

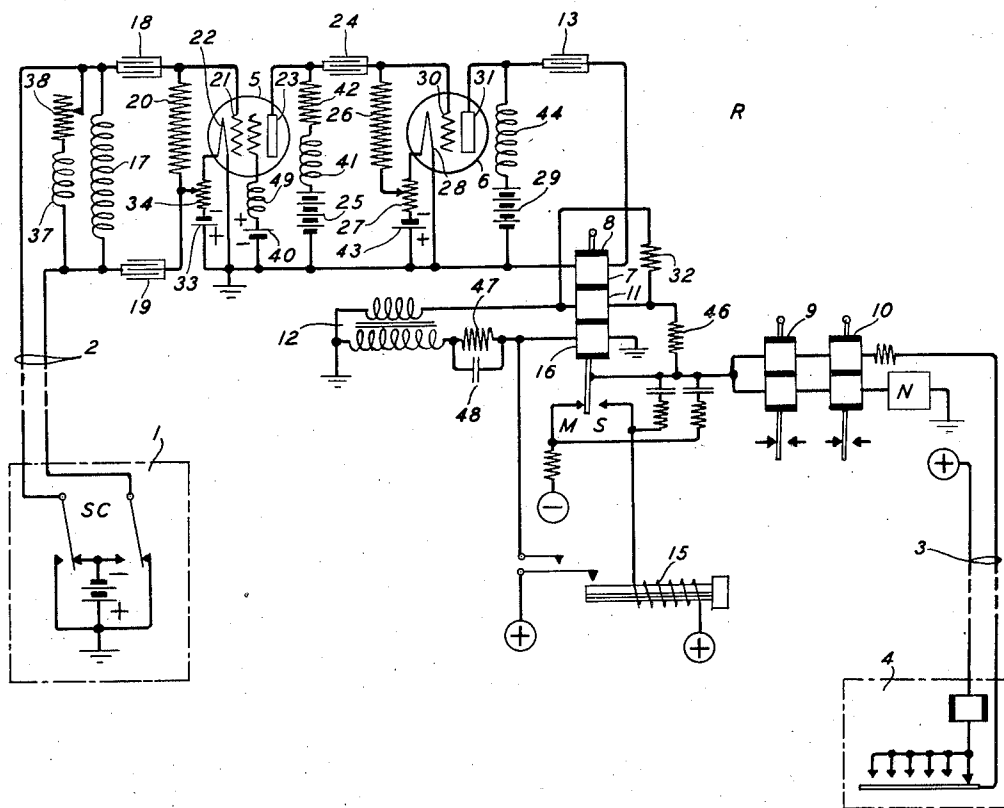
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IMPULSE TELEGRAPH REPEATER

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IMPULSE TELEGRAPH REPEATER

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This invention relates to telegraph repeaters and particularly to repeaters in which a line relay is operated into its alternate positions by induced currents caused by incoming signals of opposite polarity.

The tendency in the development of the present day telegraph plant is towards more sensitive repeaters permitting a greater spacing apart of repeater stations or use of smaller gauge line conductors or both. This object may be attained by the use of thermionic amplifiers in one or more stages combined with highly sensitive relays.

It has long been desired to provide a satisfactory arrangement for operating a line relay through a high amplification vacuum tube repeater system in response to current reversals from the distant sending station. This problem is solved in a practical manner in accordance with the invention by special arrangements of condensers in the input and the output side of the vacuum tube repeater; and where there are two stages of amplification, as in the preferred form of the invention, a similar arrangement is inserted between the stages. The general principle underlying this feature of the invention involves a quick charging of the input condensers for each amplifier stage by each current reversal from the sending station for the production of a current impulse through the line relay of sufficient strength and duration to operate that relay to its alternate position; and, when current reversals cease to arrive in regular succession, a slow decay of the charging current into the input condensers which will produce a long reversed impulse through the line relay of an amplitude too small to operate the relay back to the contact from which it was operated by the last incoming impulse.

In accordance with this feature of the invention, the input, interstage and output condensers for the amplifier are made exceptionally large and, excepting the output condenser, they are connected to charge and discharge through high resistances. Thus, quickly applied changes in potentials will cause a heavy initial flow of currents through the large condensers, and the high resistances will prolong the reversed decaying currents when the system is permitted to gradually resume its steady state.

The invention thus is especially applicable to the so-called "impulse receiving" system in which the receiving line relay has its receiving winding inductively associated with the output side of the amplifier, as through a condenser. Thus, during

periods when no signals are being received, the receiving winding will be currentless and the armature will be held in normal position by the polarizing or holding flux; when incoming signals are received, current impulses will be passed through the receiving winding, the direction of which depends upon the polarity of the incoming signals, and will operate the armature to marking or spacing accordingly.

In accordance with the invention, the relay is arranged as a "vibrating" relay having an operating winding which receives a short impulse of only sufficient strength and duration to start the armature away from the contact on which it is resting. Thus, the operating impulse may be considerably shorter than the dot impulse of the code, with the advantage that the time constants of the condenser circuits in the amplifier may be greatly reduced and that, therefore, the condensers may be considerably reduced in size. The relay, furthermore, has an accelerating winding similar to that of the "vibrating" relay, but strong enough to carry, by itself, the armature over to the other contact once it has been moved by the operating winding away from the contact at which it was at rest. The relay also has a holding winding which is operated over either relay contact to hold the relay in either position; this is necessitated by the fact that the operating winding in accordance with the invention is normally currentless. In the interest of sensitivity, the holding winding is made only strong enough to hold the relay under normal operating conditions, since the operating or line winding must overcome the holding winding in changing the position of the armature.

A relay of this type, being highly sensitive, must be delicately adjusted and therefore may easily have its armature moved from one position to the other by accidental disturbances which may be entirely of a mechanical nature or may be caused by electrical conditions in the line.

When such a relay is used for retransmitting signals into a half duplex or a full duplex line circuit it becomes necessary, during idle periods, to either prevent the armature from being disturbed or else to restore the armature to its normal position after a predetermined interval in order to condition the duplex circuit for transmission from the remote station.

In accordance with a specific application of the invention, a system is provided in which reversed impulses are received over a metallic line, are amplified by a circuit arrangement of condensers and thermionic space discharge tubes, impressed

upon the receiving winding of a sensitive vibrating relay through capacity means and retransmitted by the relay into a half duplex circuit which may be a subscriber's loop; slow-acting relay means are further provided to be operated when the receiving relay armature has been accidentally operated to spacing position for a predetermined time longer, for example, than the length of two or three break signals, the operation of the slow-acting relay means being effective in restoring the receiving relay armature to marking position, as by a temporary energization of one of the auxiliary windings on the relay, so as to establish normal operating conditions in the half duplex line circuit.

The invention will now be described more in detail as applied to a preferred embodiment, and reference will be made to the accompanying drawing, which shows a circuit diagram for a two-stage vacuum tube amplifier operating between a sending station and a half duplex line to a telewriter station.

As shown in the circuit diagram, sending station 1 is connected over line 2 to repeater station R which amplifies and shapes the signal impulses by means of amplifier tubes 5 and 6, and impresses them on winding 7 of polarized relay 8. Any signal code, which can be transmitted by means of impulses of two different polarities, may be used with the type of repeater shown in the drawing. Tube 5 is the so-called screen grid type of thermionic space discharge tube to assure stability of operation, as is well known in the art. Tube 6 is also a thermionic space discharge tube. These tubes may be tubes Nos. 246-A and 101-F respectively, manufactured by Western Electric Company, Incorporated. Relay 8 normally operates in unison with the received current impulses and transmits corresponding impulses into line 3, which is arranged on a half duplex basis.

Relay 8 is a multiple winding polar relay, such as relay 209-FA manufactured by Western Electric Company, Incorporated. The connections for this relay are made so that the relay is operated to either its marking or its spacing contacts by impulses of current through its winding 7, the direction of operation depending upon the direction of the current. When operated, it locks in either position by means of winding 11. Winding 16 is a so-called "accelerating" winding, which functions by induced current from transformer 12 so as to accelerate the movement of the armature relay 8 immediately after said armature begins its motion. In general, the action of accelerating winding 16 is similar to that of winding 22 of relay R, disclosed in my Patent 1,964,505, issued June 26, 1934. A more detailed operation of relay 8 will be given hereinafter.

A slow-operating relay 15 is provided which is arranged to operate should relay 8 remain operated on its spacing contact beyond a predetermined time interval much longer than the usual time required for the transmission of a few complete signal impulse series, which irregular condition may be caused by line disturbances or possibly by mechanical vibration. Relay 15 in operation causes the energization of winding 16 of relay 8, which, as connected, will return the armature of relay 8 to its marking contact, this being the normal condition when no message is being sent. Slow-operating relay 15 is shown in the drawing as being a thermal relay, but it should be understood that any other type of slow-operating relay, such as a dash-pot relay, may be used with satisfaction for this purpose. It would

also be possible to use a self-interrupting stepping switch, or a chain of relays, or a time-controlled device.

It will be assumed that the stations 1 and 4 are particularly adapted for operation with any of the well-known start-stop codes, in which the system is in marking condition when idle and each signal impulse series begins with a spacing impulse for starting the system.

With the system in idle condition, as shown in the drawing, the transmitter or sending contacts SC at station 1, in their marking position, apply grounded battery to the line circuit 2 and a steady current flows from the positive terminal of the battery over the right-hand side of line 2 through the parallel branches containing inductance 37, resistance 38, and inductance 17, then back over the left-hand conductor of line 2 to negative side of the battery at station 1. The low frequency path through the inductance retardation coil 37 is provided to reduce "zero-wander" effect in well-known manner. The high capacity condensers 18 and 19, interconnected through high resistance 20, thus are charged to a potential equal to the continuous potential drop across inductance 17 and establish an intermediate potential for the grid element 21 which is negative with respect to the grounded cathode element 22 of tube 5. This potential is, however, stabilized by the connection of the grid 21 through resistance 29 to an intermediate point on resistance 34 in the cathode heating circuit. By the proper choice of constants, the potential applied to the grid 21 from the cathode circuit may be made approximately equal to one-half of the potential drop across inductance 17. In the present embodiment, these constants are as follows: variable resistance 38, 500 ohms; inductance 37, 16 henries; inductance 17, 40 to 50 henries; condensers 18 and 19, 20 microfarads each; resistance 20, 2 megohms; resistance 34, 170 to 180 ohms below the tap and 30 ohms above the tap; battery 33, 24 volts; battery 40, 22½ volts, and retard coil 49, 40 to 50 henries.

With the grid 21 negatively biased in this manner, the normal impedance of the plate-cathode circuit within tube 5 will have an intermediate value, which may be increased or decreased by increasing or decreasing, respectively, the negative bias on grid 21.

With the system still in idle condition, a current of intermediate value will thus be flowing in the plate circuit of tube 5 from battery 25, producing a potential drop in the plate-cathode circuit within the tube which will keep an intermediate charge on condenser 24 over high resistance 26 and the cathode circuit for tube 6.

The grid 30 of tube 6 is negatively biased by the potential at the intermediate point on resistance 27 in the cathode circuit, which biasing potential, of course, also acts to limit the charge on condenser 24. If desired, two condensers may be connected in the input circuit of tube 6 in the manner illustrated and described for the tube 5. In the present embodiment, the constants of this part of the circuit are as follows: battery 25, 130 volts; retard coil 41, 300 henries; resistance 42, 100,000 ohms; condenser 24, 10 microfarads; resistance 26, 2 megohms; resistance 27, from 15 to 25 ohms below the tap and 30 ohms above the tap; battery 43, 24 volts.

With this negative grid bias, the tube 6 will have an intermediate impedance in its plate circuit which, similar to that of tube 5, may be increased or decreased by increasing or decreasing,

respectively, the negative bias on the grid. The potential drop over the plate-cathode circuit within tube 6, due to current from the plate battery 29, maintains an intermediate charge on condenser 13 through the winding 7 of relay 8, which consequently is currentless when the system is idle. The constants of this part of the circuit are as follows: battery 29, 175 volts; retard coil 44, 300 henries, condenser 13, 10 microfarads.

When, now, a spacing impulse is to be transmitted from station 1, the sending contacts SC are operated to the left, thereby reversing the battery with respect to the line 2 and thus reversing the polarity of the potential drop across inductance 17. A current will thus flow from the upper end of coil 17, through condenser 18 through high resistance 20 through condenser 19 to the lower end of coil 17, first discharging the condensers and then charging them in the opposite direction, and meanwhile producing a potential drop across resistance 20 which will drive the bias on grid 21 to positive.

As the impedance of the plate-cathode circuit in tube 5 now decreases, the potential applied to condenser 24 is decreased and a discharging current flows through high resistance 26 and produces a potential drop therein which will increase the negative bias on grid 30 in tube 6. The consequent increase in potential drop in the plate circuit of tube 6 will increase the charge on condenser 13, thereby causing a charging current to flow temporarily through the winding 7 of relay 8 which will move the armature from its marking to its spacing contact.

It is evident that any time thereafter the contacts at sending station 1 may be returned to marking, thereby reversing the operations just described and returning relay 8 to marking.

Let it be assumed, however, that the contacts at station 1 remain in spacing position for a long time.

The current through condensers 18 and 19 will reach a maximum and will thereafter begin to decay very slowly; during this decay the bias on grid 21 will gradually begin to return to its normal negative value, and due to the resultant slow increase in potential drop in tube 5, the discharging current through condenser 24 and resistance 26 will slowly decay to zero. The bias on grid 30 thus will also begin to approach its normal negative value with a consequent slow decrease in potential drop within tube 6. The charging current through condenser 13 and winding 7 consequently ceases.

As the process thereafter continues and the grids 21 and 30 more closely approach their normal values there will be a reversal of the currents through condensers 24 and 13, but the process is now so slow that the reversed current through condenser 13 and winding 17 will be entirely too small to operate the armature of relay 8 back to its marking position.

For the condition just described, the current through winding 7 of line relay 8 thus consists of a short impulse in the operating direction charging condenser 13, and a long impulse in the opposite direction, slowly discharging condenser 13. During the operating impulse, this current is strong enough to overcome the holding current in winding 11 and thus will start the armature away from its marking contact. When the armature reaches the spacing contact, the holding current will be reversed in winding 11 and the subsequent discharge cur-

rent from condenser 13 through winding 7 will be insufficient to affect the armature in its new position.

From this description of the operation of repeater station R, it will be apparent that when the input current through inductance 17 is suddenly reversed, there will first be a quickly rising charging current for condensers 18 and 19 which will produce sufficient current through relay 8 to overcome the holding current and operate the armature to the opposite contact; there may next be a slowly decreasing charging current for condensers 18 and 19 which will produce a reversed current in winding 7 of relay 8 which would tend to return the armature but is insufficient to overcome the holding current through winding 11. By such an arrangement, it is thus possible to operate the unsymmetric, grounded vacuum tube repeater by current reversals from the grounded source at the sending station.

In order that the current may be maintained long enough in the winding 7 of relay 8 to operate the armature, the condensers 18 and 19 should be of the order of 10 to 30 microfarads, and condensers 24 and 13 should be of about 5 to 15 microfarads, and the charging or discharging of these condensers should be prolonged by making the resistances 20 and 26 of the order of 1 to 3 megohms.

The relay 8 is arranged with windings and other equipment so that the current in the operating winding 7 will only be required to be of operating strength long enough to open the contacts which, at the time, happen to be closed by the armature; the relay will complete the armature travel without the aid of winding 7. This has the advantage of requiring less time for the reversal of the charge on the condensers 18 and 19 so that the size of all the condensers in the repeater circuit will not be excessive from an economical standpoint.

Relay 8, as already stated, is polarized and is highly sensitive. Besides the operating winding 7, it has a holding winding 11 which in either position is locked over the relay contacts to one or the other polarity battery to hold the armature in position after operation. The relay further has an accelerating winding 16 which is effective first during the travel of the armature to carry it over from one contact to the other, and next upon arrival of the armature to temporarily aid the holding winding in holding the armature against the contact to reduce chattering.

Thus, for the condition shown in the drawing, winding 11 receives current from the negative source over the marking contact and in series with the primary winding of transformer 12. When the armature opens the marking contact due to current in the operating winding 7, the circuit for winding 11 will be opened and the holding current will reduce to zero, the energy being dissipated in resistance 32. The sudden withdrawal of current from the primary winding of transformer 12 induces a heavy current in the secondary winding thereof which flows through accelerating winding 16 to aid the operating winding. The armature is thus quickly carried against the spacing contact even if the operating current should begin to wane. The circuit for holding winding 11 is then closed to the positive source through the winding of slow relay 15, and winding 11 therefore becomes effective in holding the armature against the spacing contact. The

rush of a reversed current through winding 11 and the primary winding of transformer 12 now maintains, for still a short time, the current in accelerating winding 16, which thus acts to prevent the armature from bouncing away from the spacing contact upon the first sudden impact. These operations will, of course, be similar, but reversed when the relay 8 is operated in the opposite direction.

For satisfactory operation of this part of the circuit, the transformer 12 may be of the type 58-C repeating coil manufactured by Western Electric Company, Incorporated. The constants for this circuit are as follows: condenser 48, 5 microfarad; resistance 47, 800 ohm; resistance 32, 40 ohm; resistance 46, 900 ohm; the spark protection condensers for the contact of relay 8 are each 0.5 microfarad and are connected in series with resistances of 1600 ohm each.

A repeater with equipment as described above and arranged as shown in the drawing with its input side connected to a composited No. 19 gauge cable circuit 150 miles in length and operated at a speed of 60 words per minute has been found to give a printer margin of about 60%.

The armature of relay 8 is connected to retransmit impulses of opposite polarity over the line circuit 3 to station 4, which may be equipped with a printer or other translating device, for reception of the signals. The line circuit is connected through the windings of the usual receiving relay 9 and break relay 10 and is during marking connected by means of relay 8 to sources of opposite polarities, and thus carries a normal operating current.

The station 4 transmits impulses by opening this normal line circuit at its keyboard, thereby each time operating the relays 9 and 10 to spacing. Receiving relay 9 will have its contacts connected for retransmission of signals from station 4 over a repeater circuit, not shown, into the line circuit 2 to station 1 in any desirable known manner.

The repeater R, including relay 8, thus is responsive only whenever there is a reversal from an impulse of one polarity to an impulse of the other polarity from station 1. Between such reversals the relay is held in the operated position, either to marking or spacing by current in the holding winding which, in the interest of high sensitivity and speed of operation, is made reasonably low.

It has been found necessary in certain cases to provide a safeguard against disturbances, either of electrical or mechanical nature, causing the armature of relay 8 to remain on its spacing contact beyond a predetermined time interval, while the repeater R is idle. With relay 8 in spacing position, both ends of line 3 would be connected to positive potential, as during a break signal, and station 4 would be unable to transmit through relay 9.

It is evident that at the end of a message, the contacts SC will be placed in their normal or marking position, thereby placing relay 8 and line 3 in marking condition, so that station 4 may transmit at any time. However, since relay 8 normally carries no current in its operating winding, and only enough current in its holding winding to insure good contact under normal conditions, it may easily happen that this relay accidentally would be moved to spacing during idle periods, where it would be held by its holding winding.

When relay 8 is in spacing position, the line circuit 3 will be substantially currentless, but current will flow from positive battery through the winding of slow-operating relay 15 and the lower biasing windings of line relays 9 and 10 over the artificial line to ground. Relay 15 is of a type which may require as much as a few seconds to close its contacts in response to the current through its winding. The relay 15 may thus be arranged to be unresponsive to such long impulses as may occur in the sending of ordinary messages or of special service signals. However, when relay 8 accidentally remains for a still longer time in spacing position, relay 15 will ultimately operate to close its contacts, thereby energizing winding 16 of relay 8 to operate the armature to marking and disconnecting its own operating winding.

Relay 15 must be quick-restoring or releasing so that a regular operation of relay 8 to spacing immediately subsequent to the functioning of relay 15 will not cause relay 15 to operate again until after the predetermined time interval. Thus, if relay 15 is a thermal relay, it may be well cooled to quickly open its contacts when the current in its winding is discontinued. Well-known relay means may, of course, be added to this arrangement for quickly disconnecting relay 15 from relay 8 upon its functioning and for preventing relay 15 from again operating until it has reached normal temperature, thereby preventing interference with the transmission through relay 8.

What is claimed is:

1. A telegraph repeater comprising an amplifier system including thermionic space discharge amplifying means and having an input and an output side, an inductive shunt path for passing of incoming signals, capacitance means of high capacity connected to receive potential variations from said shunt path produced by incoming impulses and to impress corresponding potential variations on said amplifier system, a polar relay for retransmission of signals and having an operating winding, capacitance means of high capacity serially connected with said winding to said output circuit to receive in response to the last impulse of a message first a short, strong current impulse for operating the armature of said relay to its alternate position and next a reversed long, weak current impulse permitting the armature to stay in said position.

2. A telegraph repeater comprising an amplifier system including a first stage and a second stage of thermionic space discharge amplifying means each having an input and an output side, a retransmitting relay having an operating winding, an inductive shunt path for passing of incoming impulse currents, first capacitance means and first resistance means serially connected to said shunt path to receive charging currents in alternate directions in accordance with incoming current reversals through said path, the input side of said first stage of amplifying means being connected to said resistance means to receive opposite voltage variations, second capacitance means and second resistance means serially connected to the output side of said first stage of amplifying means to receive opposite charging currents therefrom, the input side of the second stage of said amplifying means being connected to said second resistance means to receive opposite voltage variations, third capacitance means connected in series with said operating winding to the output side of said second stage of amplifying means to receive opposite charging currents

therefrom, said different capacitance means having high capacity for passing an impulse to operate said relay in response to a current reversal through said path and said resistance means having high resistance to prevent a reverse impulse through said amplifier system from operating said relay in response to the same current reversal.

3. A telegraph system comprising a metallic line circuit, an impulse receiving circuit, capacitance and resistance means for inter-associating said circuits, said line circuit including a metallic shunt path for passage of current impulses incoming over said line circuit, said receiving circuit including signal amplifying means having an output circuit and a polar relay having a signal responsive winding and capacitance means inter-associating said output circuit and said winding for operation of said relay by an amplified condenser current impulse, said relay also having a holding winding for self-locking over alternate contacts of said relay in both positions, and an auxiliary winding for carrying the armature over its travel distance.

4. A telegraph signaling system comprising signal amplifying means having an output circuit, a polar transmitting relay having an operating winding, a holding winding and an accelerating winding, a large capacity condenser serially connected through said operating winding to said output circuit for operation of said polar relay to one or the other position by charging and discharging impulses respectively, a transformer having its primary winding connected to sources of alternate potentials by the contacts of said polar relay and having its secondary winding connected to said accelerating winding for aiding the impulses in said operating winding in operating said armature by induced current impulses through said accelerating winding, and said holding winding being connected to sources of alternate potentials by the

contacts of said polar relay for self-locking of said relay in both positions.

5. A telegraph system comprising a receiving circuit having an output side, a polar relay having a signal responsive winding and an auxiliary winding, capacitance means for transferring signals from said output side to said signal responsive winding, and relay means responsive to the continued operation of said polar relay to one of its positions to operate said polar relay to its other position after an interval longer than the longest normal signal impulse received by said circuit.

6. A telegraph system comprising a metallic line circuit, an impulse receiving circuit, capacitance means for inter-associating said circuits and for prolonging incoming impulses sufficiently for relay response, said line circuit including a metallic shunt path for passage of signals incoming over said line circuit and for reduction of zero wander, said receiving circuit including signal amplifying means having an output circuit and a polar relay having a signal responsive winding and capacitance means inter-associating said output circuit and said winding, and slow-acting relay means operable in one position of said polar relay to operate said polar relay to its alternate position after a predetermined interval.

7. A telegraph system, in accordance with claim 5 in which said relay means is slow-acting in the responsive direction of operation and quick acting in the other direction to prevent mutilation of signals to said translating means.

8. A telegraph system, in accordance with claim 5, in which said relay means is slow-acting and has a winding connected to one contact of said polar relay for operation after an excessively prolonged closure of said contact, and has a contact connected to said auxiliary winding for restoring said polar relay to its other position when said relay is operated.

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