

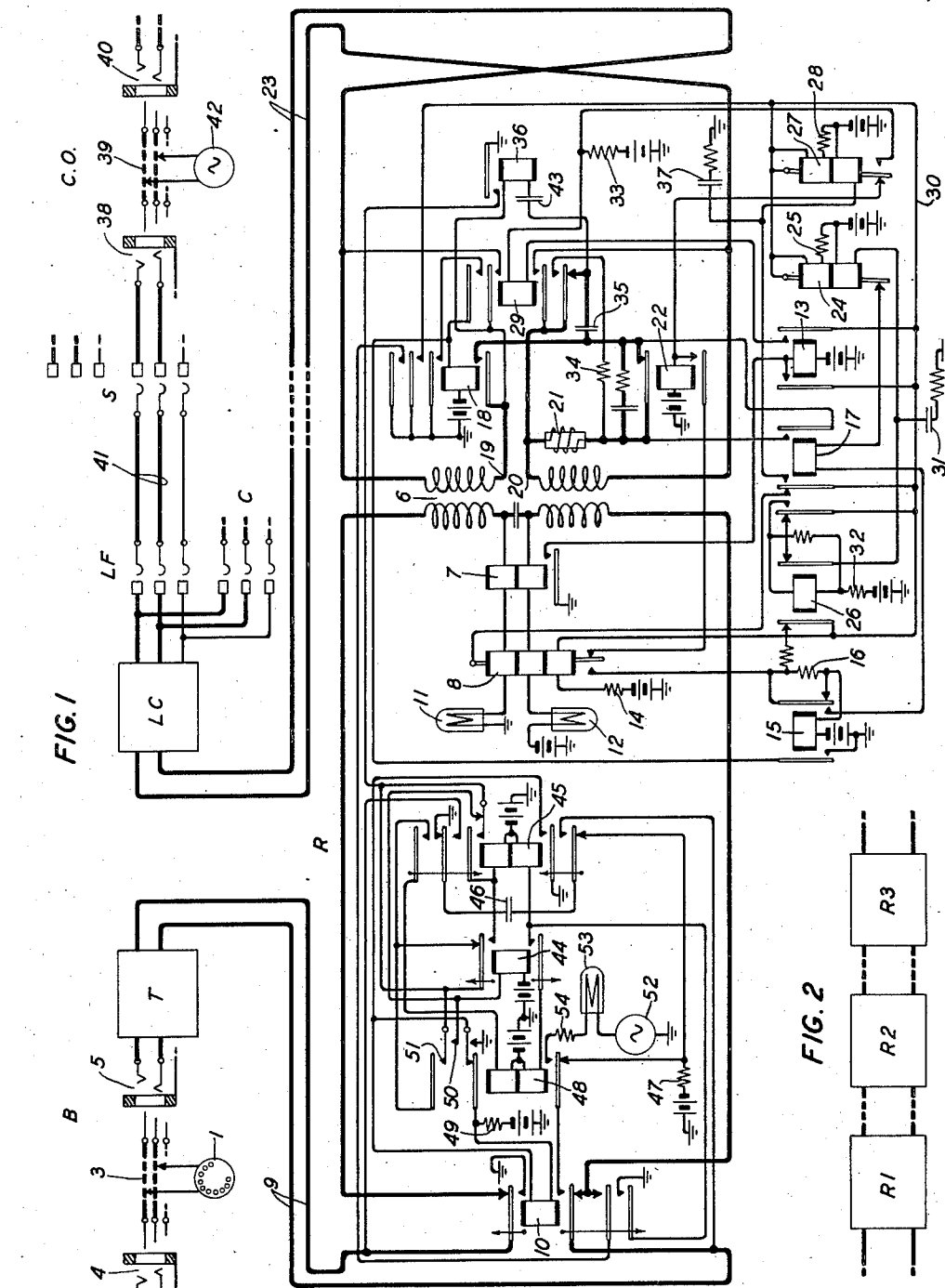
May 12, 1936.

F. R. LAMBERTY ET AL

2,040,316

TELEPHONE SYSTEM

Filed Dec. 1, 1934



INVENTORS: F. R. LAMBERTY
L. E. VAN DAMME
BY

M. R. McFarney
ATTORNEY

UNITED STATES PATENT OFFICE

2,040,316

TELEPHONE SYSTEM

Frederick R. Lamberty, Brooklyn, N. Y., and
Louis E. Van Damme, Weehawken, N. J., as-
signors to Bell Telephone Laboratories, Incor-
porated, New York, N. Y., a corporation of New
York

Application December 1, 1934, Serial No. 755,556

8 Claims. (Cl. 179-46)

This invention relates to telephone systems and particularly to systems in which lines or trunks are equipped with mechanism for repeating ringing and signaling currents.

5 The objects of the invention are to enable the introduction of delay intervals in the repetition of signaling currents without diminishing the duration thereof; to permit a plurality of such repetitions in a single connection without detrimental effect on the signals; and otherwise to improve signaling and repeating circuits.

10 Systems have been designed heretofore for repeating ringing current around a repeating coil or other similar device by so arranging the circuits that the incoming ringing signal operates a relay which causes the application of a different supply of ringing current to the outgoing line on the other side of the repeating coil. Arrangements have also been proposed for delay-
15 ing the application of the ringing current in order to guard against false ringing due to surges or other disturbances that may occur in the circuit.

20 According to a feature of the present invention, the ringing repeating circuits are so arranged that a slow-acting relay mechanism is controlled by the ringing relay in response to the incoming ringing signal to measure a predetermined interval from the beginning of the incoming ringing signal, at the end of which interval the new source of ringing current is applied to the outgoing line and is maintained for a definite interval of time following the cessation of the incoming ringing signals. A slow-acting
30 relay responsive to the ringing relay measures a predetermined interval of time and then causes the application of the ringing source to the outgoing line, and, when the ringing relay releases at the termination of the incoming ringing signal, the slow-acting relay again measures a pre-
40 determined interval of time, at the end of which the ringing source is disconnected from the outgoing line. This arrangement permits the use of several ringing repeaters in the same telephone connection without diminishing the ringing interval at the receiving end of the connection. Should the initial delay interval be introduced at each of several repeaters connected in tan-
50 dem relation, for the purpose of guarding against false ringing due to momentary surges, the ringing interval at the final end of the connection might be greatly reduced or even eliminated entirely. To avoid this defect, the arrangement
55 above mentioned has been devised to insure a

full ringing interval regardless of the number of repetitions.

The foregoing and other features of this invention will be better understood from the following detailed description.

Referring to the drawing, Fig. 1 illustrates a circuit connection between a calling station A associated with a private branch exchange B and a dial central office switchboard CO. In order to extend the operating range of the trunk, re-
10 peater R is included in the connection at the private branch exchange. In addition to the repeater, other apparatus necessary for establishing the connection is shown. This includes the jacks 4 and 5, the cord circuit 3 and trunk equip-
15 ment T at the private branch exchange, the line circuit LC, the line finder LF, and selector S and connector C at the central office, and also the jacks 38 and 40 and cord circuit 39.

Fig. 2 shows diagrammatically without details the general plan whereby a plurality of repeaters R1, R2 and R3 may be connected in tandem.

The repeater R which is shown in detail is arranged for extending the operating range of the trunk by providing means whereby, according to a feature of this invention, the private branch exchange may be signaled from the central office with ringing current without any distorting or suppressive effect on the pulses of ringing current transmitted over the trunk. In other words, the pulses of ringing current received at the terminating end are a faithful reproduction of those impressed at the transmitting end. In addition to this aforesaid feature of the invention whereby long range operation is made possible through
35 providing means for the satisfactory transmission of ringing signals, another requirement for long range operation, namely, the efficient transmission of dial pulses, is also provided in the particular arrangement shown in Fig. 1. This
40 latter feature is the subject of a copending application of B. G. Dunham, Serial No. 726,889 filed May 22, 1934 granted as Patent 2,023,011, Dec. 3, 1935.

A description of Fig. 1 will now be given, first for a call originating with the station A and terminating at switchboard CO; and secondly, after the call has been established the operation of Fig. 1 will be described for the transmission of ringing signals from switchboard CO to the
50 private branch exchange at the originating end. For a more complete description and analysis of the circuit operating details involving the transmission of dial pulses, reference should be had to the aforesaid Dunham application.

When station A originates a call, the operator at B responds to the line signal (not shown) by plugging cord circuit 3 into jack 4, and, after receiving the number of the called line, she plugs into jack 5 and closes a bridge across the talking conductors which includes the contacts of the dial 1. This causes the completion of a circuit by way of the trunk equipment T to the incoming side of the repeater R, which thereupon closes another bridge on the outgoing side of its repeating coil 6. This latter bridge causes the line circuit LC to function.

The closing of the aforesaid bridge on the incoming side of the repeating coil 6 of repeater R causes relay 7 to operate and also polarized relay 8 through a circuit which may be traced from the dial 1 over conductors 9 through normally closed contacts of relay 10, left-hand windings of repeating coil 6, windings of relay 7, upper windings of relay 8, and resistance lamps 11 and 12 to ground and battery, respectively. Relay 7, in operating, operates through an obvious circuit relay 13 which connects ground through its left-hand contacts to conductor 30. The lower winding of polarized relay 8 is now energized through a circuit from battery through resistance 14 and the lower winding of relay 8 to ground on conductor 30. Said lower winding of relay 8 magnetically opposes the upper two windings but relay 8, however, does not release. Relay 8, in operating, operates relay 15 through a circuit traceable from battery through the winding of relay 15, resistance 16, operated contacts of relay 8, left-hand inner back contacts of relay 17 to ground on conductor 30. Relay 15, in operating, operates relay 18 through an obvious circuit, and relay 18 in operating connects a bridge in series with the right-hand windings of repeating coil 6 traced from terminal 19 of repeating coil 6, through lower operated contacts of relay 18, upper break contacts of relay 22, retardation coil 21, to terminal 20 of repeating coil 6. Said bridge, including the right-hand windings of repeating coil 6, is effective over line conductors 23 to cause line circuit LC to function. This causes the line finder LF to hunt for and connect to the calling trunk 23 and extend it in the well-known manner to a selector S. Relay 18 also connects ground to conductor 30.

When relay 13 operated, it also energized both windings of polarized relay 24. These windings are connected differentially. Under this condition the contacts of relay 24 remain closed. The energizing circuit for the upper winding of relay 24 may be traced from battery through resistance 25, upper winding of relay 24 to ground on conductor 30 and for the lower winding from battery through said lower winding, right-hand normally closed contacts of relay 26, left-hand outer back contacts of relay 17 to ground on conductor 30. Relay 13, in operating, also energized the upper winding of polarized relay 27 through a circuit traceable from battery through resistance 28, upper winding of relay 27 to ground on conductor 30. Relay 27 now operates but relays 17 and 29 do not operate at this time because of short-circuits around their windings.

The operator at B now receives the usual dial tone indicating that the circuit is ready to receive dial pulses. When dial 1 is operated, relay 8 follows the pulses. Relay 7 may also follow the pulses but it performs no useful function thereby. The release of relay 8 at the first break of the contacts of dial 1 operates relay 17 by disconnecting ground at its left-hand termi-

nals. The operating circuit for relay 17 is traceable from battery through the winding of relay 15, resistance 16, right-hand operated contacts of relay 15, winding of relay 17, closed contacts of relay 24 to ground on conductor 30. Relay 15 is held operated through this circuit. Relay 17, in operating, bridges an obvious circuit with its right-hand contacts around the upper break contacts of relay 22, so as to maintain the closure of the pulsing bridge when relay 22 operates as hereinafter described. In operating, relay 17 also energizes the lower winding of relay 27 from ground on conductor 30 through its inner left-hand operated contacts. Due to the differential action of its windings relay 27 now immediately releases. Relay 17 also disconnects ground on conductor 30 from the lower winding of polarized relay 24 by opening its left-hand outer normally closed contacts. With the opposing magnetic action of its lower winding removed, relay 24 after an interval measured by the charging time of condenser 31, operates. Relay 17 also at this time operates relay 26 through a circuit traceable from battery through resistance 32, winding of relay 26 and outer left-hand operated contacts of relay 17 to ground on conductor 30. The aforesaid release of relay 27 disconnects ground on conductor 30 from the upper winding terminal of relay 29, which now operates in a circuit from battery through resistance 33, winding of relay 29 to ground on conductor 30 through the right-hand operated contacts of relay 13. Relay 22 also operates at this time through a circuit traceable from battery through the winding of relay 22, left-hand contacts of relay 27 to ground on conductor 30. Relay 29, in operating, closes a locking circuit for relay 18 which may be traced from battery through the winding of relay 18, upper outer operated contacts of relay 29 and through upper inner operated contacts of relay 18 to ground. Relay 29, in operating, also short-circuits the upper and lower right-hand windings of repeating coil 6. The upper winding is short-circuited through the upper inner contacts, the lower winding through the lower inner contacts of relay 29. Relay 29 also connects resistance 34 in multiple with retardation coil 21 by means of its lower outer front contacts, and disconnects the circuit of relay 36, including condenser 43, and condenser 35 with its lower outer back contacts. This is done to remove inductance and capacity from the pulsing bridge. When polarized relay 24 operates it opens the series holding circuit of relays 15 and 17 hereinbefore traced and these relays now release. The release of relay 17 opens at its right-hand contacts the pulsing bridge across trunk conductors 23, hereinbefore traced, thereby starting the open period of the outgoing pulse, and simultaneously removes ground from the lower winding of relay 27 by opening its left-hand inner front contacts. Relay 27 now starts to operate, due to the removal of the opposing action of its lower winding. After condenser 37 is charged in series with said lower winding of relay 27, there is no further current flow in the lower winding and relay 27 finally operates.

Relay 17, in releasing, also connects ground from conductor 30 through its left-hand inner back contacts to the armature of relay 8 and opens the circuit at its left-hand outer front contacts, through the winding of relay 26 which releases. The release of relay 26 releases relay 24 by energizing the lower winding of relay 24 over the circuit path hereinbefore traced.

When relay 27 operates, as hereinbefore described, it releases relay 22 by opening the operating circuit for this relay previously traced. Relay 22, in releasing, closes the pulsing bridge
 5 hereinbefore described with its upper normally closed contacts thereby terminating the open period of the outgoing pulse. In accordance with the foregoing, the outgoing pulse starts when relay 17 releases, it is timed by relay 27 and it
 10 terminates when relay 22 releases in response to the operation of timing relay 27. Subsequent pulses are repeated in like manner. Each time relay 27 operates it momentarily short-circuits the winding of relay 29, but the short-circuit is
 15 removed so quickly that relay 29 remains operated until the end of the digit when it releases. When relay 29 releases it removes the short-circuit from the winding of repeating coil 6 and again connects condenser 35 and the circuit of relay 36 and condenser 43 inside repeating coil 6. Relay 18 remains operated under control of relay 15.

After all digits are dialed, the switches at the terminating office establish connection to the
 25 line terminating in jack 38, causing the display of an associated line signal (not shown). The operator at CO in response to said signal plugs cord circuit 39 into jack 38, and then after receiving the necessary instructions completes the
 30 connection to the line terminating on jack 40, thereby completing the conversational circuit with the line of the called subscriber. At the end of the conversation, the operator at B removes cord circuit 3 from jack 5, causing thereby
 35 the release of relays 7 and 8. The release of relay 8 operates relay 17 as hereinbefore described. Relay 17, in operating, operates relay 26 and releases relay 27 by causing the energizing of its lower winding and operates relay 24 by
 40 opening the circuit of its lower winding. The release of relay 27 operates relay 22 and causes the operation of relay 29 as was described in connection with the establishment of the connection. Relay 18 is now locked to ground
 45 through the locking circuit hereinbefore traced. The operation of relay 24 releases relays 15 and 17. The release of relay 17 opens the bridge inside the repeating coil, thus releasing the connection at the central office, and provides a holding
 50 bridge through the back contacts of relay 8 to hold relay 22. Relay 17, in releasing, opens at its left-hand outer make contacts the circuit through the winding of relay 26, which releases and also disconnects ground at its left-hand inner
 55 make contacts from the lower winding of relay 27 which operates and short-circuits relay 29 which releases. The release of relay 29 causes the release of relay 18 which removes ground from conductor 30 releasing thereby relays 13,
 60 22 and 24, restoring the circuit to normal.

In the description hereinbefore given the operation was described to illustrate the establishment of a connection between the calling subscriber at A and the operator at CO. Said description showed how the repeater circuit functioned to correct the dial pulses. The operation of the long trunk circuit will now be described to show how ringing current, according to a feature of this invention, may be transmitted without distortion from the switchboard CO to the private branch exchange B.

Assume that the connection has been established as hereinbefore described and that the operator CO wishes to signal the operator at B.
 75 Ringing current from the source 42 will now be

applied to the conductors of cord circuit 39 which will cause repeater R, through the contacts of jack 38 and over conductors 41 and through contacts of line finder LF, to repeat ringing current to the trunk circuit T. The operation of
 5 repeater R will now be described. Ringing current over conductors 23 operates relay 36 through a circuit that may be traced from conductors 23 through the right-hand windings of repeating coil 6, lower normally closed contacts of relay 29,
 10 condenser 43 and winding of relay 36. Relay 36, in operating, operates slow-release relay 44 through a circuit traceable from battery through the winding of relay 44, upper inner back contacts of relay 45, to ground on the contacts of
 15 relay 36. The operation of relay 44 operates slow-operating relay 45, through a circuit that may be traced from battery, through the upper winding of relay 45, upper operated front contacts of relay 44 to ground on the contacts of
 20 relay 36. Relay 45 now locks through its upper inner front contacts to ground on the contacts of relay 36 and opens the operating circuit for relay 44 hereinbefore traced which releases. Relay 45 also disconnects condenser 46 from ground
 25 on its upper outer back contacts and from resistance 47 and battery on its lower outer back contacts and bridges said condenser 46 across tip and ring conductors 9. Connection to the tip conductor is made by the upper middle front
 30 contacts and to the ring conductor by the lower outer front contacts of relay 45. Relay 44 being slow-to-release remains operated momentarily after relay 45 operates. When relay 44 finally releases, relay 48 operates through a circuit
 35 traceable from battery through the upper winding of relay 48, upper outer make contacts of relay 45, upper back contacts of relay 44 to ground on the contacts of relay 36. Relay 48, in operating, locks under control of relay 36 through
 40 a circuit traced from battery through the upper winding of relay 48, upper outer operated contacts of relay 45, upper outer make contacts of relay 48 to ground on the contacts of relay 36. Relay 48, in operating, by opening its upper back
 45 contacts causes the operation of relay 10 by removing the short-circuit from its winding. The operating circuit for relay 10 may be traced from battery through resistance 49, winding of relay 10 through the upper inner make contacts of
 50 relay 48 to ground and also through the lower inner make contacts of relay 45 to ground. Relay 44 now reoperates on a circuit traceable from battery through the winding of relay 44, contact springs 50 and 51 of relay 48 to ground on the
 55 contacts of relay 36. The operation of relay 10 disconnects the tip and ring conductors 9 from the conductors leading to the left-hand windings of repeating coil 6 and connects said conductors 9 respectively to ground and the ring-
 60 ing current supply 52, the latter being in series with a resistance lamp 53 and a resistance 54. Relay 10, in operating, also closes a circuit for holding relays 48 and 45 on their lower windings. This holding circuit may be traced from ground
 65 on the lower outer make contacts of relay 10 to battery through the lower winding of relay 45, and through the lower operated make contacts of relay 44 and the lower winding of relay 48 to battery. Relays 44 and 45 are slow-acting
 70 relays and consequently insure that relay 10 will not operate falsely on momentary operations of relay 36 that might result from line disturbances. Also, relay 10 closes a circuit through its lower middle make contacts for grounding the 75

ring conductor connected to the lower left-hand winding of repeating coil 6. This ground is furnished by the upper outer operated make contacts of relay 18 and prevents relays 7 and 8 from releasing when their operating circuits are opened by the operation of relay 10. The release of said relays would cause the operation of relay 29 thereby disconnecting the circuit of relay 36 and causing a false interruption of ringing.

When ringing current is disconnected from the circuit, relay 36 releases thereby opening the energizing circuit for relay 44 which was previously traced through the contact springs 50 and 51 of relay 48. Relay 44, in releasing, releases relay 48 by opening the circuit through its lower winding. The release of relay 48 disconnects ring conductor 9 from ringing current and connects it to battery through resistance 47 thereby charging condenser 46 to battery potential to avoid the possibility of a momentary operation of relays 7 and 8 by condenser discharge when relay 10 releases which would connect the bridge hereinbefore described across the circuit and thereby prematurely trip machine ringing when this is used for signaling. After an interval, slow-release relay 10 releases due to a short-circuiting of its winding by the upper normally closed contacts of relay 48. The release of relay 10 also releases relay 45 by removing ground from its lower winding thereby disconnecting condenser 46 from the tip and ring conductors. The purpose of condenser 46 which is bridged across the talking conductors is to reduce the severity of the clicks which might be heard by the operator B if listening on the connection during ringing.

From the hereinbefore given description it is seen that after relay 36 operates in response to the incoming ringing signal a definite period of time is measured before relay 10 operates to connect ringing current to conductors 9. This is the time of operation of relays 44 and 45 plus the time of release of relay 44, plus the time of operation of relays 48 and 10. After the cessation of said incoming ringing signal there is also a definite period of time measured before relays 48 and 10 release, disconnecting ringing current from conductors 9. This interval is measured by the time of release of relay 44 plus the time of release of relays 48 and 10. Accordingly, it is seen that any ringing signal incoming to the repeater that is of sufficient duration to cause the ultimate operation of relay 10 will be repeated as an outward signal always for a certain minimum interval of time. The slow-operating relay mechanism is arranged so that the minimum ringing time of the output of the repeater is always sufficiently great to cause the operation of the ringing responsive devices beyond. With this arrangement it is seen that the invention guards against false ringing due to momentary line disturbances and at the same time provides a means for ringing through a plurality of repeaters, as illustrated in Fig. 2, without decreasing the duration of the signal received at the terminating end.

The invention has been described hereinbefore for a condition requiring a re-ringing of the originating end on a call outgoing from the private branch exchange B. The circuits function in a similar manner when the private branch exchange is signaled on an incoming call, after connection has been made to the line in the usual manner by selectors (not shown) and by connector C, indicated in diagrammatic form. Under this condition as relays 7 and 8 are not oper-

ated during the initial ringing period, relay 18 is not operated and the lower middle make contacts of relay 10 do not operate relays 7 and 8 as under the condition of a re-ring previously described. If the call is answered during a ringing interval, there is no change in the circuit of repeater R as relays 7 and 8 do not operate, since the tip and ring conductors of the left-hand winding of repeating coil 6 are open at the contacts of relay 10. At the end of the ringing interval relays 36, 44, 48, 10 and 45 release and then relays 7 and 8 operate. The circuit then functions as hereinbefore described. If the call is answered during a silent period then relays 7 and 8 operate immediately. Machine ringing is tripped by the bridge applied when relay 18 operates.

The invention has been described specifically in its application to a trunk between a private branch exchange and a dial central office. It is to be understood, however, that the invention is not limited to this particular use. The slow operative relay mechanism which is disclosed and which is used to control the impulses of ringing current may be equally well adapted by one skilled in the art for other similar applications; for example, for use in extending the operating range of a private branch exchange trunk terminating at a manual central office, of an individual subscriber's line terminating at either a dial or a manual central office, or of a subscriber's line terminating at either a manual or a dial private branch exchange.

What is claimed is:

1. The combination in a repeating mechanism of a repeating coil, a line incoming to said coil and a line outgoing from said coil, means for sending ringing current signals over said incoming line, a source of ringing current, means for connecting said source to and for disconnecting it from said outgoing line, and a relay mechanism including a slow-acting relay arranged to operate a plurality of times under control of a ringing current signal in said incoming line to measure an interval of time between the beginning of said ringing current signal and the connection of said source to said outgoing line and to measure an interval of time between the end of said ringing current signal and the disconnection of said source from said outgoing line.
2. The combination in a repeating mechanism of an incoming line and an outgoing line, a source of ringing current for connection to said outgoing line, a ringing relay responsive to ringing signals in said incoming line, means including a slow-release relay and a slow-operating relay for delaying the connection of said source of current for a definite interval following the operation of said ringing relay, and means including said slow-release relay for delaying the disconnection of said source of current for a definite interval following the release of said ringing relay.
3. The combination in a telephone system of an incoming line and an outgoing line, means for sending ringing signals over said incoming line, a ringing relay responsive to said signals, a source of ringing current for sending signals over said outgoing line, means for connecting said source of current to and for disconnecting said source from the outgoing line, and a slow-acting relay controlled in one of its actuations by said ringing relay to delay the connection of said source to said outgoing line following the operation of the ringing relay and controlled in another of its actuations by said ringing relay to delay the dis-

connection of said source from said outgoing line following the release of said ringing relay.

4. The combination in a telephone system of a line having an incoming section and an outgoing section, means for sending signaling current over said incoming section, a source for sending signaling current over said outgoing section, a slow-release relay arranged to operate and release a plurality of times in response to a ringing signal sent over said incoming section to measure successive intervals of time, and means controlled by said slow-release relay for connecting said source to said outgoing section at the end of one of said measured intervals and for disconnecting said source from said outgoing section at the end of a subsequent measured interval.

5. The combination in a signaling system of a line having an incoming section and an outgoing section, means for sending signaling current over the incoming section, a signaling relay responsive to said current, a source for sending signaling current over said outgoing section, means for connecting said source to and for disconnecting it from said outgoing section, a slow-release relay arranged to operate and release in response to the initial operation of said signaling relay, means controlled by said slow-release relay for measuring an interval of time between the operation of said signaling relay and the connection of said source to said outgoing section, means effective upon the connection of said source to the outgoing section for reoperating said slow-release relay, said latter relay again releasing in response to the release of said signaling relay, and means controlled by said slow-release relay for causing a delay between the release of said signaling relay and the disconnection of said source from the outgoing section.

6. The combination in a telephone system of an incoming line and an outgoing line, means for sending signals over said incoming line, a source of current for sending signals over said outgoing line, means for connecting said source of current to and for disconnecting said source from the outgoing line, a timing mechanism including a slow-operating relay and a slow-releasing relay, and means under control of an incoming

signal for causing said slow-operating relay to operate and slow-release relay to release to measure an interval between the beginning of said incoming signal and the connection of said source to said outgoing line, and for causing the release of said slow-release relay to measure an interval between the end of said incoming signal and the disconnection of said source from said outgoing line.

7. The combination in a telephone system of a line having an incoming section and an outgoing section, means for sending signaling current over said incoming section, a signaling relay responsive thereto, a source for sending signaling current over said outgoing section, an impulse relay in said line responsive to dial impulses sent thereover, a relay mechanism including a slow-acting relay for measuring an interval of time between the actuation of said signaling relay and the connection of said source to the outgoing section, and for measuring an interval of time between the release of said signaling relay and the disconnection of said source from the outgoing section, and means controlled by said relay mechanism for holding said impulse relay energized while signaling current is being sent.

8. The combination in a telephone system of a two-conductor line having an incoming section and an outgoing section, means for sending ringing current over the two conductors of said incoming section, a ringing relay responsive thereto, a source for sending ringing current over the two conductors of said outgoing section, a signaling relay connected to the conductors of said line and responsive to signals transmitted over said line, a relay mechanism including a slow-acting relay for measuring an interval of time between the actuation of said ringing relay and the connection of said ringing source to the outgoing section, and for measuring an interval of time between the release of said ringing relay and the disconnection of said source from said outgoing section, and means controlled by said relay mechanism for holding said signaling relay while ringing current is being transmitted over said line.

FREDERICK R. LAMBERTY.
LOUIS E. VAN DAMME.