Jan. 6, 1931. H. H. ABBOTT ET AL 1,788,007

TELEPHONE REPEATER SYSTEM

Filed Oct. 4, 1929 4 Sheets-Sheet 1

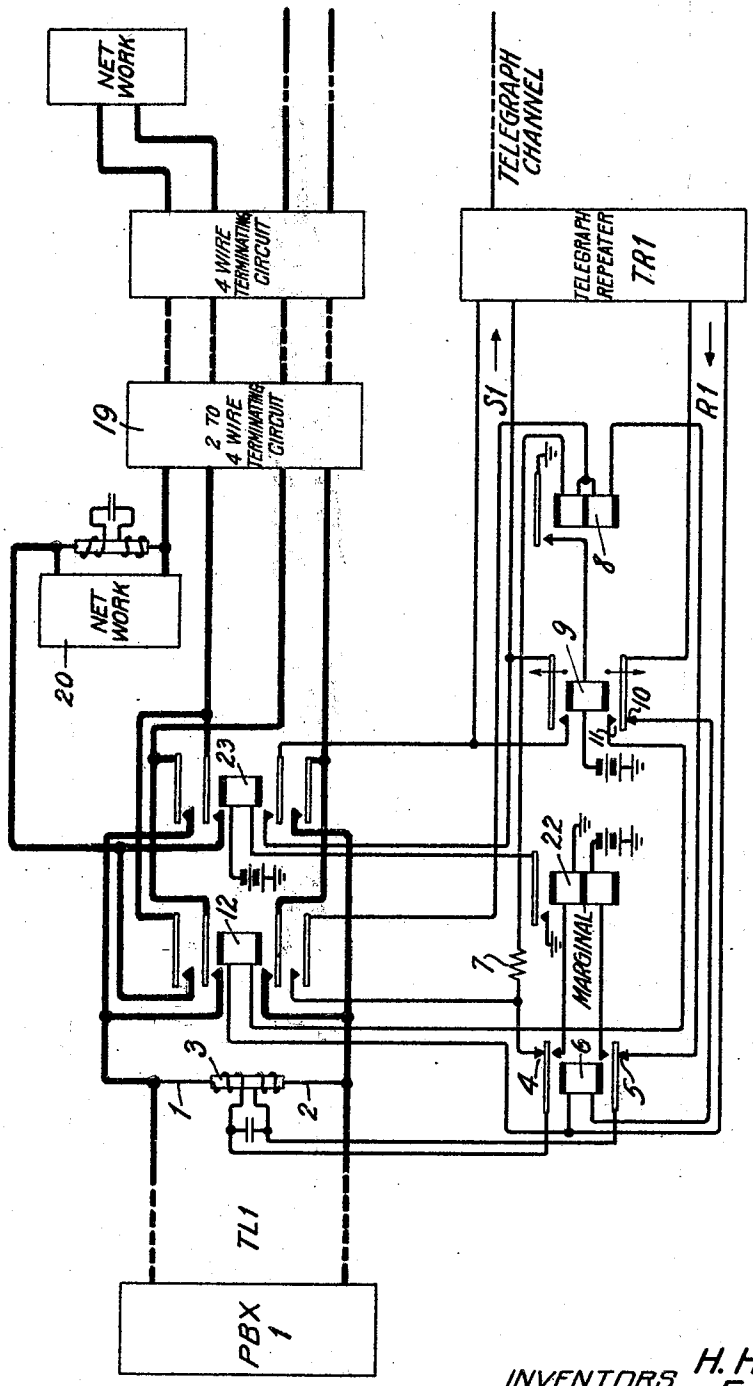

FIG. 1.

INVENTORS H. H. ABBOTT
F. S. ENTZ

BY

ATTORNEY

Jan. 6, 1931. H. H. ABBOTT ET AL 1,788,007

TELEPHONE REPEATER SYSTEM

Filed Oct. 4, 1929 4 Sheets-Sheet. 2

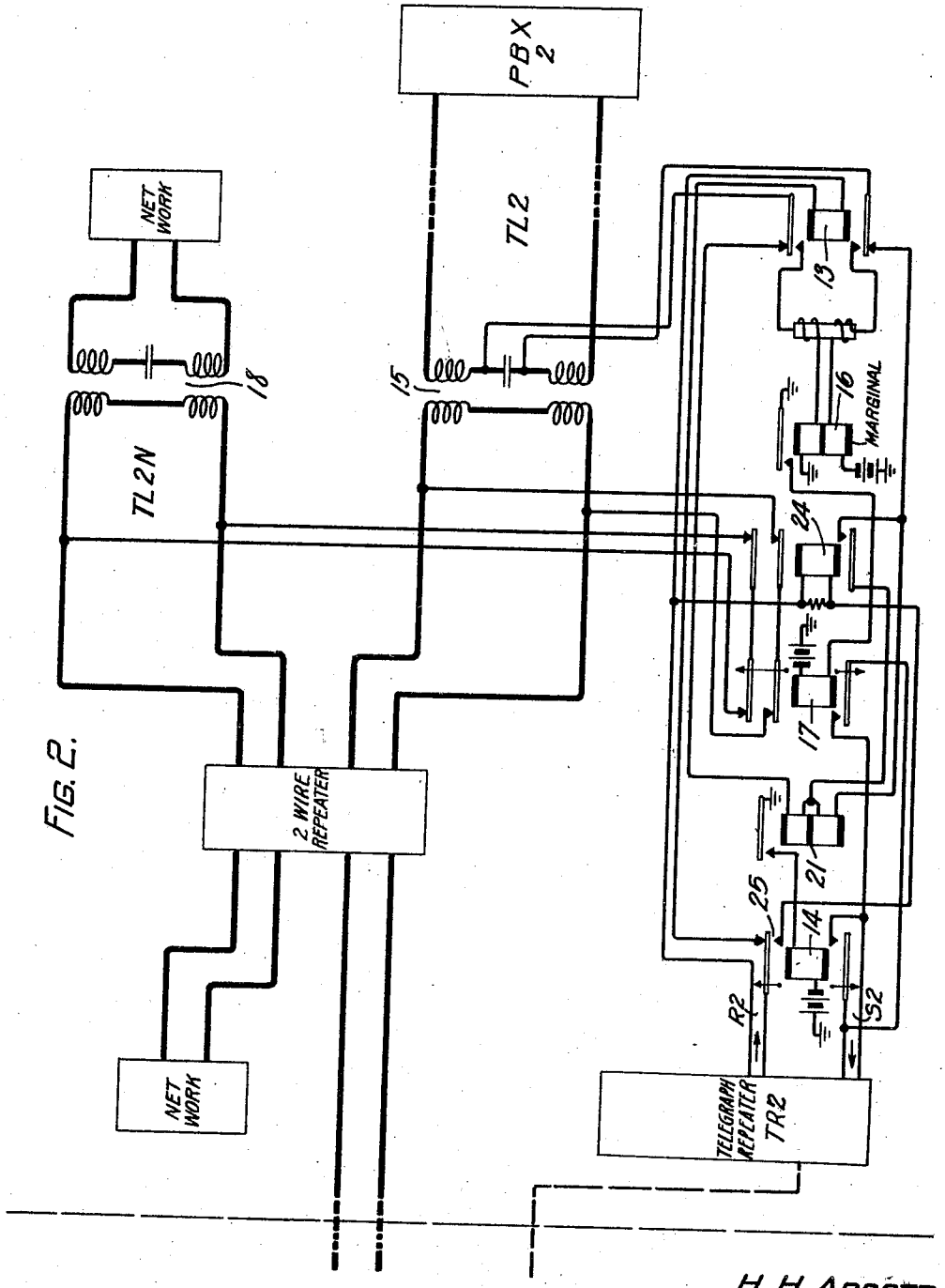

FIG. 2.

INVENTORS H. H. ABBOTT
F. S. ENTZ

BY John A. Hall

ATTORNEY

Jan. 6, 1931. H. H. ABBOTT ET AL 1,788,007

TELEPHONE REPEATER SYSTEM

Filed Oct. 4, 1929 4 Sheets-Sheet. 3

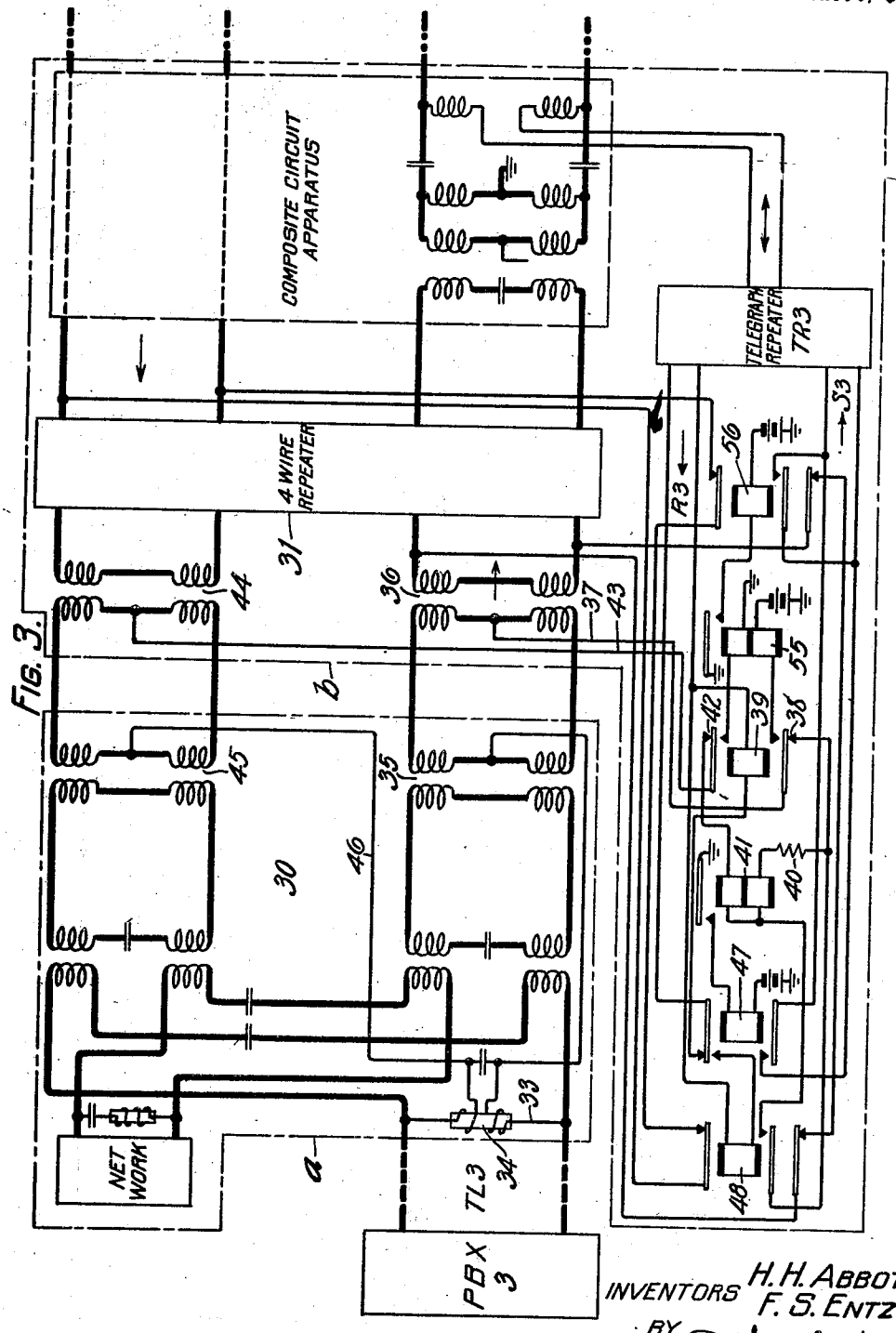

FIG. 3.

INVENTORS H. H. ABBOTT
F. S. ENTZ

BY John A. Hall

ATTORNEY

Jan. 6, 1931. H. H. ABBOTT ET AL 1,788,007

TELEPHONE REPEATER SYSTEM

Filed Oct. 4, 1929 4 Sheets-Sheet 4

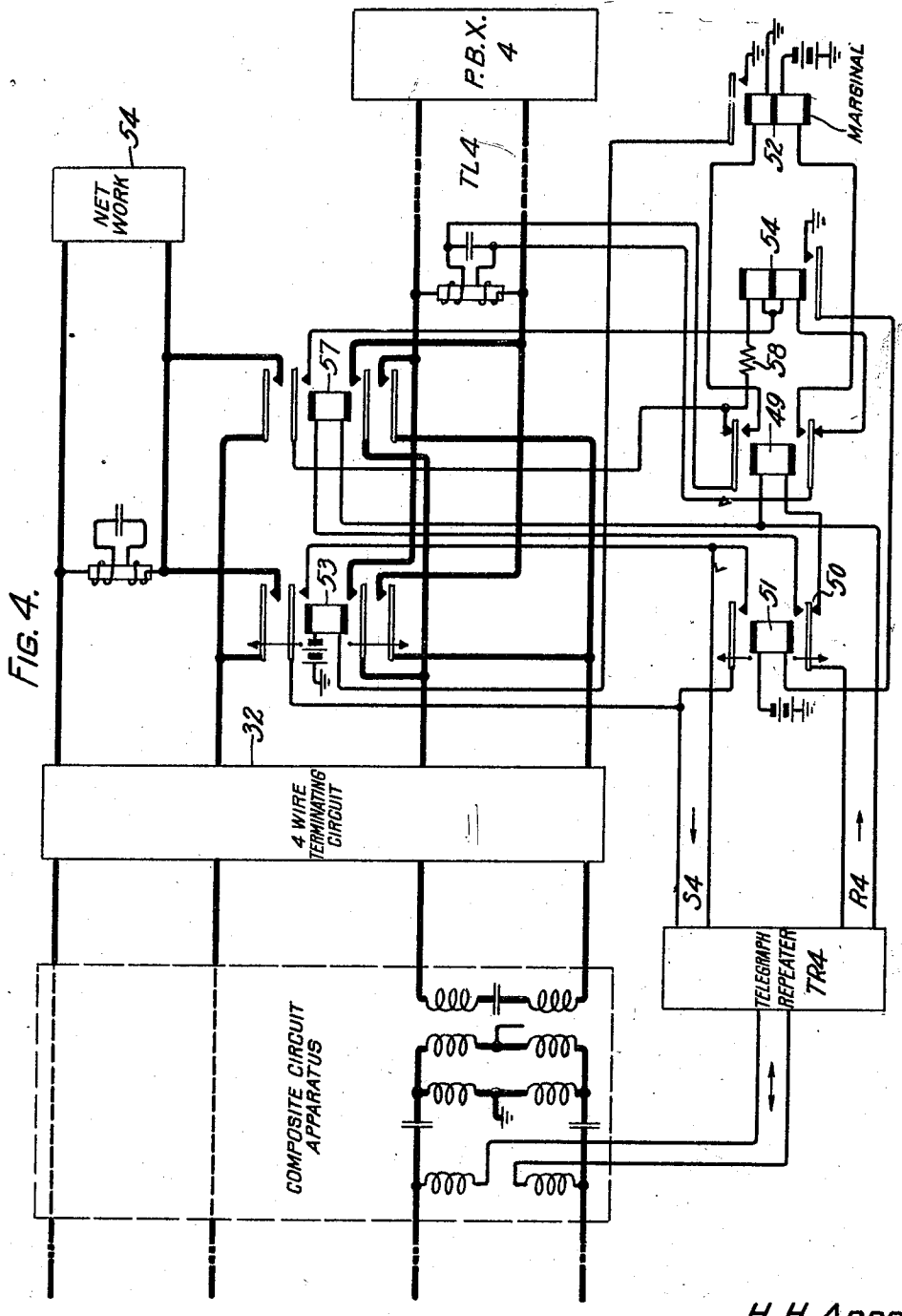

FIG. 4.

INVENTORS H. H. ABBOTT
F. S. ENTZ
BY John Attale.
ATTORNEY

Patented Jan. 6, 1931 1,788,007

UNITED STATES PATENT OFFICE

HENRY H. ABBOTT AND FERDINAND S. ENTZ, OF NEW YORK, N. Y.; SAID ABBOTT ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK, AND SAID ENTZ ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

TELEPHONE REPEATER SYSTEM

Application filed October 4, 1929. Serial No. 397,196.

This invention relates to signaling arrangements for long or highly attenuated P. B. X. tie-lines or inter-office trunks having telephone repeaters or other circuits, opaque to direct current, included therein.

The object of the invention is to increase the direct current signaling range of lines of this character.

A feature of the invention whereby the above object is attained resides in an auxiliary circuit including a two-way telegraph repeater channel connected to the line around the opaque circuits, whereby direct current signals applied to the line at either exchange are repeated and passed around the opaque circuits to control respective signal devices at the other exchange.

The invention will now be described with the aid of the accompanying drawings:

Figs. 1 and 2 of the drawing when placed together, with Fig. 2 at the right, represent a tie-line circuit extending between two widely separated private branch exchanges, which circuit includes certain intermediate equipment, Fig. 1 showing a terminating circuit for joining a two-wire to a four-wire line and another terminating circuit for joining a four-wire line to a second two-wire line and Fig. 2 shows a two-wire telephone repeater inserted in the last named two-wire line. These figures also show a telephone repeater "by-pass" arrangement in accordance with the present invention which is adapted to translate direct current calling and supervisory signals, originating at either P. B. X., into standard telegraph impulses and to transmit them, over any available telegraph channel, around the above mentioned terminating circuits and repeaters and retranslate them into direct current impulses to operate line or supervisory signal devices at the other P. B. X.

Figs. 3 and 4 when placed together, with Fig. 4 at the right, represent a tie-line circuit extending between two widely separated P. B. X.'s, which includes intermediate equipment comprising a terminating circuit for joining a two-wire line to a four-wire line, a four-wire repeater and composite circuit apparatus therein, as shown in Fig. 3, and other composite circuit apparatus and a terminating circuit for joining the last named four-wire directly to another two-wire line, as shown in Fig. 4.

These figures (3 and 4) show an arrangement similar to Figs. 1 and 2 for by-passing direct current signals around the repeaters and terminating circuits, in which the telegraph channel is superimposed on one of the telephone lines. Fig. 3 also shows an arrangement for by-passing direct current signals around the terminating circuit which joins the two-wire with the four-wire line.

Considering the arrangement shown by Figs. 1 and 2, we will assume the operator at P. B. X. 1 (Fig. 1) desires to communicate with P. B. X. 2 (Fig. 2) over the arrangement of lines shown. This is accomplished in the usual manner by plugging into the jack (not shown) of the tie-line TL1, whereupon battery flows out over the tip and ring conductors of the tie-line TL1 in the well known manner. The calling supervisory lamp is lighted at this time as usual. Conductors 1 and 2 are bridged across the tie-line TL1 and serve to connect the "by-pass" circuit to the tie-line and therefore current from the tie-line TL1 flows through the retard coil 3, back contacts 4 and 5 of relay 6, high resistance 7 and the high resistance upper and low resistance lower windings of relay 8, whereupon relay 8 is energized and closes its contacts to energize relay 9 in an obvious circuit. Due to the high resistance values of resistance 7 and the upper windings of relay 8 the P. B. X operator's cord supervisory relay does not operate at this time.

Relay 9 in operating closes, at its upper contacts, the sending loop S1 of the telegraph repeater TR1 which causes the repeater to send a telegraph impulse out over the telegraph channel.

Repeaters TR1, TR2, TR3 and TR4 are standard telegraph repeaters well known in the art and a description of their circuit arrangements and operation is not necessary, it being sufficient to state that a closure of the sending loop S1 causes a telegraph impulse to be transmitted out over the telegraph channel and a telegraph impulse incoming over

the telegraph channel causes a corresponding impulse of direct current to be connected to the receiving loop R1.

When relay 9 was energized it also opened its contacts 10 and closed its contacts 11, thereby connecting the receiving loop R1 of the telegraph repeater to relay 12, which relay is thereupon in condition to be operated when the operator at the distant P. B. X. 2 answers the call.

Returning to the transmission of the telegraph impulse from repeater TR1, when this impulse is received at repeater TR2 (Fig. 2) it causes battery and ground to be connected to the receiving loop R2, which causes the operation of relay 13 in a circuit which includes the upper back contacts of relay 14. Relay 13 in operating connects at its inner contacts battery and ground to the tie-line TL2 and thence to P. B. X. 2 which energizes a line relay (not shown) to display a signal before the operator to indicate the call.

Relay 16, which is in the battery circuit just referred to, is marginal and does not operate in series with the line relay bridged across TL2. However, when the operator answers, the bridged resistance is decreased sufficiently to cause relay 16 to operate. The answering supervisory relay of the cord circuit now operates and prevents lighting of the supervisory lamp at this time. Operation of relay 16 completes an obvious circuit to operate relay 17 which opens, at its upper contacts, normal short-circuits across the repeater side of the transformers 15 and 18, thereby conditioning that end of the telephone circuit for talking.

Operation of relay 17 also closes, at its lower contacts, the sending loop S2 of telegraph repeater TR2, which causes a telegraph impulse to be sent back over the telegraph channel toward P. B. X. 1, which is received by telegraph repeater TR1, which sends a corresponding impulse of direct current over the receiving loop R1 and contacts 11 of operated relay 9 to energize relay 12. Relay 12 in operating connects the tie-line through to the terminating circuit 19, closes the circuit of the compromise network 20 and, at its lowermost contacts, shunts high resistance 7 and the upper, or high resistance, winding of relay 8, thereby lowering the bridge resistance across TL1 to cause the supervisory relay in the operator's cord circuit at P. B. X. 1 to operate, thereby extinguishing the calling supervisory lamp which was lighted when the operator plugged into the line to initiate the call. When the calling operator disconnects, relays 8, 9, 12, 13, 16 and 17 release. Relay 13 in releasing disconnects battery feed relay 16 from its bridged association with TL2. This causes release of the supervisory relay of the cord circuit at P. B. X. 2 and the consequent lighting of the supervisory lamp to indicate to the operator at P. B. X. 2 that the operator at P. B. X. 1 has disconnected. Relay 17, when released, applies short circuits to the repeater side of transformers 15 and 18, thereby disabling the talking circuit.

In case the calling operator should immediately replug line TL1, before the operator at P. B. X. 2 has disconnected, relays 8 and 9 would reoperate to send another telegraph impulse which would cause relay 13 to operate and again connect battery and ground to the tie line TL2 to again extinguish the supervisory lamp of the cord circuit at P. B. X. 2. Operation of relay 16 would follow, which in turn would cause relay 17 to reoperate, thereby removing the disabling condition from the talking circuit. Relay 17 in reoperating also closes the sending loop S2 of repeater TR2 to transmit a telegraph impulse to repeater TR1 which connects battery and ground to receiving loop R1 to again operate relay 12.

Alternate removal and insertion of the plug at P. B. X. 1 will obviously cause the supervisory lamp at P. B. X. 2 to flash.

Assuming a call from P. B. X. 2 to P. B. X. 1, the operator at P. B. X. 2 inserts a cord plug in TL2 which lights the supervisory lamp at her position and connects battery and ground to TL2 which operates relay 21, which in turn operates relay 14 This relay closes at its lower contacts sending loop S2 of the repeater TR2 which causes repeater TR1 (Fig. 1) to connect battery to the receiving loop R1 to operate relay 6 over contacts 10 of relay 9. Relay 6 connects battery and ground to the tie line TL1, through the windings of marginal relay 22, to light the line lamp at P. B. X. 1. Relay 22 being marginal does not operate until the called operator answers, at which time, however, it closes an obvious circuit for relay 23, which closes the compromise network circuit 20, connects the tie line TL1 to the terminating circuit 19, and at its inner lower contacts closes the sending loop S1 of the telegraph repeater TR1, which transmits a telegraph impulse over the telegraph channel to repeater TR2 where battery is connected to receiving loop R2 to operate relay 24 in a circuit including contact 25 of relay 14, which is operated at this time. Relay 24 in operating, short-circuits the lower (high resistance) winding of relay 21, thereby decreasing the bridge resistance across TL2 sufficiently to cause operation of the supervisory relay at P. B. X. 2, and the consequent darkening of the cord supervisory lamp which indicates that the called operator has answered. Relay 24 in operating also removes the normal short circuits from the repeater side of the transformers 15 and 18. Disconnection by the operator at P. B. X. 2 releases relay 21 which in turn releases relay 14 to open the sending loop S2. This releases relay 6 which dis-

connects battery and ground from the tie line TL1 to cause release of the supervisory relay in the cord circuit and the consequent illumination of the supervisory lamp controlled thereby. Relay 22 releases and in turn releases relay 23 which opens the circuit of compromise network 20 and also disconnects the line TL1 from the terminating circuit 19. Release of relay 23 also opens the sending loop S1 to repeater TR1.

From the foregoing description, it will be understood that the P. B. X. operators signal in either direction in the usual manner, these signals being repeated and transmitted, by means of a telegraph repeater system, around the intermediate equipment without affecting it or being affected thereby.

The tie line circuit connecting P. B. X. 3 with P. B. X. 4 (Figs. 3 and 4) is made up of a two wire line TL3 at one end, an intermediate four-wire line and another two-wire line TL4 at the other end. The two-wire line is connected to the four-wire line through a terminating circuit 30 shown within the broken line rectangle *a*. A four-wire repeater 31 is inserted between the terminals of the four-wire line, and a four-wire terminating circuit 32 serves to connect the four-wire line to the two-wire line TL4.

In the present case the telegraph repeater TR3 is not associated with the two-wire line TL3, as in Fig. 1, but is associated with the four-wire line at the point where the four-wire telephone repeater is located, line and supervisory signals being by-passed around the terminating circuit 30 over a simple "phantom" circuit, well known in the art and perfectly obvious from an inspection of the drawing.

The intermediate four-wire telephone repeater, and the telegraph repeater TR3 together with its associated equipment, are shown enclosed within a second broken line *b*.

The other end of the four-wire circuit is joined to the two-wire line TL4 at which point the other end of the telegraph repeater channel is located.

The telegraph repeater channel in this instance is a composite circuit formed by the two conductors of one side of the four-wire line.

The operation of the telegraph repeater by-pass arrangement, as shown in Figs. 3 and 4, is substantially the same as previously described.

When the operator at P. B. X. 3 plugs into TL3 battery from the ring conductor of TL3 flows over lead 33 through the retardation coil 34 to the mid-point of the right-hand winding of transformer 35, over the two conductors of the lower pair of wires in parallel to the mid-point of the left-hand winding of repeating coil 36, thence over conductor 37, contacts 38 of relay 39, high resistance 40, both windings of relay 41 in series, contacts 42 of relay 39, conductor 43 to the mid-point of the left-hand winding of transformer 44 and thence in parallel over both conductors of the upper side of the four-wire line to the mid-point of the right-hand winding of transformer 45. From this point the circuit passes over conductor 46 and retardation coil 34 to ground on the tip conductor of TL3.

The operator's cord supervisory lamp lights, as usual, and relay 41 operates thereby completing an obvious circuit to operate relay 47. Due to the high values of resistance 40 and the lower winding of relay 41 the supervisory relay in the operator's cord circuit (not shown) does not operate at this time.

Relay 47 in operating closes, at its lower contacts, the sending loop S3 of the telephone repeater TR3 which causes the repeater to send a telegraph impulse over the telegraph channel including both conductors of one-half of the four-wire circuit.

Relay 47, in operating, also connects the receiving loop R3 to relay 48 thereby conditioning that relay for operation when the operator at P. B. X. 4 answers.

The telegraph impulse following operation of relay 47 is received by repeater TR4 which connects battery and ground to the receiving loop R4 which causes the operation of relay 49 in a circuit which includes contacts 50 of relay 51.

Relay 49 in operating connects battery and ground, through the windings of relay 52, the tie line TL4. This causes the usual line signal to be lighted before the operator. Relay 52 is marginal and does not operate until the operator answers, at which time it completes a circuit for operating relay 53 which closes the circuit of network 54, connects the terminating circuit 32 to the tie line TL4 and, at its upper inner contacts, closes the sending loop S4 of the repeater TR4 which causes a telegraph impulse to be sent back over the telegraph channel to repeater TR3 which translates it into a direct current impulse over receiving loop R3 which in turn operates relay 48. Relay 48 opens, at its upper and lowermost contacts, normal short-circuits across the input circuits of the four-wire repeater 31, thereby conditioning the repeater for talking, and closes at its inner lower contacts a shunt path around the high resistance 40 and the bottom winding of relay 41 thereby lowering the bridge resistance across TL3 to cause the supervisory relay in the operator's cord circuit to operate and extinguish the supervisory lamp.

When the calling operator disconnects, relays 41, 47, 48, 49, 52 and 53 release. Relay 49 disconnects battery and ground from the tie line TL4 which causes release of the cord supervisory relay and the consequent lighting of the supervisory lamp at P. B. X. 4. Relay 53, released, opens the circuit of network 20,

disconnects TL4 from the terminating circuit 32 and opens the sending loop S4 which causes battery to be removed from the receiving loop R3 to prevent operation of relay 39 at this time.

In case the calling operator immediately replugs the line, relays 41 and 47 operate to send another telegraph impulse to operate relay 49 which again connects battery and ground to the tie line TL4 to again extinguish the supervisory lamp at P. B. X. 4. Relay 52 will reoperate in this circuit and cause relay 53 to operate to again condition the circuit for talking. Relay 53 causes 48 to operate which removes the disabling condition from the repeater 31.

A call originating at P. B. X. 4 operates relay 54 which operates relay 51 which sends an impulse to the other end of the telegraph channel to operate relay 39. Relay 39 connects battery and ground to conductors 37 and 43 in series with double wound relay 55.

When the operator at P. B. X. 3 answers, relay 55 operates which completes a circuit to energize relay 56 which removes the normal short-circuit across the input of repeater 31 and closes the sending loop S3 which causes an impulse to be transmitted to TR4 which in turn causes relay 57 to operate. This closes the network circuit 54 and connects the terminating circuit 32 to the line TL4. Relay 57 in operating also shunts the resistance 58 and the upper (high resistance) winding of relay 54. This causes the supervisory lamp P. B. X. 4 to be extinguished.

What is claimed is:

1. In a telephone system, in combination with a line extending between two exchanges and having circuit arrangements included therein which are substantially opaque to direct current, of an auxiliary circuit for relaying direct current line and supervisory signals around said opaque circuits in both directions, said auxiliary circuit including two two-way telegraph repeaters interconnected by a telegraph channel.

2. In a telephone system, in combination with a line extending between two exchanges and having circuit arrangements substantially opaque to direct current included therein, an auxiliary circuit for relaying direct current line and supervisory signals around said opaque circuits in both directions, said auxiliary circuit comprising two two-way telegraph repeaters interconnected by a telegraph channel, one of said repeaters being associated with said line through relay means intermediate the opaque circuits and one exchange and the other repeater with the line through relay means intermediate the opaque circuits and the other exchange.

3. In a telephone system, a line extending between two exchanges having its terminals arranged for direct current signaling in both directions and including circuit arrangements substantially opaque to direct current, an auxiliary circuit including two two-way telegraph repeaters and an interconnecting telegraph channel therefor, and means associating said line and repeaters to cause direct current signals applied to said line at one exchange to be translated into telegraph signals by one repeater and transmitted over said channel, received and retranslated into direct current signals by the other repeater to actuate the signaling apparatus at the other exchange.

4. In a telephone signaling system, two exchanges, a line interconnecting them having interposed circuit arrangements substantially opaque to direct current, a direct current signaling device associated with said line at each exchange, an operator's link circuit at each exchange adapted to be connected to said line, a source of direct current at each exchange adapted to be connected to said line under control of its respective link circuit, a circuit including a plurality of telegraph repeaters, one end of said circuit being connected to said line between one exchange and the opaque circuits, and the other end between the opaque circuits and the other exchange, and means in said circuit between said line and said repeaters to cause direct current applied to the line at either exchange to be translated into telegraph signals by one repeater and transmitted to a second repeater, and other means between said line and said repeaters responsive to the reception of telegraph signals by either repeater to connect direct current to said line to operate one of said signal devices.

5. In a telephone signaling system, two exchanges, a line extending therebetween including circuit arrangements substantially opaque to direct currents, means at each of said exchanges for transmitting to and receiving from said line direct current line and supervisory signal impulses, and means including telegraph repeaters and an interconnecting telegraph channel therefor to relay said direct current signals around said opaque circuit arrangements in both directions.

In witness whereof, we hereunto subscribe our names this 1st day of October, 1929.

HENRY H. ABBOTT.
FERDINAND S. ENTZ.