plate circuit portions connected in series to permit the flow of direct current when such tubes are excited, means for exciting one of said tubes in accordance with the polarity and duration of each of said impulses on said first line circuit, means for exciting the other of said tubes in accordance with the rate of change in magnitude of each of said impulses, a source of direct current, and a second line circuit connected in series with said series plate circuit portions and said source of direct current.

11. In a repeating system for a code type communication system, a first line circuit having a series of time spaced direct current impulses applied thereto, a vacuum tube having a plate circuit and a controlling grid element, a gas filled tube having a plate circuit and a triggering grid element, circuit means conductively connecting said grid element of said vacuum tube to said first line circuit so as to render the plate circuit of such tube conductive only when there is impulse current in such line circuit, a transformer having its primary connected in said first line circuit and having its secondary connected to control said triggering grid element, a second line circuit, a source of direct current, and circuit means connecting said plate circuits in series with each other, said source of direct current and said second line circuit, whereby a series of time spaced impulses is impressed on said second line circuit corresponding to the series of impulses on said first line circuit.

12. In a repeating system for a code type communication system; a first line circuit; means for applying a series of time spaced impulses to said first line circuit; a first vacuum tube having an anode, a cathode and a control electrode, said vacuum tube being so constructed and arranged that current continues to flow in the anode-cathode circuit after being started by a momentary critical starting potential applied to the control electrode; a second vacuum tube having an anode, a cathode and a control electrode, said second vacuum tube being so constructed and arranged that current continues to flow in the anode-cathode circuit only when a potential above a predetermined value continues to be applied to the control electrode; circuit means conductively connecting the control electrode of said second vacuum tube to said first line circuit in a manner to supply a continuous potential above said predetermined value to such control electrode during each impulse on said first line circuit; circuit means inductively connecting the control electrode of said first vacuum tube to said first line circuit so as to supply a momentary critical starting potential to such control electrode at the beginning of each impulse on said first line circuit; a second line circuit; a source of direct current; and circuit means connecting the anode-cathode circuit of said vacuum tubes in series with each other and in series with said source of direct current and said second line circuit; whereby a series of time spaced impulses is impressed on said second line circuit corresponding to the series of impulses on said first line circuit.

13. In a vacuum tube repeating system for a code type communication system; a first pair of tubes and a second pair of tubes, one tube of each pair having an anode and a cathode with a control electrode and being so arranged and constructed that current flows in its anode-cathode circuit only while its control electrode is supplied with a positive potential above a predetermined value, and the other tube of each pair having an anode and a cathode with a control electrode and being so arranged and constructed that current flows in its anode-cathode circuit only after its control electrode is supplied with a critical starting positive potential which current continues to flow independently of the discontinuance of such starting potential until such anode-cathode circuit is deenergized; a first line circuit conductively connected to the control electrode of said one tube of each pair and inductively connected to the control electrode of said other tube of each pair; means for energizing said first line circuit with sustained direct current of either polarity and for deenergizing such line circuit; two sources of direct current; a first out-put circuit connecting the anode-cathode of both tubes of one pair in series with one of said sources of direct current to allow current to flow depending upon the energization of the control electrodes of such pair; a second out-put circuit connecting the anode-cathode of both tubes of the other pair of tubes in series with each other and the other source of direct current to allow current to flow depending upon the energization of the control electrodes of that pair; a second line circuit connected to said first and second out-put circuits in multiple in opposite relationships so as to be energized in one direction or the other depending upon the particular pair of tubes which is rendered effective; and means including the in-put circuits of each pair of tubes, for rendering one or the other pair of tubes effective upon the initial energization of said first line circuit with one polarity or the other and causing said such pair of tubes to remain effective so long as said first line circuit remains energized.

14. In a vacuum tube repeater for direct current impulses of different polarities, a first pair of tubes and a second pair of tubes, an in-coming line circuit inductively connected to the in-put circuit of one tube of each pair and inductively connected to the in-put circuit of the other tube of each pair, means for energizing said in-coming line with continuous direct cur-

rent of either polarity and for deenergizing such line circuit, two sources of direct current, a first out-put circuit means connecting the out-put circuits of both tubes of one pair in series with one of said sources of direct current to allow current to flow in one direction, a second out-put circuit means connecting the out-put circuits of both tubes of the other pair in series with the other of said sources of direct current to allow current to flow in the other direction, an out-going line circuit connected to said first and second out-put circuit means in multiple so as to be energized in one direction or the other depending upon which pair of tubes is activated, and means, including the in-put circuits of each pair of tubes, for rendering one or the other pair of tubes activated upon the initial energization of said in-coming line circuit with one polarity or the other.

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