April 13, 1937. C. E. LOMAX 2,076,656

TELEPHONE SYSTEM

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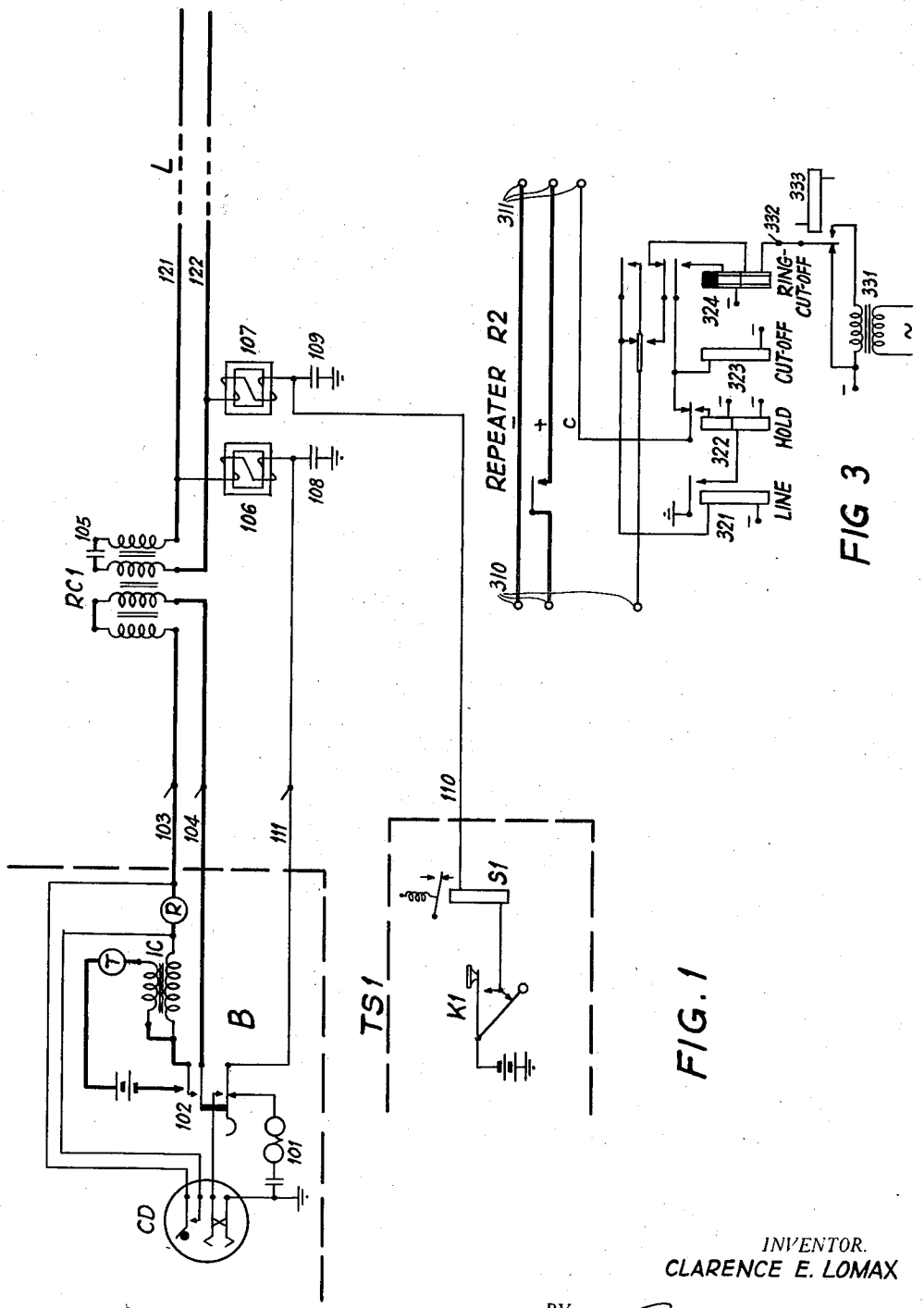

FIG. 1

FIG 3

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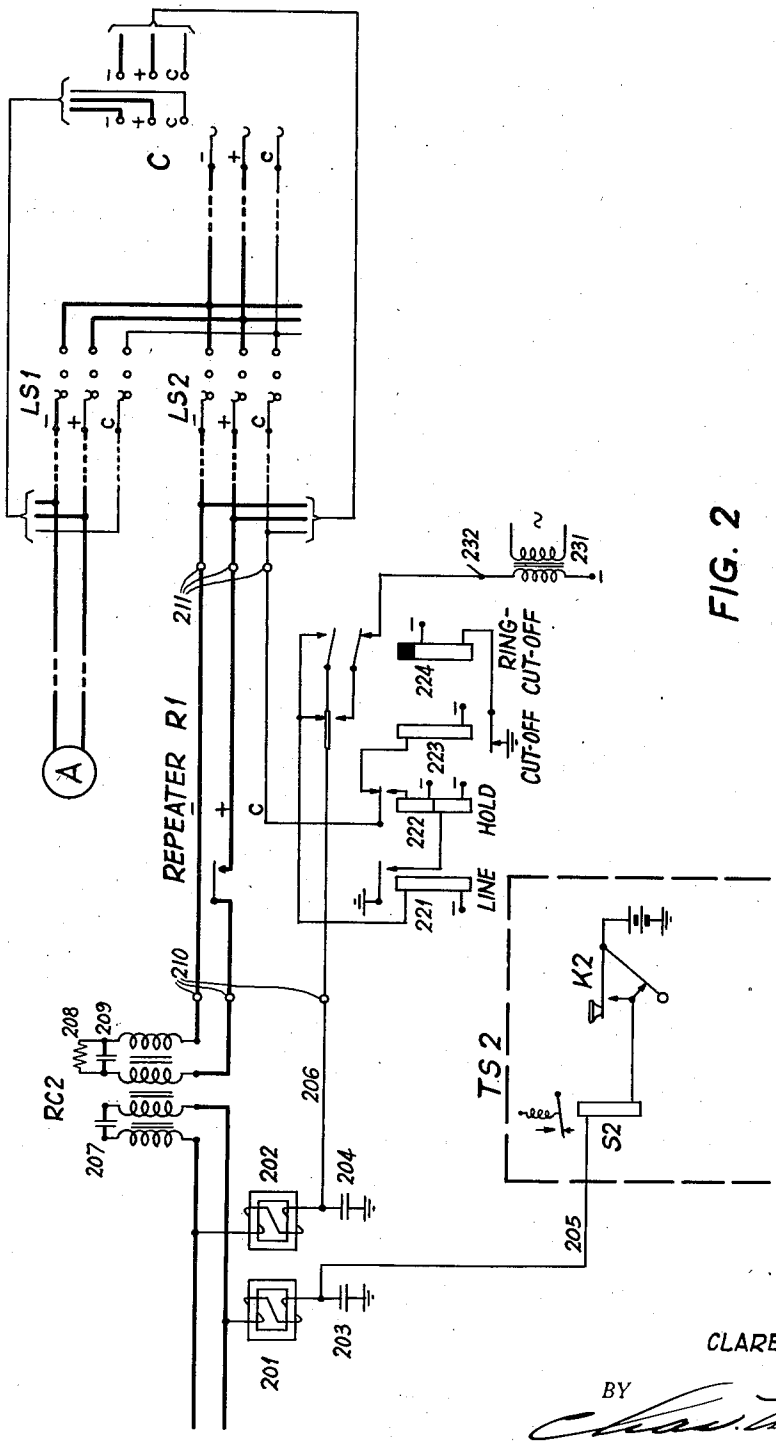

FIG. 2

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TELEPHONE SYSTEM

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3 Claims. (Cl. 179—3)

The present invention relates to telephone systems in general, but is concerned more particularly with telephone systems wherein a line used for telephone purposes is used also for the transmission of telegraph messages. The object of the invention is the production of new and improved circuit arrangements which enable a pair of conductors to serve as a metallic subscriber telephone line and as a ground-return telegraph line without mutual interference when the line is used for telephone and telegraph purposes at the same time.

General description

It has been chosen to illustrate the invention as applied to a subscriber line of considerable length, composited to provide two ground-return telegraph channels in addition to the metallic telephone channel, with one telegraph channel used for the transmission of telegraph messages and the other telegraph channel used for the transmission of ringing current and signalling current incidental to the use of the line for telephone purposes. Since the impulses generated by the calling device in an automatic telephone system may be transmitted over the telegraph channel assigned to the use of the telephone subscribers, it has been chosen to illustrate the invention as applied to an automatic telephone system.

A feature of the invention is that the exchange apparatus is permitted to remain unchanged as regards the setting up of connections between standard lines, while a repeater is provided individual to the combination telephone and telegraph line, to provide for the transmission of ringing current over the line when the line is called and for the transmission of switchhook and calling-device signals from the telephone substation to the switchboard apparatus.

One situation in which the invention is particularly useful is encountered in privately owned railroad exchanges. Certain railroad telephone lines extend many miles from the exchange to a telephone substation, with the result that a considerable economic gain is realized if the pair of conductors can be used to furnish telegraph service in addition to telephone service.

Referring now to the drawings, comprising Figs. 1 to 3, they show the invention applied to a line of a 100-line automatic telephone system. Figs. 1 and 2 show equipment involved in the handling of both telephone and telegraph traffic over the subscriber line L, while Fig. 3 shows a desirable modification of the repeater R1, Fig. 2, providing automatic intermittent ringing.

In Figs. 1 and 2, the telephone line L, comprising conductors 121 and 122, extends between the repeating coil RC1, located adjacent the telephone substation B, and the repeating coil RC2, located in the telephone exchange. The substation B is a local-battery automatic substation, suitably modified to permit ringing and signalling over the separate conductor 111, while conversation is carried on over conductors 103 and 104.

In the telephone exchange, Fig. 2, the repeater R1 is interposed between the repeating coil RC2 and the exchange apparatus for the purpose of repeating the signal impulses at the upper contacts of line relay 221 and of controlling the application of ringing current over the associated one of the two telegraph channels to signal the subscriber at substation B.

Through its terminals 211, the repeater R1 is connected with the individual lineswitch LS2. Fig. 2 shows also the line of telephone substation A, having the individual lineswitch LS1. The lineswitches LS1 and LS2 have common access to a group of connectors, of which the connector C is one. This connector has access to all of the lines entering the exchange through groups of terminals such as those indicated as individual to the respective illustrated lines. Of the lineswitches LS1 and LS2 and the connector C, only the wipers and illustrated bank terminals are shown, as the circuits and mechanisms of these switches are well understood.

The telegraph substation TS1, Fig. 1, and the telegraph substation TS2, Fig. 2, are shown as of the Morse, key-and-sounder type.

Condensers 105 and 207 associated with the line windings of the repeating coils RC1 and RC2 isolate the conductors 121 and 122 from each other as regards direct current, thereby preventing direct-current interference between the two telegraph channels. The differentially connected retard coils 106, 107, 201, and 202 are provided to avoid grounding of conductors 121 and 122 as regards the voice currents impressed on these conductors during conversation and also to provide the required gradual current change in the line conductor to prevent signal noises from being superimposed on the telephone circuit. The condensers 108, 109, 203, and 204 are paired with the respective coils 106, 107, 201, and 202 in furtherance of the arrangement for preventing sharp voltage fluctuations occasioned by telegraph signalling. It will be understood, of course,

that while the coils such as 106 and 107 are each differentially wound so that they are substantially non-inductive to the relatively gradual changes in current flow that take place in signaling over a telegraph channel, they are highly inductive to the relatively rapid changes that take place in voice-current transmission, because of the leakage magnetic return path through the air for each of the coils of the pair independent of the other.

It is to be understood, of course, that the compositing arrangement for deriving the telegraph channels herein disclosed is merely illustrative, and that any suitable well-known method of deriving the low-frequency telegraph channels may be used.

Detailed description

The disclosure having been described generally, a detailed description of the operation of the apparatus shown will now be given. For this purpose it will be assumed first that the subscriber at substation A, Fig. 2, desires to converse with the subscriber at substation B, Fig. 1, for which purpose the subscriber at substation A removes his receiver (not shown) and manipulates his calling device in accordance with the digits in the number assigned to the line of substation B. It will be understood, of course, that the substation A is a standard two-wire automatic substation.

Call from substation A to substation B

When the receiver is removed at substation A, the lineswitch LS1 operates in the usual manner to search for an idle connector. Assuming that the connector C is the first one found to be idle, this connector is seized through the wipers of the lineswitch LS1, when they come to rest in engagement with the terminals of the connector C. The connector C is thereupon prepared for operation in the usual manner.

When the subscriber at substation A dials the two digits in the number of substation B, the wipers of the connector C are first raised opposite the level of bank contacts in which the line terminates and are then rotated across this level until they come to rest in engagement with the terminals from which conductors extend to the local exchange leads of the line L. The line is tested as to its busy or idle condition in the usual manner. Assuming that the line is idle, connection is made therewith and the connector C applies ringing current in the usual manner. The ringing current, however, is not permitted to reach the line L, because of the open connection at the upper contacts of line relay 221.

Ground potential is applied by way of the C wiper of the connector C to the "C" lead of the called line for the purpose of energizing the cut-off relay (not shown) of the lineswitch LS2 to thereby disconnect the usual line relay of the lineswitch. This ground potential is also effective to guard the called line from further seizure by another of the connectors.

The application of ground potential to the C lead of the called line results also in the closure of a circuit through contacts of relay 222 of the repeater R1 for the associated cut-off relay 223 in the repeater. Relay 223 operates to disconnect the incoming line relay 221 of the repeater from the associated telegraph lead 206. The lead 206 is also extended by the upper armature of cut-off relay 233, through contacts of the normally energized ring-cut-off relay 224, to the generator lead 232 associated with the ringing-current transformer 231. Ringing current from lead 232 now passes to the ringer 101 of substation B through contacts of cut-off relay 223 and thence over the telegraph channel including retard coils 202 and 106, and conductor 111. The condenser in series with ringer 101 normally prevents direct current from flowing over the associated telegraph channel, thereby normally preventing line relay 221 from operating. Ringer 101, however, operates on the alternating ringing current passing through the associated condenser, to signal the subscriber at substation B.

As a further result of the energization of cut-off relay 223, the normally existing circuit for ring-cut-off relay 224 is broken. Relay 224, as is indicated by the solid-black upper portion thereof, is equipped with a copper collar on the armature end thereof so as to render the relay slow-acting. As a result relay 224 delays somewhat in restoring after its circuit is opened. When it does restore, relay 224 disconnects ringing lead 232 to terminate the "splash" application of ringing current, and at its upper contacts it reconnects line relay 221 to the lead 206.

When the subscriber at substation B responds to the operation of the ringer 101 brought about as above described, the removal of the receiver R permits the switchhook spring-combination 102 to move to alternate position. The local circuit is closed through the transmitter T and the primary winding of the induction coil IC; the receiver R is bridged across the talking conductors 103 and 104 in series with the secondary winding of the induction coil IC; and the telegraph conductor 111 is disconnected from the ringer 101 and is extended to ground through the normally closed impulsing contacts of the calling device CD. The substation B is thereby prepared for conversation, and a current flow is established over conductor 111 and through retard coils 106 and 202, upper contacts of the now-restored ring-cut-off relay 224 and through the winding of line relay 221 to the negative pole of the exchange battery. Relay 221 energizes over this circuit and at its inner armature closes a circuit for hold relay 222. Hold relay 222 operates and disconnects cut-off relay 223, at the same time locking itself to the C lead of the lineswitch LS2 and of the connector C, which locked condition is maintained until the connection is broken down. Cut-off relay 223, being disconnected by hold relay 222, now restores and connects line relay 221 to conductor 206 at another point, at the same time opening an additional point in the previously established ringing circuit and closing a reoperating circuit for ring-cut-off relay 224. Relay 224 now reoperates preparatory to timing the application of ringing current on the next call received.

At its upper contacts, line relay 221 closes a loop across the associated negative and positive talking conductors and the right-hand windings of repeating coil 209. The resistor 208 simulates the resistance characteristics of a subscribed line of optimum value, while condenser 209 bypasses voice currents around the resistor 208.

In the connector C, the usual ring-cut-off operation and the operation of the usual back-bridge or battery-feed relay now take place responsive to the current flow through the upper contacts of the line relay 321. The connector C is thereby brought into talking condition to permit conversation between the substations A and B over the outlined heavy talking conductors.

At the end of the conversation, when the subscriber at substation B replaces his receiver, line relay **221** restores when it is reconnected in circuit with the ringer **101** and associated condenser. Upon restoring, line relay **221** opens the initial circuit of holding relay **222**, but relay **222** remains operated and locked to the associated C conductor for the time being. At its upper contacts, line relay **221** opens the back-bridge circuit through the connector C and permits the back-bridge relay (not shown) of the connector C to restore for whatever purpose desired.

When the subscriber at substation A replaces his receiver, the connection established through the lineswitch LS1 and the connector C is broken down in the usual manner, and the connector C is restored to the normal position.

Call from substation B to substation A

Assuming now that he desires to converse with the subscriber at substation A, the subscriber at substation B removes his receiver R and then turns the calling device CD in accordance with the digits in the number of substation A. Upon the removal of the receiver, the receiver R and the transmitter T are connected in circuit at hookswitch contacts **102**, as before, and the telegraph lead **111** is switched over from ringer **101** to the impulse contacts of the calling device CD. When this occurs, line relay **221** of the repeater R1 becomes operated over the associated telegraph circuit.

Upon operating, line relay **221** operates hold relay **222** to disconnect cut-off relay **223** and to prepare a locking circuit for the upper winding of relay **222**, whereby operation of relays **223** and **224** responsive to the placing of ground potential on the C lead is prevented.

At its upper contacts, line relay **221** closes a circuit over the associated talking conductors and through the resistor **208** and right-hand windings of repeating coil RC2 for the line relay (not shown) of the lineswitch LS2. By this operation, the lineswitch LS2 is caused to search for an idle connector, and ground potential is returned on the associated C lead to guard the calling line against seizure by a connector. This grounding operation closes a locking circuit for the upper winding of relay **222**. It may be assumed that the lineswitch LS2 extends connection to the connector C, in which event the connector C is prepared for operation in the usual manner.

When the calling device CD is operated, the upper contacts thereof (off-normal shunt contacts) shunt the receiver R to by-pass disturbances created at the upper contacts of relay **221**.

Responsive to the dialling of the digits in the number of the line of substation A, line relay **221** restores each time its circuit is opened, and each time it does so it breaks the impulse circuit at its upper contacts to cause the connector C to be operated under control of its line relay in the usual manner. Relay **222** is held operated and does not restore responsive to the dialling operation because it is held locked over the associated C lead.

The connector C is caused to raise its wipers opposite the desired level of bank contacts when the first digit is dialled and it brings its wipers into engagement with the illustrated terminals of the line of substation A when the second digit is dialled. Ringing current is applied to the line of substation A in the usual manner, and the ringing operation is automatically terminated when the subscriber at the called substation responds.

Conversation may now proceed as desired.

When the conversation is ended, the subscriber at substation A replaces his receiver, but the connection remains established until the subscriber at substation B replaces his receiver and permits line relay **221** to restore and open the control circuit of the connector C at its upper contacts. The restoration of the usual slow-acting release relay (not shown) of the connector C permits the connector C to restore to normal condition, and permits the clearing out operation to be performed at the lineswitch LS2, responsive to removal of ground potential from the C lead. Relay **222** of the repeater R1 restores responsive to the said ungrounding of the associated C lead, returning the repeater R1 to the normal condition indicated in the drawings.

It is to be noted that the common-connection symbols are shown associated with leads **103**, **104**, and **111**, extending to substation B. These common-connection symbols indicate that these three leads may be common to two or more substations, whereby a call transmitted to the line L may be received at any one of these substations, or a call may be originated over any one of these substations in the manner described in connection with the operation of originating a call from substation B.

Regarding the telegraphing from telegraph station TS1 to station TS2, this telegraphing is carried out in the usual manner by opening and closing the circuit at either of the keys, and the current changes produced thereby in line **122** and the accompanying voltage changes on conductor **122** with respect to conductor **121** are prevented from telephonically influencing conversation being carried on over the line L by the illustrated retard coils and by-pass condensers, as previously described.

The modified repeater R2

Referring now particularly to Fig. 3, the modified repeater R2 will be discussed. This repeater includes relays **321**—**324**, corresponding in function respectively to relays **221**—**224** of the repeater R1. The difference between the two repeaters line in the ring-cut-off relay **324** and the way it is controlled, in contrast to the ring-cut-off relay **224** and the way it is controlled. In the system as illustrated in Figs. 1 and 2, only a single, measured application of ringing current is made to the called line. In Fig. 3, the ring-cut-off relay **324** is arranged to operate responsive to current flow which takes place over the called line when the receiver is removed thereat, for which reason the ringing operation may proceed until the called subscriber replies. The ringing-interrupter relay **333** is operated intermittently in the usual manner in order to cause the application of ringing current to be intermittent instead of continuous.

The operation of the repeater R2 will now be described briefly from the standpoint of the reception of a call for the associated line.

Assuming that the repeater R2 is substituted for the repeater R1, the grounding of the associated C lead when a call is received through a connector such as the connector C results in the operation of cut-off relay **323** to disconnect the telegraph conductor from line relay **321** and extend it through contacts of ring-cut-off relay **324** to the intermittent ringing lead **332**. The ring-cut-off relay **324** is of the usual construction of a ring-trip relay, having a copper collar around

the armature end thereof and a copper sleeve under the winding space, both of which contribute to slow up the magnetic response of the relay sufficiently to prevent its operation from the ringing current passing through its lower winding. The relay operates from the continuous flow of current through its lower winding from the negative pole of the exchange battery when the called subscriber replies. The upper winding of the relay is then included in a locking circuit through the inner upper contacts of the relay, to ground over the C lead. The ringing circuit is opened at the middle armature of the relay, while the line relay **321** is reconnected at the upper armature.

Line and hold relays **321** and **322** now operate successively. Relay **322**, in addition to closing its own locking circuit, breaks the holding circuit of relay **323** and the locking circuit of relay **324**. Quick-acting cut-off relay **323** restores immediately to open a further point in the ringing circuit and to keep line relay **321** connected in circuit, while slow-acting ring-cut-off relay **324** restores a short time later in preparation for the next call.

In the event that the invention is to be used in connection with a manual exchange, the substation B may be used as illustrated, or the calling device CD may be eliminated, in which case the associated switchhook contact is connected directly to ground. The terminals **211** of the repeater R1 are connected to the ring, tip, and sleeve conductors, respectively, of the manual switchboard, while the current-supply connections to the upper winding of relay **222** and to the winding of **223** are made to agree with the alteration of potential on the sleeve conductor of the manual line circuit when a plug is in the jack, as compared with the potential that normally exists thereon. The usual manual common battery signalling is then accomplished at the upper contacts of line relay **221**, while relays **222** and **223** are controlled over the sleeve conductor in the manner described in connection with their control over the illustrated C conductor.

What is claimed is:

1. In combination, a telephone exchange and a subscriber station, a two-conductor line connecting the subscriber station with the telephone exchange, a pair of telegraph channels superimposed on the two conductors respectively of said line, means for accomplishing switchhook signalling operations from the substation to the exchange over one of the telegraph channels, a pair of telegraph stations, and a circuit between said telegraph stations including the other of said telegraph channels.

2. In combination, a telephone exchange and a telephone substation, a two-conductor line extending from the telephone exchange to the substation, a metallic channel established over said line for the passage of voice currents thereover from the substation to the exchange, a ground-return direct-current signal channel superimposed on one of the conductors of said line and extending between the substation and the exchange, a pair of telegraph stations, and a ground-return telegraph channel superimposed on the other conductor of said line and extending between said stations.

3. In combination, a telephone exchange and a substation set interconnected by a two conductor line, means for transmitting voice currents to and from said substation over a metallic circuit including the two conductors of said line, means for transmitting ringing current from the exchange to the substation over one conductor of the line and the return circuit separate from the other conductor thereof, means for transmitting signal impulses from the substation to the exchange over the above mentioned conductor used for the transmission of ringing current and the said separate return conductor, a pair of telegraph stations, and means for transmitting telegraph signals between said stations by way of the other conductor of said line and a separate ground return circuit, and means for preventing mutual interference between the several operations set forth.

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