

April 8, 1941.

J. T. NEISWINTER

2,237,498

TELEGRAPH SYSTEM

Filed Dec. 22, 1939

3 Sheets-Sheet 1

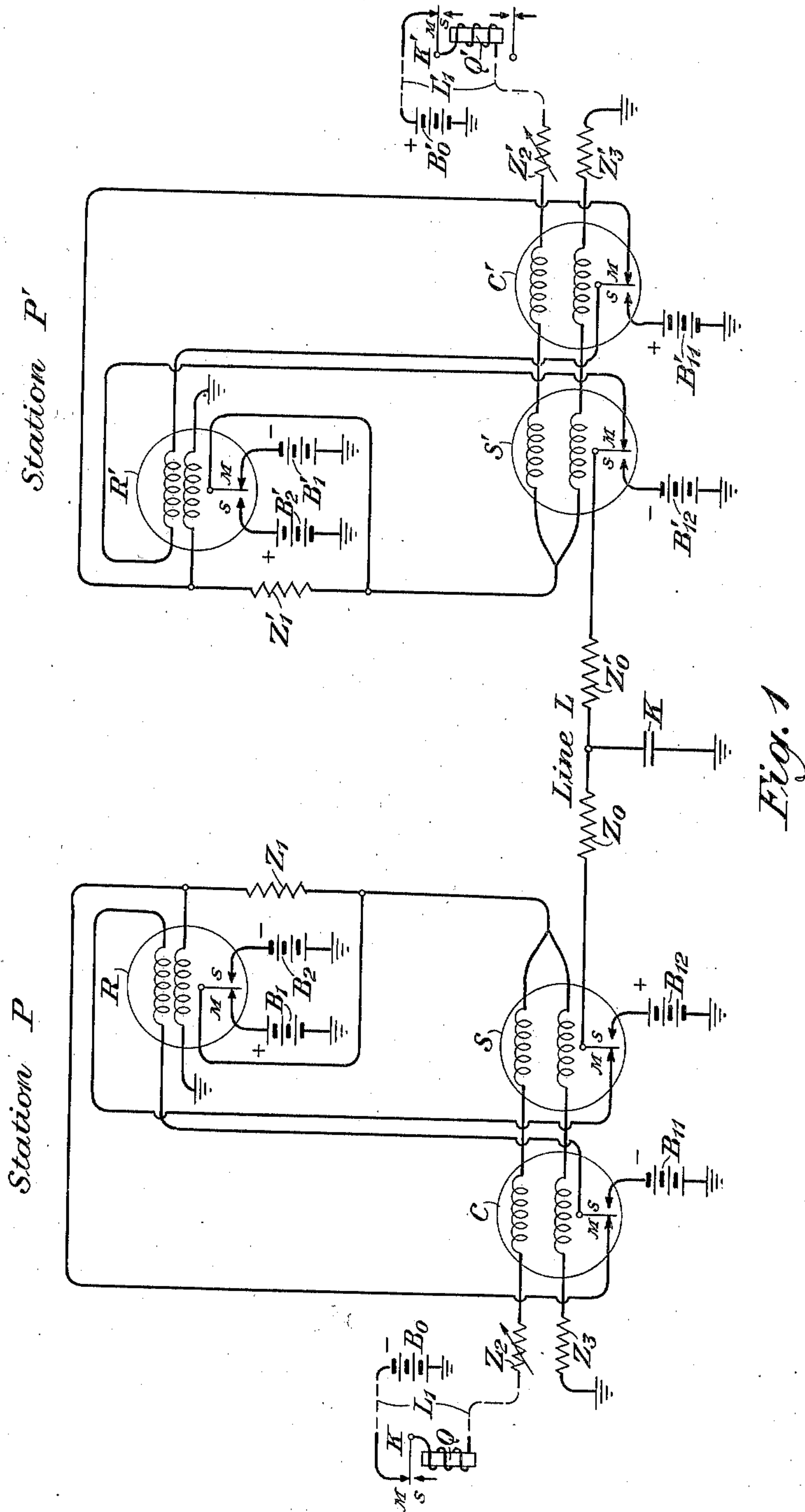


Fig. 1

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3 Sheets-Sheet 2

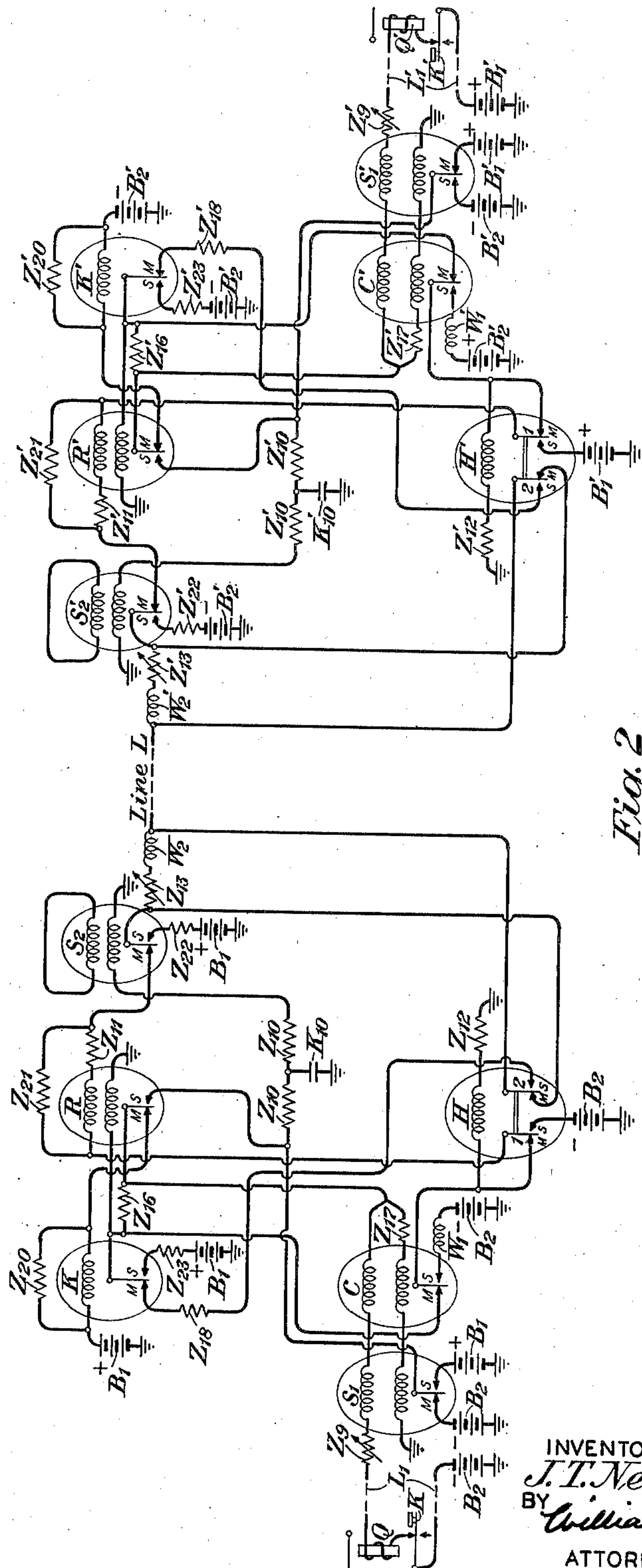


Fig. 2

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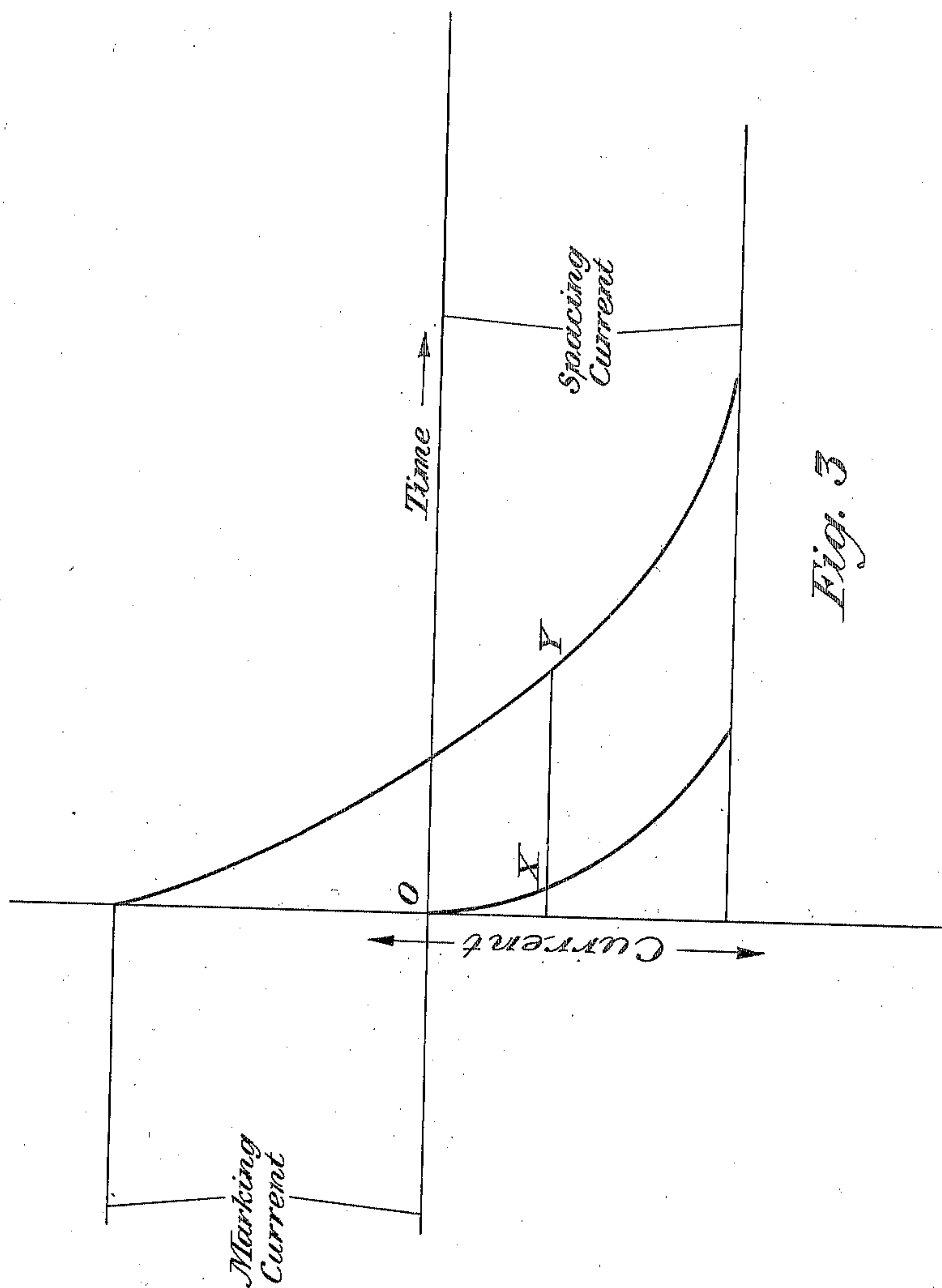
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TELEGRAPH SYSTEM

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3 Sheets-Sheet 3



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TELEGRAPH SYSTEM

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6 Claims. (Cl. 178—71)

This invention relates to telegraph systems and to repeaters for telegraph systems. More particularly, this invention relates to repeaters for telegraph systems in which two-way communication may be carried on over a single line circuit.

The repeaters included in the telegraph system of this invention are each capable of sending and receiving signals over a line circuit in one direction at a time. When two such repeaters are connected to each other over a line circuit, each repeater is set up to receive signals coming from the other repeater when the system is in an idle condition. During the period of idleness no battery potential whatever is applied to the line circuit. When a subscriber's loop circuit transmits signals to one of the repeaters, that repeater will be rearranged by the first spacing impulse so that the repeater may relay the signals to the other repeater. After a predetermined period of idleness upon the conclusion of signaling, the two repeaters will be rearranged to the idle or receiving condition.

This invention, together with its further objects and features, will be better understood from the detailed description hereinafter following; when read in connection with the accompanying drawings, in which Figure 1 represents one embodiment of the invention, this figure schematically representing a circuit illustrating the principles of the invention; Fig. 2 represents a more detailed embodiment of the invention, and Fig. 3 illustrates certain curves used to explain the operation of certain of the apparatus of the invention.

Referring to Fig. 1 of the drawings, two repeater stations designated P and P' are shown interconnecting two subscribers' loop circuits designated L₁ and L₁' which form part of a telegraph system. The apparatus at station P' may be identical with that at station P, corresponding apparatus being designated by the same reference characters except that they are primed at station P'. Station P includes three telegraph relays designated C, S and R, the relay C being a fast operate slow release control relay, the relay S a sending relay and the relay R a receiving relay. The apparatus at station P is connected to the apparatus at station P' by a line L, which may have lumped or uniform resistance, lumped resistances designated Z₀ and Z₀' being shown connected to the interconnecting line for illustrative purposes. The terminal common to the two resistances Z₀ and Z₀' may be connected to ground by a condenser K. The repeater apparatus at stations P and P' may be used to relay

signals in opposite directions between the subscribers' loops L₁ and L₁' in a manner to be described more clearly hereinafter.

When the circuit is idle, i. e. when no signals are being transmitted or received over the system, the armatures of all of the relays will be on their marking contacts *m*, as indicated in the drawing. Each end of the line L will be grounded and hence no current will be transmitted over the line L. The circuit connecting the line L to ground at station P will include the armature and marking contact *m* of relay S, the upper winding of the relay R, the armature and marking contact *m* of relay C, the lower winding of relay R and ground. A similar circuit will connect the opposite end of line L to ground at station P'.

While the circuit remains idle, the armatures of the two receiving relays R and R' will be held on their marking contacts by a small current circulating through the lower windings of the two relays. This holding current will emanate from the battery B₁ at station P and will flow over the marking contact *m* and armature of relay R, the resistor Z₁, the lower winding of the relay R and ground. A similar holding circuit, which need not be described, will permit a small current to flow from battery B'₁ at station P' through the lower winding of the receiving relay R' at that station.

Assume now that a spacing signal is transmitted over the loop L₁ from the subscriber's apparatus (at the left) connected to the loop. This may be accomplished by moving the armature of the key K to its spacing contact *s*. When this occurs the loop circuit L₁ will be opened and hence no current will flow from the battery B₀ over the loop circuit L₁ and through the resistor Z₂ and through the upper windings of the relays C and S at station P. The armatures of the two relays C and S will then close their spacing contacts *s* under the influence of current flowing from battery B₁ through the lower windings of relays S and C through resistor Z₃ to ground. Upon the closure of the spacing contact *s* of relay S, the spacing battery B₁₂ will be connected to the line L, this battery supplying current to operate the receiving relay R' at station P'. The circuit operating relay R' includes the armature and marking contact *m* of relay S', the upper winding of relay R', the armature and marking contact of relay C', the lower winding of relay R' and ground. The current traversing the upper winding of the receiving relay R' will be greater than the small holding current emanat-

ing from battery B'₁ and traversing resistor Z'₁ and the lower winding of the receiving relay R'. The current received will therefore act to move the armature of the receiving relay R' to its spacing contact.

Upon the closure of the spacing contact *s* of the receiving relay R', battery B'₂ will oppose battery B'₀ and no current will flow over the circuit including, in addition to spacing contact *s* and armature of the relay R', the upper windings of the relays S' and C', the resistor Z'₂ and the loop circuit L'₁ to which the sounder Q' is connected. This sounder will register a spacing signal. It will be seen therefore that the apparatus at stations P and P' will relay signals between the loop circuits L₁ and L'₁. Relay S' and C' will be held on their marking contacts by a current which flows from battery B'₂ through the lower windings of these relays.

The closure of the spacing contact *s* of the control relay C at station P will disconnect ground from the marking contact *m* of relay S, this grounded connection having previously been established through the upper winding of relay R, the armature and marking contact of relay C and the lower winding of relay R. At the same time the battery B_{T1} will be substituted for ground at the marking contact *m* of relay S, the interconnecting circuit including the upper winding of relay R in addition to the armature and spacing contact *s* of relay C. Hence the closure of the spacing contact *s* of relay C will produce a situation in which the armature of the sending relay S will move between two contacts which are connected to equal and oppositely poled batteries B₁₁ and B₁₂.

If now a marking signal is transmitted over the subscriber's loop circuit L₁, as for example, by closing the contact *m* of key K, the current now traversing the upper windings of relays C and S will be such as to tend to move the armatures of these relays to their marking contacts *m*. The relay S, being of the fast-releasing type, will move its armature to its marking contact *m* immediately after the marking signal is impressed upon the system. However, the relay C, which is of the slow release type, will require a delay of a substantial time interval as, for example, 200 milliseconds, before its armature will return to its marking contact *m*. Hence before the relay C has released, the marking battery B₁₁ will remain connected to the marking contact *m* of the sending relay S through the upper winding of the relay R, and therefore marking current will be transmitted over the line L. This marking current will flow over a circuit at station P' which includes the armature and marking contact *m* of relay S', the upper winding of relay R', the armature and marking contact *m* of the relay C', the lower winding of relay R' and ground. This current will cause the armature of the receiving relay R' to promptly close its marking contact *m*. A marking signal will then be sent over the subscriber's loop circuit L'₁ to operate the sounder Q'. This signal will be relayed over a circuit which includes the battery B'₁, the marking contact *m* and armature of relay R', the upper windings of relays S' and C', the resistor Z'₂ and the loop circuit L'₁, which includes the sounder Q'. The sounder Q' will, of course, register the marking signal. Relays S' and C' will be held on their marking contacts by a current which flows from battery B'₁ through the lower windings of these relays.

It has been assumed that the marking signal

transmitted over the subscriber's loop circuit L₁ to the station P was not of sufficient duration to cause relay C to return to its marking contact. If, however, the marking signal has exceeded the releasing time of relay C, the armature of relay C will have returned to its marking contact *m*. Then upon the closure of the contact *m* of relay C, the marking contact of relay S will be reconnected to ground. The grounded connection will be re-established over a circuit including the upper winding of relay R, the armature and marking contact *m* of relay C, the lower winding of relay R and ground. Thus the circuit will be restored to the condition formerly prevailing when it was idle. The apparatus at station P is now ready to receive signals coming from station P'.

If marking and spacing signals are transmitted in rapid succession over the subscriber's loop L₁ to the apparatus of station P before the relay C has released its armature to its marking contact *m*, then the battery B₁₁ will be continuously connected to the marking contact *m* of relay S through the upper winding of the relay R. These marking and spacing signals will be relayed over the line L as the armature of relay S moves back and forth between its marking and spacing contacts *m* and *s*. Moreover, the movement of the armature of relay S between the two oppositely poled batteries B₁₁ and B₁₂ will cause substantial oppositely directed currents to traverse the windings of the receiving relay R' and consequently the armature of relay R' will move between its two corresponding contacts *m* and *s* in accordance with the signals. The apparatus of station P' will then relay the same signals over the loop circuit L'₁ to the sounder Q'.

It will be noted that after the telegraph system of Fig. 1 has been idle with substantially no current in the line L and a spacing signal is thereafter transmitted over the line, the line current will change from a zero value to a large spacing value. This current will be obtained, as already explained, from the battery B₁₂ at station P and it will traverse the windings of the receiving relay R' at station P' to operate that relay. This current change is in contrast to subsequent current changes for corresponding spacing signals in which the current changes from a large value for a marking signal to an oppositely directed substantially equally large value for a spacing signal. The initial spacing signal will therefore be somewhat abnormal and distorted.

Fig. 3 graphically illustrates this condition. The marking current is illustrated as approximately equal and opposite to the spacing current. The change from the marking condition to the spacing condition is shown by the curve drawn through the point Y. But in the system of Fig. 1, the first spacing impulse follows the idle condition of the circuit in which no current is in the line. The growth of current in the line of Fig. 1 during the first spacing signal is shown by the curve drawn through the points O and X.

It will be observed that if the ordinate of the point Y corresponds to the current required to operate the armature of the receiving relay to its spacing contact after a marking signal was received, the abscissa of the point Y will measure the time which must elapse before the spacing signal will be effective in the relay. The first spacing impulse in the Fig. 1 system, however, will operate the receiving relay after a briefer interval of time which is measured by the abscissa of the point X. The difference between

these two intervals results in signal distortion. The circuit of Fig. 1 may nevertheless be employed for telegraph transmission where such distortion may be tolerated.

The distortion just referred to may be obviated by delaying the operation of the sending relay S of station P. That is, with the receipt of the first spacing impulse from the loop circuit L₁, the relay C will operate to close its spacing contact s before the relay S will be operated to its spacing contact s. Thus, the marking battery B₁₁ will be connected to the line L through the upper winding of the relay R before the spacing battery B₁₂ will be connected to the line L. The operation of the relay C will first cause a large current corresponding to a marking signal to flow over the line L, and the subsequent operation of the relay S will cause a reversal of the current to correspond to a spacing condition. This will entail some delay in the transmission of the first spacing signal. However, the delay will be substantially the same as the delay for any subsequent spacing signal. There will, therefore, be no appreciable distortion in the signals. A circuit suitable for eliminating signal distortion in a two-way, one-path telegraph system is illustrated in Fig. 2.

In the circuit of Fig. 2 the repeater apparatus at station P includes two sending relays S₁ and S₂, the relay S₂ being controlled by the relay S₁, as will be explained hereinafter. This repeater also includes a holding relay H and a break relay K. During the idle condition of the Fig. 2 circuit, the armatures of all of the relays at both of the repeater stations P and P' will be on their marking contacts, as shown in the drawing, and the loop circuits L₁ and L'₁ will be closed. The line L will be connected to ground at each end. The connection to ground at station P will be completed through a circuit including the armature 2 and marking contact m of relay H, the armature and marking contact m of relay S₂, the resistor Z₁₁, the upper winding of relay R, the armature 1 and marking contact m of relay H, the armature and marking contact m of relay C, the lower winding of relay R and ground. A similar circuit for grounding the other end of the line L will be completed at station P'. No current will then be transmitted over the line L.

A spacing signal may be transmitted by opening the loop circuit L₁ at the key K. When this happens the relays S₁ and C will close their spacing contacts simultaneously. The operation of the relay C will connect the spacing battery B₂ to the line L over a circuit which includes the coil W₁, the spacing contact s and armature of relay C, the marking contact m and armature 1 of relay H, the upper winding of relay R, resistor Z₁₁, marking contact m and armature of relay S₂, and the marking contact m and armature 2 of relay H to the line L. Thus marking current will be transmitted over the line L. The receiving relay R' at station P' will, however, maintain its armature on its marking contact where it previously was.

The closure of the spacing contact of relay C will also operate the holding relay H to its spacing contacts s. The circuit for operating the relay H will include, in addition to the battery B₂, the winding W₁, the spacing contact s and armature of relay C, the winding of relay H, resistor Z₁₂ and ground. The operation of the relay H will then open a shunt circuit around a noise killer comprising a coil W₂ and a resistor Z₁₃,

the shunt circuit having been previously established by the closure of the right-hand marking contact m of relay H by its armature 2. The operation of the relay H also substitutes the battery B₂ connected to its left-hand spacing contact s for the battery B₂ formerly connected to the spacing contact s of the relay C. The new battery is now connected to the line L over a circuit which includes the spacing contact s and armature 1 of relay H, the upper winding of relay R, the resistor Z₁₁, the marking contact m and armature of relay S₂, the resistor Z₁₃, and the coil W₂ to the line.

The operation of the relay S₁ to its spacing contact s will also cause the operation of the relay S₂ to its spacing contact s after the lapse of a predetermined time interval. The operating circuit for relay S₂ will include the battery B₁ connected to the spacing contact of relay S₁, the armature of relay S₁, the two equal resistors Z₁₀, the lower winding of relay S₂ and ground. The resistors Z₁₀ have their common terminal grounded through a condenser K₁₀. The resistors Z₁₀ and the condenser K₁₀ comprise a delay circuit which allows the relay S₂ to operate a predetermined interval of time after the relay S₁ has operated. Additional delay in the operation of relay S₂ is obtained by shortening the upper winding of relay S₂. The constants of the delay circuit may be changed as desired and the delay may, for example, be 15 milliseconds. This delay circuit is interposed between the two sending relays S₁ and S₂ for delaying the operation of relay S₂ according to one of the primary features of this invention.

After the spacing contact s of the relay S₂ is closed, the spacing battery B₁ will be connected to the line L through the armature of relay S₂, the resistor Z₁₃ and the coil W₂. The latter battery will send a spacing current over the line L to the repeater station P'. It will be noted that the spacing battery B₁ will be connected to the line L in response to a spacing signal only after the marking battery B₂ has previously been connected to the line.

The receipt of the spacing current at station P' will cause the receiving relay R' to close its spacing contact s. The circuit for so operating the relay R' will include the line L, the armature 2 and marking contact m of relay H', the armature and marking contact m of relay S'₂, the resistor Z'₁₁, the upper winding of relay R', the armature 1 and marking contact m of relay H', the armature and marking contact m of relay C', the lower winding of relay R' and ground. It will be observed that the spacing current will flow through the two windings of relay R' which are effectively connected in series with each other.

In response to the closure of the spacing contact s of relay R' a spacing signal will be transmitted to the subscriber's loop circuit L'₁, the interconnected circuit including battery B'₁ connected to the marking contact of relay S'₁, the armature of relay S'₁, the spacing contact s and armature of relay R', the upper windings of relay C' and S'₁, the resistor Z'₉, the winding of the sounder Q', the key K', the battery B'₁ and ground. The sounder Q' will register the spacing signal.

A marking signal may be transmitted to the distant subscriber's station by closing the loop circuit L₁. When the loop circuit L₁ is closed, the relays S₁ and C will operate to close their marking contacts m simultaneously. The relay

H, which is of the slow-release type, will remain on its spacing contacts *s* during the time required for the relay H to become released. This interval may be, for example, 200 milliseconds. Relay S₂ will be operated in response to the operation of the relay S₁ after a predetermined delay determined by the constants of the network formed by resistors Z₁₀ and condenser K₁₀, a delay which may be of the order of 15 milliseconds, as already explained. The operation of the relay S₂ will cause a marking current to be transmitted over the line L, the circuit completed by the operation of relay S₂ including the battery B₂ connected to the left-hand spacing contact of relay H, the armature 1 of relay H, the upper winding of relay R, the resistor Z₁₁, the marking contact *m* and armature of relay S₂, the resistor Z₁₃ and the coil W₂, which is connected to the line L.

In response to the received marking current, relay R' at station P' will return its armature to its marking contact *m*. The circuit now completed at station P' will include the line L, the armature 2 and marking contact *m* of the relay H', the armature and marking contact *m* of the relay S'₂, the resistor Z'₁₁, the upper winding of the relay R', the armature 1 and marking contact *m* of relay H', the armature and marking contact *m* of relay C', the lower winding of relay R' and ground. A marking pulse will then be relayed to the loop L'₁ over a circuit including battery B'₂, the winding of relay K', the marking contact *m* and armature of relay R', the upper windings of relays C' and S'₁, the resistor Z₉ and the loop L'₁. The sounder Q' will then register the marking signal.

If, after the last marking impulse, the subscriber's loop circuit L₁ remains closed longer than a predetermined time interval, as, for example, 200 milliseconds, then the slow release relay H will return its armatures to their marking contacts *m*. When this happens the line L will be re-connected to ground over a circuit which includes the armature 2 and marking contact *m* of relay H, the armature and marking contact *m* of relay S₂, the resistor Z₁₁, the upper winding of relay R, the armature 1 and marking contact *m* of relay H, the armature and contact *m* of relay C, lower winding of relay R to ground. It will be noted that the return of the armature 2 of relay H to its marking contact *m* has replaced the shunt circuit around the noise killer W₂—Z₁₃. The apparatus at station P will now be ready to receive signals arriving from the opposite direction.

On the other hand, if the loop circuit L₁ remains closed for a period which is less than the predetermined interval of, for example, 200 milliseconds, relay H will remain operated to maintain its spacing contacts *s* closed. At the same time the marking contact of the relay S₂ will continue to be connected to the marking battery B₂ over a circuit which includes the resistor Z₁₁, the upper winding of relay R, the armature 1 and spacing contact *s* of relay H, battery B₂ and ground. The armature of relay S₂ will then continue to travel back and forth between its marking and spacing contacts to connect equal and opposite battery potentials to the line L for the purpose of transmitting marking and spacing signals.

If while signals are being sent from the subscriber's loop circuit L₁ the subscriber at loop circuit L'₁ desires to "break" the transmission, the latter subscriber will open his loop circuit. After a predetermined period, relay K' will re-

lease since the current previously flowing through the upper windings of relays C' and S'₁ through the winding of relay K' has now been interrupted. Relay K' then operates to its spacing contact. Although current continues to flow through the winding of relay K', the relay adjustment is such that it will agree to spacing.

After the loop L'₁ has been opened to transmit the break signal, the relays S'₁ and C' will close their spacing contacts *s* after the relay R' has returned to its marking contact *m*. The relays S'₁ and C'₂ will close their spacing contacts because the current traversing their lower windings from battery B'₂ is spacing in its direction. The closure of the spacing contact of relay C' will connect battery B'₁ to the line L over a circuit which includes the spacing contact *s* and armature of relay C', the marking contact *m* and armature 1 of relay H', the upper winding of relay R', the resistor Z'₁₁, the marking contact and armature of relay S'₂, the marking contact *m* and armature 2 of relay H' to the line L.

The closure of the spacing contact of relay C' will also cause relay H' to close its spacing contacts, the circuit operating the relay H' including the battery B'₁, the spacing contact *s* and armature of relay C', the winding of relay H', the resistor Z'₁₂ and ground. The closure of the right-hand spacing contact *s* of relay H' will act to substitute the battery B'₁ connected to this spacing contact *s* of relay H' for the battery B'₁ connected to the spacing contact of relay C'. Thus the circuit now connected to the line L will include the battery B'₁, the spacing contact and armature 1 of relay H', the upper winding of relay R', resistor Z'₁₁, the marking contact *m* and armature of relay S'₂, the marking contact *m* and armature 2 of relay H', to the line L. Closure of the left-hand spacing contact *s* of relay H' will at the same time remove the shunt around the noise killer W'₂ and Z'₁₃.

The operation of the relay S'₁ to its spacing contact will also operate the relay S'₂ to its spacing contact after a predetermined time interval determined by the constants of the delay circuit Z'₁₀—K'₁₀. The closure of the spacing contact of relay S'₂ will connect spacing battery B'₂ to the line through the noise killer Z'₁₃ and W'₂.

This will cause the receiving relay R at station P to be operated to close its spacing contact *s*. In this connection it will be noted that there are several currents jointly effective on the windings of the relay R at station P. One of these currents coming from battery B'₂ of station P', will be sent through the upper winding of relay R over a circuit which includes the armature and marking contact of relay S₂, resistor Z₁₁, the upper winding of relay R, the armature 1 and spacing contact of relay H, battery B₂ and ground. Another current will be transmitted through the lower winding of relay R, this current also emanating from battery B'₂. The circuit for supplying the latter current may be traced over line L, the armature 2 and spacing contact of relay H, resistor Z₁₃, the marking contact and armature of relay K, the lower winding of relay R and ground. Still another current will be obtained from the local battery B₁ and this current will flow through the lower winding of relay R over a circuit which includes the battery B₁, the winding of relay K, the marking contact and armature of relay R, the resistor Z₁₆, the lower winding of relay R and ground. The combined effect of all of these

currents will cause relay R to close its spacing contact *s*, as already pointed out.

When the spacing contact *s* of relay R is thus closed, battery *B*₂ will be applied to the distant subscriber's loop *L*₁ over a circuit which includes battery *B*₂, marking contact *m* and armature of relay *S*₁, the spacing contact and armature of relay R, the upper windings of relays C and *S*₁, the resistor *Z*₂ and the loop *L*₁. The sounder Q will therefore be released and the subscriber will receive the break signal.

It is to be noted that both of the receiving relays R and R' are held on their previously made contacts by a holding circuit. Current will always flow through the lower windings of the two receiving relays and this current will be in such a direction as to hold the armature of these relays on their previously made contacts.

Should an accidental spacing "hit" arrive at station P from line L, for example, the relay R might be caused to close its spacing contact *s*. This is promptly rectified by the circuit of this invention which includes an auxiliary break relay K included for this purpose. After a predetermined delay such as 150 milliseconds, the relay K will close its spacing contact. When this happens, battery of proper polarity will be applied to the windings of the receiving relay R to restore its armature to its associated marking contact.

The two-way one-path telegraph circuit above described includes two repeater stations P and P' for interconnecting two loops *L*₁ and *L*'₁. It will be clear that any pair of similar repeater stations may be interposed between any two different subscribers' loop circuits.

The constants referred to hereinabove have been given only for the purpose of explaining the operation of the system. It will be understood that any other constants may be employed in the practice of this invention.

While this invention has been shown and described in certain particular arrangements merely for the purpose of illustration, it will be understood that the general principles of this invention may be applied to other and widely varied organizations without departing from the spirit of the invention and the scope of the appended claims.

What is claimed is:

1. In a half-duplex telegraph repeater interconnecting a loop and a line, the combination of a receiving relay, a sending relay, means responsive to signals transmitted from the loop to operate the sending relay in accordance with the transmitted signals, means responsive to signals received from said line to operate the receiving relay in accordance with said received signals, and means for grounding said line a predetermined interval of time after the termination of signaling.

2. In a telegraph system, the combination of a line over which marking and spacing pulses may be transmitted, means for producing substantially equal but opposite currents corresponding to marking and spacing pulses for transmis-

sion over said line, and means responsive to the first spacing pulse to transmit current corresponding to the marking pulse over said line and for subsequently transmitting current corresponding to the first spacing pulse over said line.

3. In a telegraph system, the combination of a line interconnecting two subscribers' loops over which no current is transmitted when both loops are idle, means for transmitting equal and opposite currents corresponding to marking and spacing signals from one loop to the other over said line, and means responsive to the first spacing signal to transmit current over said line corresponding to a marking signal, said latter means including means to delay the transmission over said line of current corresponding to all signals.

4. In a telegraph system, the combination of a line, two loop circuits, two repeaters connecting said loop circuits with said line, means for sending marking and spacing signals from one loop circuit to the other loop circuit through said repeaters and over said line, each repeater including means for delaying by a predetermined time interval the first spacing signal to be transmitted by said repeater over said line, and means for transmitting over said line a current corresponding to a marking signal during said predetermined time interval.

5. In a telegraph system, the combination of a subscriber's loop, a line, a repeater connecting said loop and said line, said repeater including means responsive to the first spacing signal received from said loop for transmitting over said line during a predetermined time interval a current corresponding to a marking signal and for delaying the first spacing signal by said predetermined time interval, said repeater also including means for relaying all signals received from said line to said loop substantially without delay.

6. A telegraph repeater for interconnecting a loop and a line, comprising a first sending relay connected to said loop, a delay network having a predetermined time interval, a second sending relay controlled by said first sending relay through said delay network, a receiving relay, said second sending relay and said receiving relay being connected to said line, means responsive to signals received from said line for operating the armature of said receiving relay between its contacts for relaying said received signals to said loop, said first sending relay being controlled by currents transmitted from said loop, means responsive to the first spacing signal transmitted from said loop for operating said second sending relay for transmitting to said line a current corresponding to a marking signal for an interval corresponding to the time constant of said delay network, and means for operating said second sending relay after the expiration of said time interval for transmitting a current corresponding to the first spacing signal over said line.

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