

March 8, 1932.

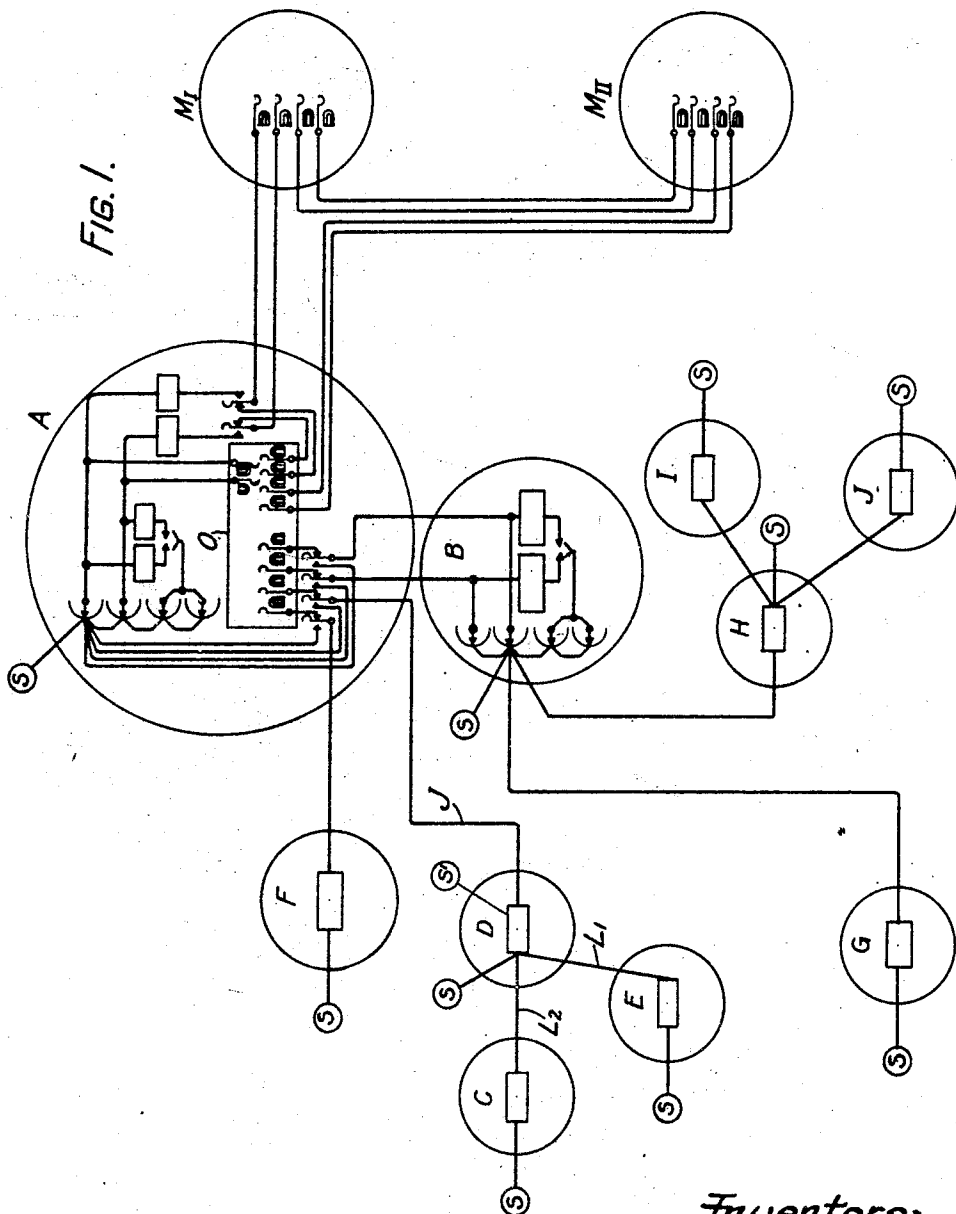
L. POLINKOWSKY ET AL

1,848,196

SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

Filed Feb. 6, 1930

6 Sheets-Sheet 1



Inventors:
L. Polinkowsky, deceased,
by Edward From, administrator,
and O. C. From;
BY P. C. Smith

ATTORNEY

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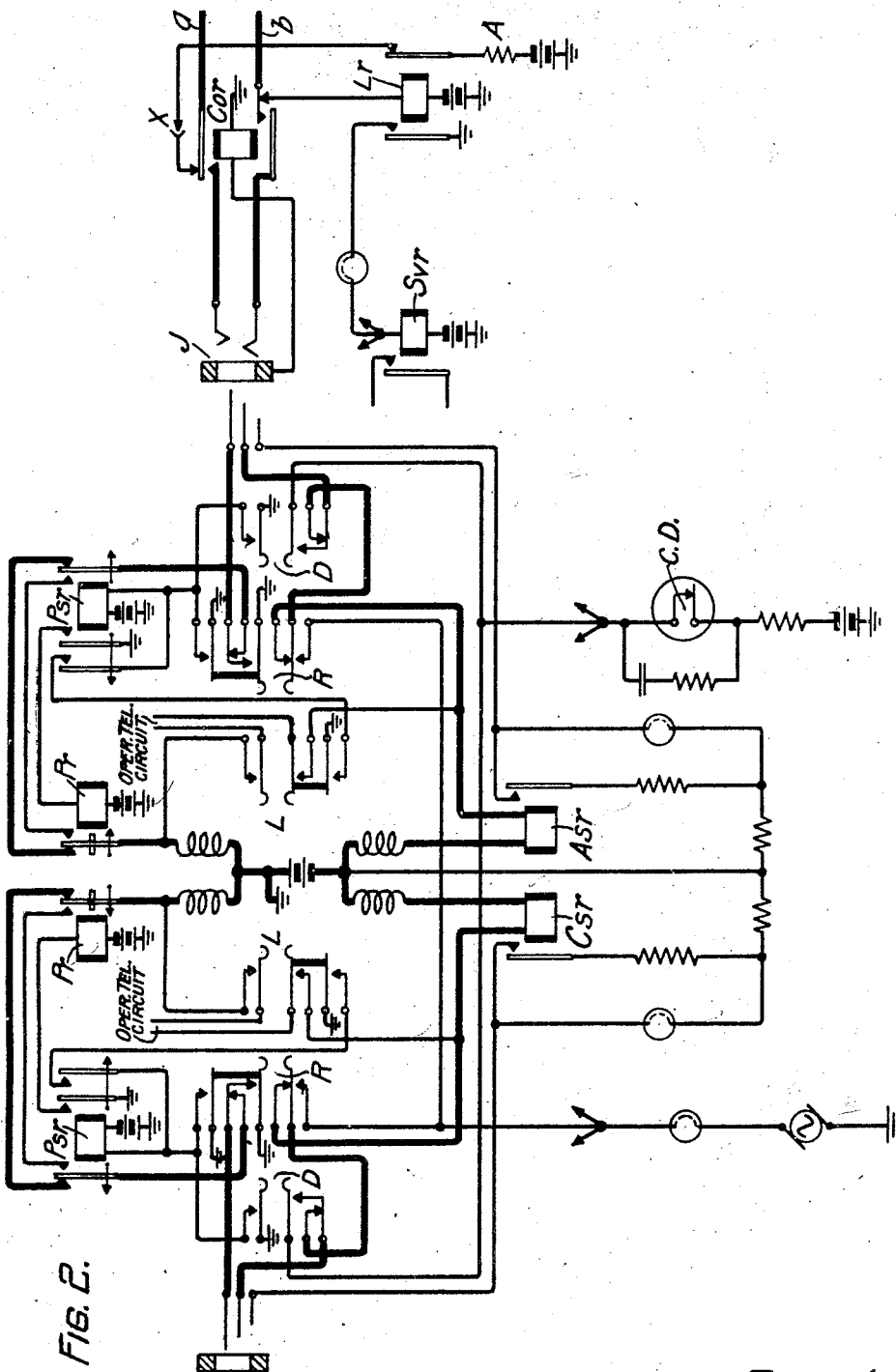
L. POLINKOWSKY ET AL

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SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

Filed Feb. 6, 1930

6 Sheets-Sheet 2



Inventors:

L. Polinkowsky, deceased,
by Edouard From, administrator,
and O. C. From;
BY P. C. Smith

ATTORNEY

March 8, 1932.

L. POLINKOWSKY ET AL

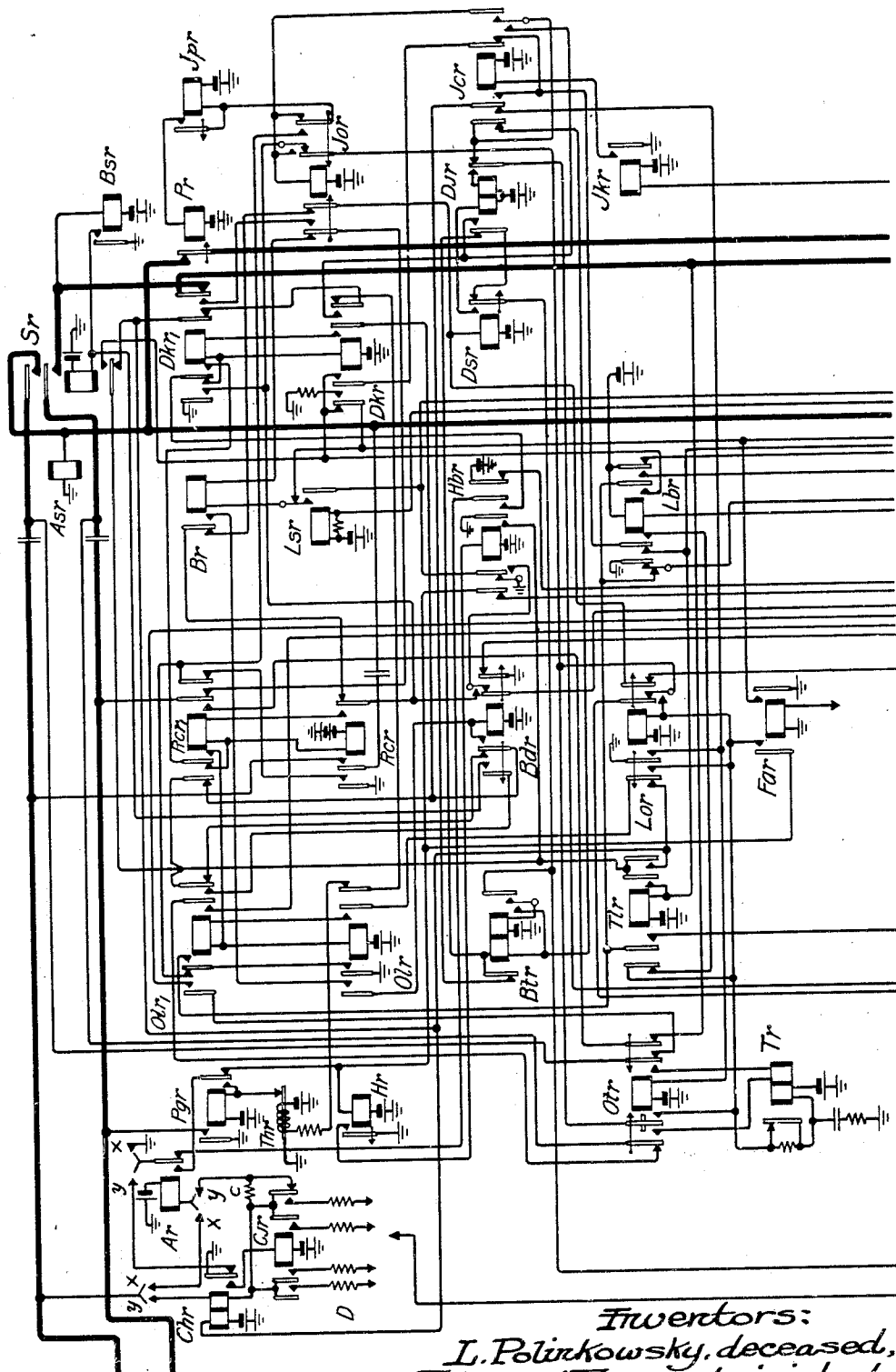
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SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

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6 Sheets-Sheet 3

FIG. 3.



Inventors:
L. Polinkowsky, deceased,
by Edouard From, administrator,
and O. C. From;
BY P. C. Smith

ATTORNEY

March 8, 1932.

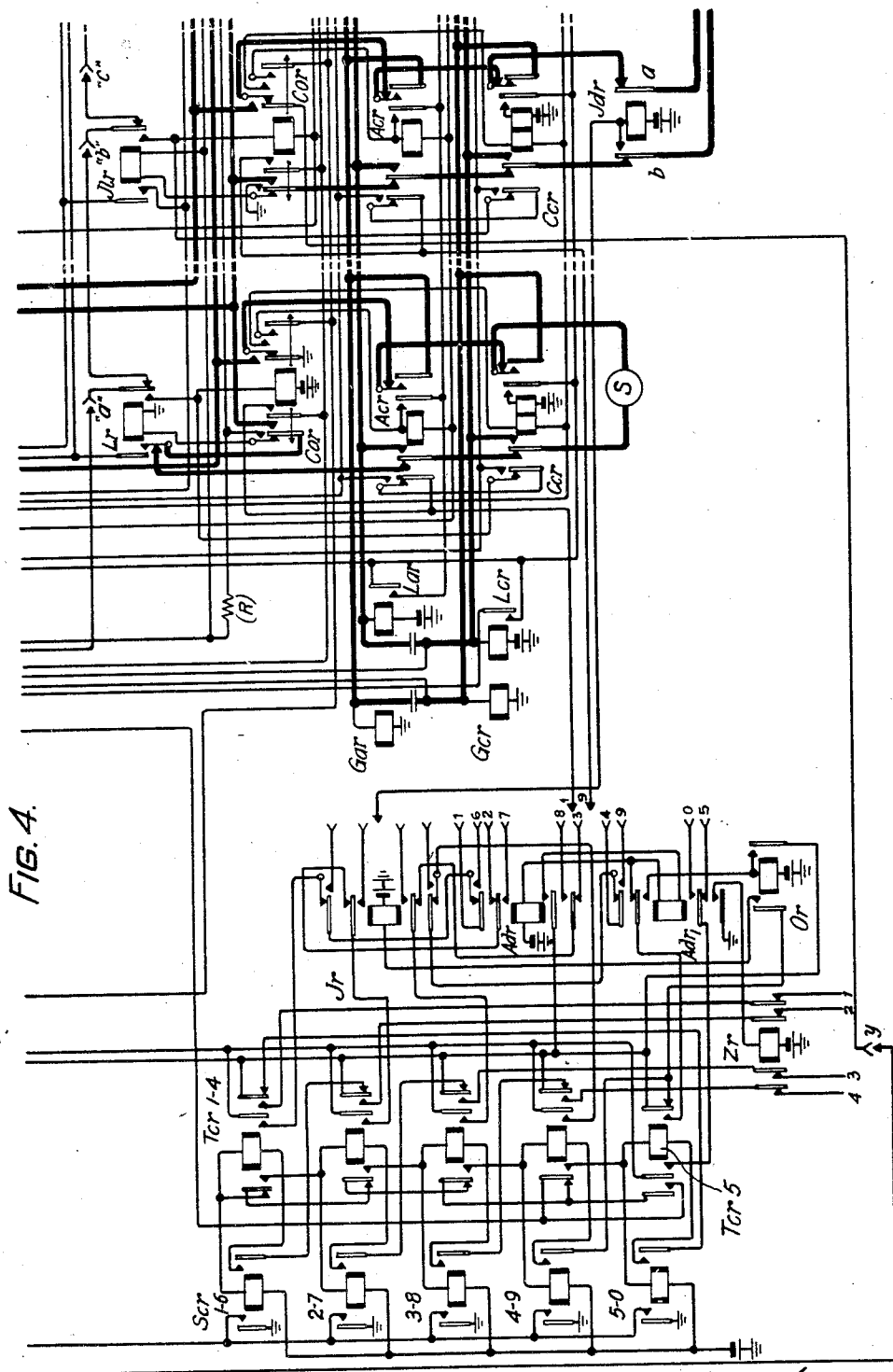
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Filed Feb. 6, 1930

6 Sheets-Sheet 4



Inventors:
L. Polinkowsky, deceased;
by Edouard From, administrator;
and O. C. From;
BY P. C. Smith

ATTORNEY

March 8, 1932.

L. POLINKOWSKY ET AL

1,848,196

SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

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6 Sheets-Sheet 5

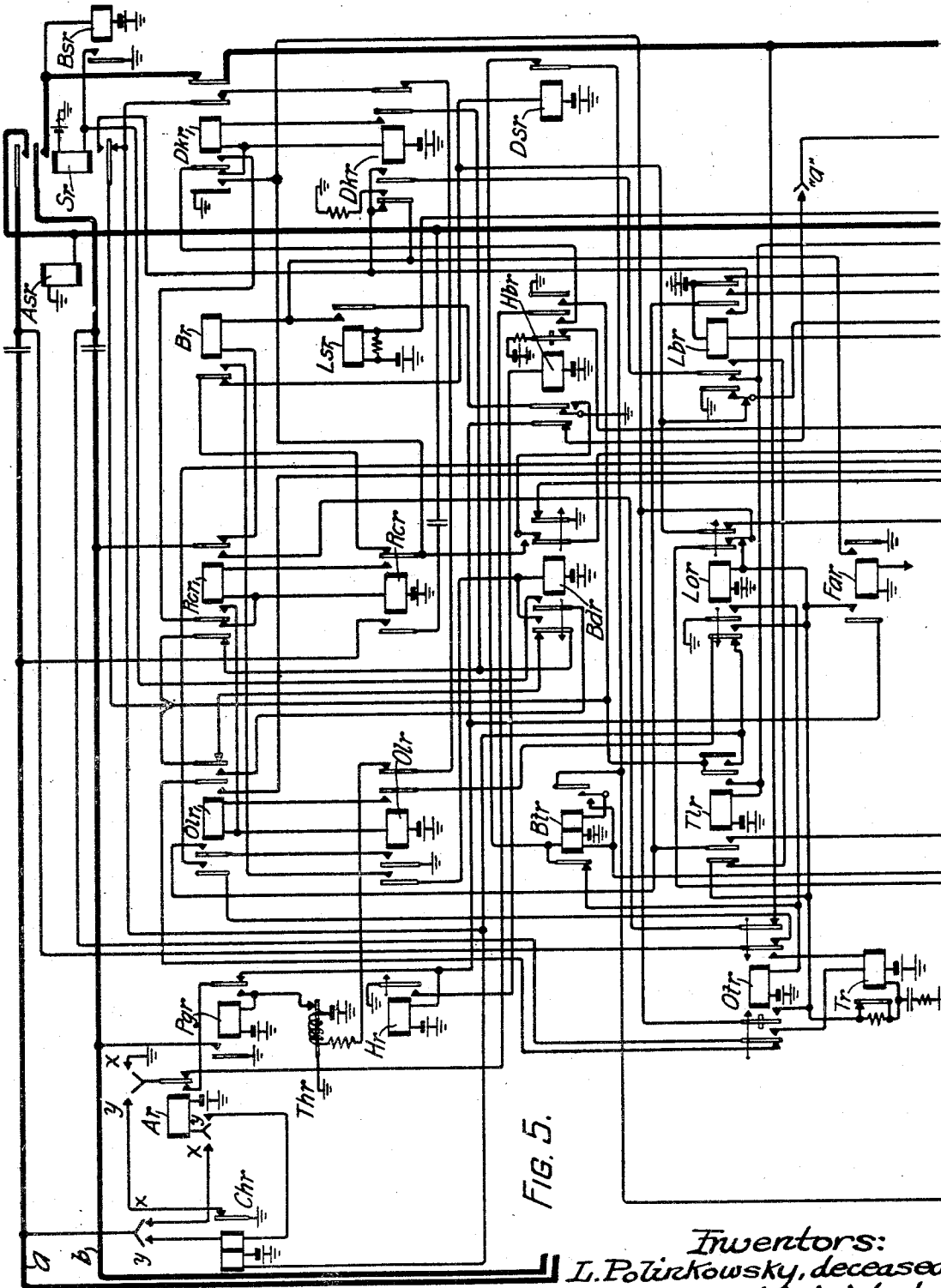


FIG. 5.

Inventors:
L. Polinkowsky, deceased,
by Edouard From, administrator;
and O.C. From;

BY P. C. Smith

ATTORNEY

March 8, 1932.

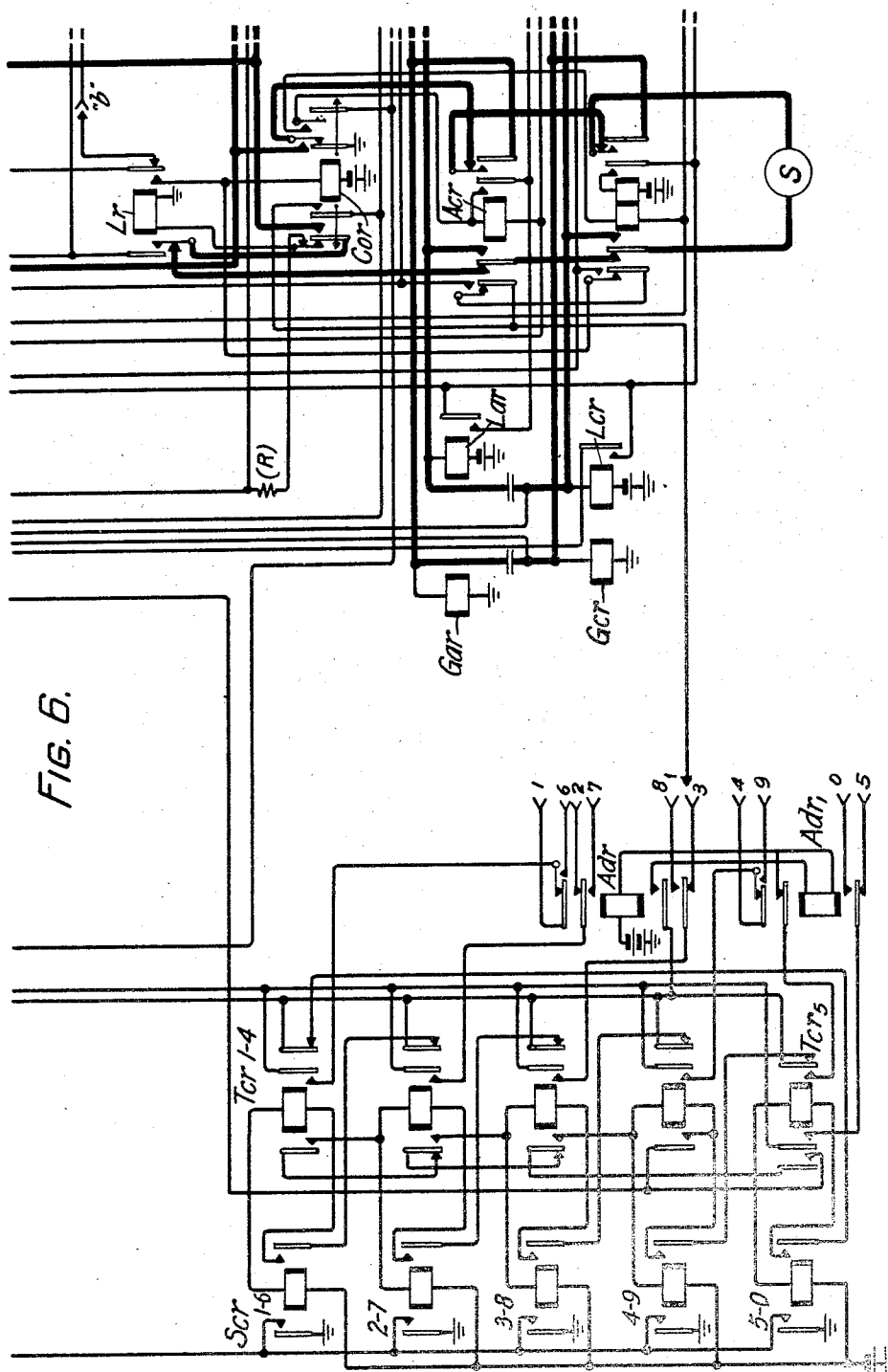
L. POLINKOWSKY ET AL

1,848,196

SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

Filed Feb. 6, 1930

6 Sheets-Sheet 6



Inventors:
L. Polinkowsky, deceased,
by Edward H. From, administrator,
and O. C. From;

BY P. C. Smith

ATTORNEY

UNITED STATES PATENT OFFICE

LIPA POLINKOWSKY, DECEASED, LATE OF ANTWERP, BELGIUM, BY EDOUARD FRUM, ADMINISTRATOR, AND OWEN C. FROM, OF NEW YORK, N. Y., ASSIGNORS TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

SEMI-AUTOMATIC RURAL TELEPHONE SYSTEM

Application filed February 6, 1930, Serial No. 426,857, and in Great Britain February 14, 1929.

This invention relates to semi-automatic rural telephone systems of the type in which connections may be established automatically by and under the control of an operator located at some central exchange, called in this description the "main" exchange, between subscribers located in the same or different rural exchanges including the main exchange.

In sparsely populated districts, where the maximum number of subscribers in one rural office is, say, 10 or 20, it would be uneconomical to provide each rural exchange with its own manual or automatic switching facilities. This invention provides one semi-automatic central switching exchange for a network of rural exchanges where switching to and from any subscriber in the area, as well as points beyond, is done from this exchange. The main exchange is connected to all the rural exchanges in the area either directly by a trunk line or through tandem offices which themselves serve as junction centers to a plurality of rural exchanges. The number of trunks direct from the outlying rural exchanges or from their tandem junction centers is, of course, a function of the calling rate and the number of talking connections per unit of time between the various exchanges involved, but in rural areas when the exchange unit comprises but 10 subscribers, one trunk line would be sufficient for all needs, including its utilization for additional signaling service when not being used as a part of a talking connection. With the switching control mechanism at one point only, these trunks or junction lines are used to call the operator at the main central or, vice versa, for the operator to call subscribers directly (if a direct junction line connects the rural with the main exchange) or via the junction tandem center. The operator at the main exchange is informed of the wanted number. With the aid of suitable dialing equipment the called subscriber is reached via the same trunk or junction, if the exchange in which he is located is connected to the main exchange by the same trunk or junction center. Once the talking connection is established and its commence-

ment properly supervised by the operator, that part of the junction line not used as a part of the talking loop is liberated. It may then be used by other subscribers in the same junction center or exchange for initiating other calls while the subscribers just connected talk over a local connecting circuit.

The object of the invention, then, is to provide an improved semi-automatic rural system in which the connections may be established between subscribers in small outlying exchanges by an operator at the main exchange.

In accordance with the present invention, one embodiment of which has been disclosed herein by way of example, connections are established in such a manner that the trunk line or junction used by the operator for setting up the connection becomes free as soon as the connection is established, thereby rendering the junction line available for establishing another call. Means are also provided whereby the junction line may be automatically connected to the wanted party after the completion of the dialing operation in such a way that the wanted party is rung from the manual exchange without any special operation necessary on the part of the operator supervising the setting up of the call. Means are provided whereby the operator at the main exchange, after establishing the connection, is connected in a listening position to supervise the commencement of a conversation. Means are also provided for the operator to break down a local connection, hold the desired line, and connect it to the junction for the establishment of a talking connection with some distant toll point.

Means are also provided for charging the battery in a tandem exchange and the batteries in the rural exchanges connected thereto over the junction line connecting the tandem and the main exchange; the charging current being disconnected when the junction is seized in either direction.

To enable the operator to set up connections the tandem office and each rural office is provided with a set of five pairs of counting relays and a pair of adding relays. These relays are so arranged that each pair of count-

ing relays, when operated, releases a previously operated pair so that, when the dialing operation is completed, only one pair of counting relays is energized.

Provision is also made for the transmission of a special signal which enables the operator at the main exchange to break the junction line between the tandem exchange and the distant rural exchange.

Preferably a subscriber in a rural exchange, when initiating a call, is connected through a tandem exchange to an operator at the main exchange who controls the arrangement of a connection to other subscribers located either in the main exchange or in the said tandem exchange or in the said rural exchange or in another rural exchange having access to the same tandem exchange. After the connection has been established, the junction line extending between the main exchange and the tandem exchange is free for use to establish other calls, and the subscribers talk over a local connecting circuit in the said tandem exchange or in their respective rural exchanges. Necessarily, when the subscribers are located in two rural exchanges not connected by a common tandem junction and a call is to be established between them, the two junction lines connecting the calling and called rural exchanges with the main exchange form a part of the subscribers' talking circuit. During such times, the junction lines so used cannot, of course, be used for establishing other connections.

Similarly, in the case of a call originating from a subscriber at a tandem exchange, a connection may be extended by the operator in the main exchange to another subscriber in the said tandem exchange, or to a subscriber located in the rural exchange connected by a junction line to the tandem exchange, whereupon the junction line between the main and the tandem is freed as before.

The nature of the invention will be more completely understood from the following detailed description which is given in connection with the accompanying drawings, in which

Fig. 1 shows a diagrammatic illustration of the layout of the system.

Fig. 2 shows a cord circuit for either a rural or tandem exchange with a line circuit ending in the usual jack and supervisory equipment for a rural or tandem exchange.

Figs. 3 and 4 show a single junction tandem rural exchange circuit arrangement for use in an exchange such as (D) Fig. 1, wherein subscribers' lines local to the said tandem exchange and junctions extending to outlying rural exchanges terminate.

Figs. 5 and 6 show the circuit arrangement for a single rural exchange terminating either in the main exchange, in which case the line wires (a) and (b) end in a jack of the character shown in Fig. 2, or at a

tandem exchange such as Figs. 3 and 4 in which case the line wires (a) and (b) are connected to the armature springs (a) and (b) respectively of the relay *Jdr* of Fig. 4.

Referring particularly to Fig. 1, the manual exchanges *M*₁ and *M*₂ are shown to the right of the drawing having access to the main semi-automatic tandem exchange *A*. This semi-automatic tandem exchange has access to a small rural exchange such as *F*, a tandem rural exchange such as *D*, and a mechanical tandem exchange such as *B*. It will be seen that the tandem exchange *D* is connected directly to two small rural exchanges *E* and *C*, while the tandem exchange *B* is connected both to a rural exchange *G* and over another junction to an intermediate tandem exchange *H* which, in turn, has access to a plurality of rural exchanges such as *I* and *J*.

When a call originates from a subscriber *S* in the tandem exchange *D* say, or in either of the rural exchanges *C* and *E*, a connection is extended through the tandem exchange *D* over the junction line *J* to an operator in the semi-automatic tandem exchange *A*, who then dials the number of the wanted subscriber in the usual way. If the wanted subscriber is in the exchange *D*, after the connection is set up the junction line *J* is freed for use to establish other calls and the subscribers talk over a local connecting circuit in the exchange *D*. If the wanted subscriber is located in the exchange *E*, the junction line *J* is freed as before and the subscribers talk over the local connecting circuits in exchanges *D* and *E* over the interconnecting local junction line *L*₁. Similarly, if the call originates in exchange *C* and is to terminate in exchange *E*, the call will be established over the junction lines *L*₁, *L*₂ and *J*; junction line *J* being liberated as before, leaving the subscribers to talk over the local junction lines *L*₁ and *L*₂.

The calls to other exchanges such as *F*, *H*, *I*, *J*, and *G* will be dealt with in a like manner by the operator at the main tandem exchange *A*; the junction lines in all cases extending to those exchanges being released for other calls after the connection is once established.

Establishing a connection between local subscribers in a tandem rural exchange (Figs. 2, 3 and 4)

Referring now to Figs. 2, 3 and 4, when the subscriber *S* located in an exchange such as *D*, Fig. 1, on initiating a call operates his magneto the line relay *Lr* operates. This relay upon operating locks in series with the *Lsr* relay which also operates at this time through its continuity contacts and through a back contact of the *Cor* relay. The *Lsr* relay is common to all the subscriber line relays

Lr of the tandem exchange through the make contacts of the continuity spring set of contacts which lock each *Lr* relay. The *Lsr* relay, in operating, closes a ground from the back contact of the *Hbr* relay through the winding of the *Br* relay to the (*b*) wire of the junction to the manual exchange; the circuit path being traced also through the back contacts of the *Jor* and *Rcr*₁ relays. The *Br* relay operates in series with the *Lr* relay of the tandem junction line circuit in the manual exchange, causing the *Lr* relay there also to operate, lighting the junction line lamp *Jlp*.

The operator, on getting the line signal, inserts the answering cord shown in Fig. 2 into jack J of the junction thereby operating cut-off relay *Cor*. The ground through the transformer windings of the cord circuit is connected to the (*a*) wire of the junction causing the operation of the *Ar* relay in Fig. 3. The *Ar* relay operates relay *Hr* which, in turn, operates relay *Hbr*, thereby removing the ground connected to the (*b*) wire of the junction through the *Br* relay. It will be noted that the ground which operated the *Hr* relay extends in parallel through a back contact of the *Hbr* relay and down in a preference circuit through the transfer contacts of the *Lr* relays of the subscribers' lines (and the rural line relays *Jlr* as well) in such a fashion that the operation of any *Lr* relay cuts off this ground to all succeeding relays in the chain and transfers it to the *Cor* relay winding of the subscriber initiating the call. The object of this preference arrangement is to cut off the possible operation of other *Cor* relays of other subscribers initiating calls during the time that the junction is busy setting up one call. When the *Ar* relay operates, therefore, the ground which operates the *Hr* relay also extends down to the *Lr* relays and causes the operation of the *Cor* relay. The operated *Cor* relay is provided with a locking circuit from battery through its own winding through normal contacts of relays *Crr* and *Acr*, a front contact of relay *Cor* to ground through the back contacts of the *Bdr* relay and make-before-break contact of the operated *Hbr* relay. The *Cor* relay must be operated before the *Hbr* relay operates and is, therefore, slow in releasing so as to hold up during the interval of time between the opening of the back contact on the *Hbr* controlling the *Cor* operating circuit and the closing of the make-before-break contact combination controlling the locking ground. The *Cor* relay, when operated, connects battery through a high resistance *R* from the back contact of the *Hbr* relay to the winding of the *Lr* relay so as to prevent the release of the *Lr* before the *Hbr* operates. This is to insure that the ground series preference chain will not be disturbed by a false release of the *Lr* relay and transfer the

ground to the next operated line relay, thereby causing the false operation of its associated *Cor* relay. When the *Hbr* has operated, the *Lr* relay releases.

The operation of the *Cor* relay and the release of the *Lr* relay closes the subscriber's loop through to the *Bsr* relay and *Asr* retard coil. Relay *Lr* upon releasing also releases relay *Lsr*. If the subscriber should have remained on the line after ringing up the *Lr* relay, the *Bsr* relay operates over the subscriber's loop to ground through the *Asr* retard coil and operates, in turn, the *Sr* relay. The *Sr* relay closes the talking circuit through to the junction. It also connects the *Br* relay to the (*b*) wire of the junction through the operated contacts of the *Hbr* and *Sr* relays and causes the operation of the *Asr* relay in the cord circuit thereby extinguishing the cord supervisory lamp and indicating to the operator that the subscriber is still on the line. Since the talking circuit between the subscriber and operator is closed through, the operator may ascertain the desired number by operating the listening key *L*. If, however, the subscriber is not on the line, the *Bsr* relay and *Asr* retard coil will not operate and the supervisory lamp will remain lighted. This is a signal to the operator to ring the subscriber back.

In order to ring the party, the operator must prepare a ringing circuit before ringing by operating the dialing key *D* of the cord circuit and restoring it. The operation of the dialing key *D* causes the operation of the *Psr* and *Pr* relays in the cord circuit.

This momentarily breaks the (*a*) wire to the junction, releasing the *Ar* relay. The release of the *Ar* relay causes the ground through its back contact to operate the *Dkr* relay; this same ground, together with the ground on the armature of the operated relay *Dkr* at the same time holds the *Dkr* relay short-circuited. When the *Psr* and *Pr* relays have operated, the (*a*) wire to the junction is reclosed, causing the operation of the *Ar* relay, the removal of the short-circuiting ground around the *Dkr* relay and the operation and locking of this relay in series with the *Dkr* relay under the control of locking ground on the *Hbr* relay through the back contacts of the *Olcr*₁ relay. The *Psr* and *Pr* relays are sufficiently slow in operating, not only to permit the aforementioned operation during the travel time of their armature contacts from the back to the front contacts respectively, but also for the additional operation of other relays mentioned later. When the operator releases the dialing key, the *Pr* and *Psr* relays release, repeating the operation of the *Ar* relay and causing the operation and consequent locking of the *Rcr* and *Rcr*₁ relays in the same manner as the *Dkr* and *Dkr*₁ relays were previously operated and locked. The

operation of the Rcr_1 relay transfers the (b) wire of the junction to one side of the subscriber's line while the Rcr closes the (a) wire of the junction through a condenser to the other side of the subscriber's line thereby completing the ringing circuit from the subscriber's line to the operator's cord. The operator then throws the listening key L and the ringing key R, applying ringing current to the (b) wire of the junction, the current returning over the other side to ground through the Asr retard and through the condenser to the (a) wire of the junction. The condenser is for the purpose of reducing the return ringing current to the (a) wire so that the Ar relay will not follow the ringing current pulsations.

When the subscriber answers, the operator restores both ringing and listening keys, causing the (a) wire to the junction to be opened and closed in the manner already described. The Ar relay, by following the break in the (a) wire of the junction, causes the Olr and Olr_1 relays to operate and lock. The Olr_1 relay releases the Dkr and Dkr_1 relays and the release of the Dkr_1 causes the release of the Rcr and Rcr_1 relays. With the release of the Dkr_1 relay, the subscriber's loop is connected to the Bsr relay and Asr retard coil, causing the operation of the Bsr and Sr relays, thereby closing once more the subscriber's talking loop to the manual exchange. The condensers in the (a) and (b) wires and the connection of the (b) wire of the junction through the Br relay to ground through the operated Sr relay makes a balanced transmission circuit. This talking circuit operates the Asr relay of the cord which extinguishes the operator's supervisory lamp. The operator then inquires for the wanted number.

On ascertaining the number, the operator operates the dialing key D and dials the number of the wanted line. As explained previously in connection with preparing the line for ringing, the operation of the dialing key breaks the (a) wire and causes the operation and locking of the Dkr and Dkr_1 relays. When the Dkr relay operates, but before the release of the Sr (which occurs as a consequence of operating the Dkr_1 relay), a ground is passed from the front contact of the Sr relay through the back contact of the Jcr and Lbr relays operating the Tlr relay which locks to ground on the Hbr relay. The Tlr relay closes a ground from the back contact of the Lbr relay to a lead common to a make contact of all the Cor relays of the tandem exchange. The Cor relay of the calling subscriber using the junction, being operated, extends this ground through to the connecting relays Cer and Acr . The local connecting circuit, being free, has battery from the back contact of the Lbr relay connected to the operating windings of the Cer relays so that

the calling party will be connected to the calling side of the local connecting circuit. With the ground supplied from the operated Tlr relay through the contacts of the operated Cor relay and battery from the back contact of the Lbr , the Cer relay operates and transfers the calling subscriber's line to the supervisory relay Lcr and retard coil Ger of the local connecting circuit. The Lcr is now connected across the subscriber's line and operates from the ground through the Ger retard coil over the subscriber's loop to battery through the relay Lcr . The Lcr relay connects ground from the back contact of the Bbr relay to the locking contact of the relay Cer locking this relay and operating the relay Lbr which transfers the battery from the operating winding of the Cer relay to the answering side of the local connecting circuit Acr relay so that, when the called line is connected, the Acr relay and associated supervisory relay Lar and retard coil Gar will be in an operative circuit. The Lbr relay also disconnects the ground for operating the local connecting relays so that the Cer relay is now exclusively under the control of its locking winding. The Cer relay, in operating, also opens the locking circuit for the Cor relay, but the Cor relay holds operated through a make-before-break set of contacts on the Cer relay to a ground on the back contact of the Lbr relay so that the Cor relay will not release until the Cer relay is locked. The operation of the Lbr relay then removes this supplementary locking circuit of the Cor relay. The calling subscriber now waits on the local connecting circuit for the called party.

When the Dkr relay operated, it connected a ground to the Br relay for dialing through a compensating resistance equivalent to 1500 ohms minus the resistance of the (b) wire of the junction to the manual exchange. The Dkr_1 relay disconnects the junction line from the Bsr relay which releases the Sr relay and removes the subscriber's talking circuit during dialing. The Dkr_1 relay also connects ground to the armature of the Br relay for pulsing, and holding ground for the counting relays Ser and Ter described below. At the same time the Dsr relay is placed in parallel with the dialing lead and is made slow to release so that it will not release during the cycle of pulses from the dial.

The set of five pairs of counting relays Ter and Ser shown in Fig. 4 are connected to the Cor relays of the subscribers' lines, and the Cor relays of the rural exchange junction lines terminating at the tandem exchange, through the contacts of the adding relays Adr and Adr_1 in such a manner that an operated pair of counting relays prepares a circuit for one of the Cor relays. The Cor relays are preferably arranged in two groups of five each, if there are ten Cor relays in

the exchange; the first five being connected to the back contacts of the *Adr* and *Adr₁* and the relays of the second group to the front contacts of these relays.

5 The dialing key *D* connects battery through the calling device *C. D.* to the (*b*) wire of the junction so that the dialing impulses pass over the (*b*) wire operating and releasing the *Br* relay in succession following the making and breaking of the circuit of the calling device. The back contact of the *Br* relay operates the counting relays *Scr* and *Tcr* in the usual manner; namely, the *Scr₁* relay operating from the back contact of the *Br* relay during the open period of the calling device, closing a holding circuit in series with the *Tcr₁* relay so that when the *Scr₁* relay operates, the *Tcr₁* relay is connected in series with the *Scr₁*, but the *Tcr₁* will not operate during the open period of the impulse since it is short-circuited from ground on the back contact of relay *Br* over the right contact of relay *Scr*, inner right back contacts of relay *Lor*, inner right back contacts of the *Jor* relay to ground at the operated *Dkr₁* relay. when the calling device reoperates the *Br* relay, the short-circuiting ground is removed and the *Tcr₁* relay operates, locking in series with the *Scr₁* relay. The *Tcr₁* relay transfers the pulsing lead to the *Scr₂* relay and *Tcr₂* relay so that the second impulse operates the second pair of relays. When the *Tcr₂* relay operates at the end of the second impulse, it opens the holding circuit for the *Scr₁* and *Tcr₁* relays. The counting relays continue in this manner to the end of the digit except that when the *Tcr₃* relay operates, it closes the pulsing lead back to the first pair of counting relays *Scr₁* and *Tcr₁* and also operates the *Adr* relay from the ground on the *Dkr₁* which also closes a holding circuit through the *Adr₁* relay but holds it short-circuited during the open period of the impulse. If the digit is above five, the *Tcr₁* relay, operating a second time, releases the *Scr₁* and *Tcr₁* relays and removes the shunt around the *Adr₁* relay, causing it to operate and lock in series with relay *Adr*, both of which are now locked as previously pointed out. The *Adr* and *Adr₁* relays transfer the counting relay switching contacts from the first five *Cor* relays to the second five.

65 The slow releasing *Dsr* relay which holds up during the train of impulses, releases at the end of the digit and closes a ground from the front contact of the operated *Scr* relay through the back contact of the *Dsr* and *Djr* relays through the operating winding of the *Btr* relay, back contacts of the relays *Jcr* and *Djr*, front contacts of the operated *Tcr* relay, contacts of either the *Adr* or *Adr₁* relays, back contacts of the local connecting relays *Acr* and *Cor* of the called subscriber's line to the winding of the *Cor* relay operating the *Btr* and *Cor* relays and locking

them to ground at the relay *Hbr*. If the called subscriber's line is busy, either the corresponding *Cor* or *Acr* relay will be operated, depending upon whether the subscriber originated the call or has been called. In such a case the circuit for the *Btr* relay will be broken at the contacts of one of these relays and neither the *Cor* nor the *Btr* relay will operate. However, the ground from the *Scr* relay, not only passed through the winding of the *Btr* relay but also through one of its back contacts so that if the subscriber is busy and the *Btr* does not operate, a path is closed for the operation of the slow operating relay *Otr* from battery through its winding, back contacts of the relay *Jcr* and *Btr* to ground on the operated *Scr* relay. The operation of the *Otr* relay connects the interrupter winding of the *Tr* relay to ground at the contact of relay *Dkr*. These interruptions are induced in the secondary winding which, through the operated contacts of the *Otr* relay, is connected directly to the talking circuit connected with the main exchange. The tone thus induced is transmitted as a signal to the operator that the called line is busy. The *Otr* relay is made slow to operate so as to give sufficient time for the *Btr* relay to operate if the subscriber is idle and a path exists for it. Should the line be free and the operating path for *Btr* relay be closed, the *Btr* and *Cor* relays will both operate; the *Btr* locking to its own operating ground, short-circuiting at the same time its operating winding, and the *Cor* relay locking to ground at the relay *Hbr* through a back contact of the *Bdr* relay.

When the operator restores the dialing key and causes the break in the (*a*) wire of the junction in the manner already described, the *Rcr* and *Rcr₁* relays are operated, closing a ringing circuit over contacts of the operated *Cor* relay to the called line as previously described for ringing back the calling party. After restoring the dialing key, the operator operates the listening key *L* to ascertain if the line is busy, then holding the listening key operated, operates the ringing key intermittently until the party answers. It will be noted that the intermittent operation of the ringing key does not cause successive breaks in the (*a*) wire to the junction due to the fact that the operated listening key holds the *Psr* and *Pr* relays of the cord circuit locked. When the called subscriber answers, the operator restores both the ringing and listening keys once more breaking the (*a*) wire of the junction and causing the *Olr* and *Olr₁* relays to operate. The operation of the *Olr₁* relay releases the *Dkr* and *Dkr₁* relays and the release of the *Dkr₁* relay releases the relays *Rcr* and *Rcr₁*. The operation of the *Olr₁* relay connects ground through the front contact of the *Tr* relay to the lead common to the *Cor* relays for operating the local con-

necting relays. Since the *Lbr* was operated when *Acr* relay was connected to the calling line only the *Acr* relays will have battery connected to their windings at this time from the contacts of relay *Lbr*.

The *Acr* relay of the called line is then operated from ground at the front contact of the *Cor* relay of that line, transferring the called subscriber's line to the supervisory relay *Lar* and retard coil *Gar*. The *Lar* relay operates over the subscriber's line loop to ground through the *Gar* retard coil and locks the *Acr* relay to ground on the back contact of the *Bdr* relay through the operated contacts of the calling line connecting relay *Ccr*. The *Acr* breaks the holding circuit of the called subscriber's *Cor* relay but holds it operated through a make-before-break contact until the *Tlr* relay is released so as to insure that the *Acr* relay is locked before the *Cor* relay is released. The calling and called parties are then connected together in a talking circuit over the local connecting circuit having condensers interposed therein.

When the *Olr* relay operated it connected the (a) and (b) wires of the junction through a condenser in each wire over back contacts of relay *Otr* to the listening connection on the local connecting circuit so that the operator can observe the beginning of the conversation. The *Tlr* relay was locked to ground on the front contact of the *Hbr* relay and also locked the relays *Olr₁* and *Olr* to the same ground through the operated contacts of the relay *Tlr*. After the operator observes the beginning of the conversation on the local connecting circuit she withdraws the plug from the junction line releasing the *Ar* relay, in turn releasing the *Hr* relay which also releases the *Hbr* relay. When the *Hbr* relay releases, all relays except those held by the local connecting circuit are then released. At the end of the conversation on the local connecting circuit either subscriber, in restoring the receiver, releases the corresponding supervisory relay *Lcr* or *Lar*, in turn releasing the corresponding local connecting relay. If the calling subscriber restores his receiver first, the *Lcr* relay releases and removes the locking circuit from both local connecting relays *Acr* and *Ccr*. But if the called subscriber should restore his receiver first, the release of the *Lar* relay releases the *Acr* relay only, and the *Lcr* relay holds the *Lbr* relay operated, thereby keeping the local connecting circuit busy to any other calling subscriber until the first calling subscriber being described restores his receiver.

If a connection exists on the local connecting circuit when a call is received, the *Lbr* relay is locked with the *Ccr* relay of the busy subscriber and prevents the *Tlr* relay from operating when the dialing key is operated. This operates the *Lor* relay through the back contacts of the *Tlr* relay and front contacts

of the *Lbr* relay to ground over the front contacts of the *Sr* relay; this operation taking place before the release of the *Sr* relay (which occurs as a result of the operation of the *Dkr₁* relay) and prevents the calling party from being connected to the local connecting circuit when the *Dkr₁* relay operates. The release of the *Sr* relay disconnects the subscriber from the junction line while the operator is dialing.

The operation of the *Lor* relay operates the *Otr* relay and opens the pulsing lead to the counting relays preventing them from being operated when dialing takes place. The locking contact of the *Lor* relay or the front contact of the *Otr* relay causes the *Tr* relay to buzz and produce a busy tone which is transmitted to the operator in the manner already described. When the dialing key is restored, operating the *Rcr* and *Rcr₁* relays by the break in the (a) wire of the junction line, the operator throws the listening key before ringing and hears the tone.

The ringing circuit from the (b) wire to the subscriber's line is opened by the *Otr* relay so that the operator cannot ring on the subscriber's line. The operator then operates the ringing key and restores both ringing and listening keys causing the release of the *Olr*, *Olr₁*, *Dkr*, *Dkr₁*, *Rcr* and *Rcr₁* relays as before described. The release of the *Dkr₁* relay reconnects the subscriber's line to the *Bsr* relay and the *Acr* retard coil, operating the *Bsr* and *Sr* relays and reconnecting the subscriber's line through the condensers to the junction line so that the operator may inform the calling subscriber that the local connecting circuit is busy. The release of the *Dkr₁* relay releases the *Lor* relay, in turn releasing the *Otr* and *Tr* relays and stopping the busy tone. The operation of the *Lor* relay also transfers the locking circuit for the *Olr* and *Olr₁* relays to the ground on the front contact of the *Dkr₁* relay so that the *Olr* and *Olr₁* relays release when the *Dkr₁* relay releases, thereby preventing the operator from being connected to the listening connection on the local connecting circuit.

In case the local connecting circuit is free when the dialing key is operated, the calling subscriber will be connected to the calling side of the local connecting circuit as previously described. If the called party does not answer, the operator restores both the ringing and listening keys, causing the operation of the *Olr* and *Olr₁* relays as before. The *Tlr* relay, being operated when the calling party was connected to the local connecting circuit, holds the *Olr* and *Olr₁* relays operated, connecting the operator to the listening connection on the local connecting circuit so as to inform the calling subscriber that the called party does not answer. When the plug is withdrawn from the junction line,

all relays are released except the local connecting relays and the relays they control.

Establishing a connection between a calling subscriber in a tandem rural exchange (Figs. 3 and 4) and a called subscriber in one of the satellites (Figs. 5 and 6)

When the calling party is a subscriber in a tandem rural exchange such as S in Figs. 3 and 4, the subscriber initiates the call in the manner previously described. When the dialing key is operated for dialing the wanted number, the calling subscriber is likewise connected by the Cor relay to the local connecting circuit as previously described. The first digit dialed closes the circuit through the Cor relay of the junction line extending to the satellite in which the called subscriber is located, as for example, subscriber S in Figs. 5 and 6. The operation of the Cor relay closes the (a) and (b) wires of the junction to the satellite, causing the Ar relay in the satellite to operate in series with the Asr retard coil of the tandem exchange. The operated Ar operates the Hr relay, in turn operating the Hbr relay. When the Cor relay is operated by ground from the Scr relay as previously described, the pilot relay Jkr, which is common to all the junction Cor relays, operates in series with it. The Jkr relay, in operating, operates the Jcr relay which then closes through the locking ground of the Cor relay through to the Jor relay operating it and locking it to ground on the front contacts of the Dkr₁ relay.

The operating ground for the Jor relay is also closed through by this relay to the Jpr and Pr relays. The Jor relay is slow to operate in order to give sufficient time to operate the Jpr and Pr relays, while the Jpr relay is made slow to release so that, when operating ground is removed, sufficient time will be allowed for prolonging the operation of the Pr relay. It will be noted that the operating ground of the Jpr relay is controlled through the operated contacts of the counting relays and these relays, in turn, are locked by a ground on the back contact of a make-before-break set of contacts on the Jor relay. When the Jor relay operates, therefore, the counting relays release and the ground for operating the Jpr relay is lost. To insure that the Jpr relay operates, a supplementary ground is closed through the make and break contacts of the Jor relay to a ground on the front contact of the Dkr₁ relay. The operation of the Pr relay produces a break in the (a) wire of the junction to the satellite and the Ar relay of the satellite releases, causing the operation of the Dkr relay. When the Jor relay is fully operated, the circuit for the Jpr relay is opened, eventually releasing the Pr relay, reclosing the (a) wire to the satellite, reoperating the Ar re-

lay and operating the Dkr₁ which locks in series with the Dkr relay. The grounded Br relay of the satellite is now connected through the proper compensating resistance to the (b) wire through the operated contacts of relay Cor in the tandem exchange, operated contacts of the Dkr₁ relay, operated contacts of relay Jor, back contacts of relay Rcr₁ relay to the (b) wire of the junction to the main exchange. The circuit at the satellite is now ready to receive dial impulses.

The slow operating Jpr relay and the slow releasing Pr relay are designed to give a break in the (a) wire of the junction to the satellite exchange of the proper duration under extreme voltage limits. The Jor relay also releases the pair of counting relays in the tandem exchange last operated in response to the first digit dialed and transfers the (b) wire of the junction from the manual exchange direct to the (b) wire of the junction to the satellite exchange as already explained. The operator now dials the second digit, causing the Br relay at the satellite to respond to the dial impulses. The consequent dialing operations are the same as already described. At the end of the second digit the Cor relay of the called line in the satellite is operated by the path established by the counting relays Scr and Tcr in Figs. 6 and 7 in the same manner as previously described in connection with the tandem exchange. When the dialing key is restored and a break in the (a) wire of the junction to the manual exchange takes place, relays Rcr and Rcr₁ in the tandem exchange are operated as before. When relay Rcr operates, it closes a ground through the back contact of the Rcr₁ relay to the front contact of the Jor relay causing the Jpr and Pr relays to operate, breaking the (a) wire of the junction to the satellite and causing a corresponding operation of the Rcr relay in the satellite. When the Rcr₁ relay is operated at the tandem exchange due to the reclosure of the (a) wire between the tandem exchange and the manual exchange, the circuit for the relays Jpr and Pr is broken, causing a reclosure of the (a) wire to the satellite and thereby allowing the operation of the Rcr₁ relay in the satellite.

It will be recalled that mention was made in the earlier part of the description that the break period in the (a) wire at the tandem exchange occurring during the traveling period of the armatures of the Psr and Pr relays in the cord circuit was not only sufficient to operate the Rcr relays but other relays as well. The additional relays are relays Jpr, Pr in the tandem exchange and Dkr in the satellite. The operation of the Rcr and Rcr₁ relays in the satellite establishes the ringing circuit from the (b) wire of the tandem exchange directly to the (b) wire of the satellite to one side of the subscriber's line through

the operated contacts of the Rcr_1 relay at the tandem exchange, through the operated tandem exchange relay Cor to one side of the subscriber's line at the satellite exchange and to the other side of the subscriber's loop to ground through the Asr retard in the satellite and through a condenser in the satellite exchange to the (a) wire of the tandem exchange and thence to the manual exchange, but also through a condenser at the tandem exchange. The operator now rings the called subscriber at the satellite in the same manner as in ringing a called subscriber at the tandem exchange. When the subscriber answers, the operator restores both the ringing and listening keys as before producing a break in the (a) wire at the tandem exchange and causing the operation of the Olr and Olr_1 relays at the tandem exchange. This operates the Acr relay of the satellite at the junction. As before, the operation of the Olr relay at the tandem exchange closes a circuit through the operated contacts of the Jor relay to operate the Jpr and Pr relays producing a break in the (a) wire to the satellite and thereby causes the operation of the Olr relay at the satellite. The operation of the Olr_1 relay at the tandem exchange opens this circuit, causes the release of the Jpr and Pr relays, recloses the (a) wire to the satellite and likewise causes the operation and locking of the Olr_1 at the satellite. The operation of the Olr_1 at the satellite releases the Dkr and Dkr_1 relays. The Bsr relay and Asr retard coil at the satellite are now across the subscriber's loop, operating the Bsr relay and connecting the subscriber's line to the junction over a condenser and impedance talking circuit. The operation of the Sr relay releases the Olr and Olr_1 relays in the satellite and connects ground through the Br relay to the (b) wire of the junction in series with the Bsr relay of the junction, establishing a balanced transmission circuit and switching supervision to the tandem exchange as more fully described below. The Olr and Olr_1 relays in the tandem exchange, however, remain operated due to the holding circuit established by the Tlr relay which, it will be remembered, became operated when the calling subscriber was connected to the local connecting circuit and connects the junction to the satellite on the answering side of the local connecting circuit in the tandem exchange for the operator to observe the commencement of conversation as has already been described for a local connection. The talking circuit for the subscribers extends over the subscriber's loop, since the Cor relay of the satellite does not release during talking being held from relay Hbr , in the satellite through the (a) and (b) wires to the junction with the Gar retard coil on the (a) wire holding the Ar relay of the satellite and the battery of relay Lar holding the Bsr relay. As already ex-

plained, this not only forms a balanced transmission circuit, but also brings supervisory control to the supervisory relays of the local connecting relays at the junction.

It will be noted that in this type of connection the Acr relay of the called subscriber's local connecting circuit is not operated since the local talking circuit is not to be used. The circuit for this relay depends on the operated condition of the Lbr relay at the satellite whose operation, in turn, is controlled by the operation of the Cor relay of the calling subscriber. Since the calling subscriber is at the junction exchange, no Ccr relay at the satellite is distributed and therefore the Acr relay does not operate.

The operator also listens in on a local connection through this circuit to observe the beginning of the conversation as previously described. When the operator removes the plug from the jack of the junction, all the relays are released at the tandem exchange except those held by the local connecting circuit. The junction from the tandem exchange to the manual exchange is now free for other service. The removal of the plug at the manual exchange, however, does not cause the release of the relays at the satellite due to the fact that the Ar relay is held up during talking by the Gar retard coil of the tandem office. The operated Ar relay holds the relays depending upon it.

At the end of the conversation the local connecting circuit is released as previously described, except that if the called subscriber in the satellite restores his receiver first, it will release the Bsr relay in the satellite which releases relay Sr , opens the (b) wire of the junction to the tandem exchange, in turn releasing the supervisory relay Lar in the local connecting circuit of the tandem office which then causes the release of the local connecting relay Acr . If the calling subscriber restores his receiver first, the Lcr relay will release, in turn releasing both the local Ccr and Acr relays. The Acr relay will close the (b) wire of the junction from the satellite to the Jlr relay, thus creating a call momentarily until the subscriber restores his receiver.

If the local connecting circuit in the tandem exchange is busy, the operator receives the busy tone by the operation of the Otr relay at the tandem office as already described and informs the calling subscriber that the line is busy. But if the local connecting circuit in the tandem exchange is free and the called subscriber is busy within the satellite itself, the calling subscriber will be connected to the calling side of the local connecting circuit and the operator receives the busy tone from the satellite exchange. This tone is likewise received by the calling subscriber.

If the called subscriber is free but does not answer, the operator restores both the ringing

and listening keys producing a break in the (a) wire in the junction to the tandem exchange causing the *Olr* and *Olr*₁ relays to operate, in turn operating the *Jpr* and *Pr* relays which repeat the break in the (a) wire to the satellite and there likewise cause the operation of the *Olr* and *Olr*₁ relays. The *Tlr* relay in the tandem exchange, being operated, holds the *Olr* and *Olr*₁ relays and connects the operator to the listening position on the local connecting circuit to inform the calling subscriber that the called subscriber does not answer. At the same time the junction to the satellite exchange was connected to the answering side of the local connecting circuit, but since there is no party on the line in the satellite, the subscriber's loop at the satellite is not closed and no operating ground for the *Lar* relay is available on the (b) wire from the satellite and therefore the junction to the satellite releases.

Establishing a connection between a calling subscriber at the satellite (Figs. 5 and 6) and a called subscriber at the tandem exchange (Figs. 2, 3 and 4)

When the calling subscriber is located at the satellite he rings up the *Lr* relay which locks up in series with relay *Lsr* in the manner already described. This operation closes the grounded *Br* relay to the wire (b) wire of the satellite, causing it to operate in series with the *Jlr* relay at the tandem exchange from battery supplied from the back contact of the *Hbr* relay, the *Jlr* relay also operating at this time and closing through the chain wire from the contact of the *Ar* relay to the winding of the satellite junction *Cor* relay. The *Jlr* relay also closes a ground from a back contact on relay *Hbr* through the winding of relay *Br* to the (b) wire of the junction, connecting this relay in series with the *Lr* relay of the junction line circuit at the manual exchange. Both the *Lr* and *Br* relays operate, giving the operator the usual signal from a calling subscriber. When she inserts the plug of her cord, the operation of the *Ar* and *Hr* relays follows in the usual way, operating the satellite junction *Cor* relay which now locks in series with the *Jkr* relay to ground on the *Hbr* relay. The *Jkr* relay operates at this time, causing the operation of the *Jcr* relay and which, in the proper sequence of operation, controls the operation and release of the *Jpr* and *Pr* relays for reproducing breaks in the (a) wire to the satellite when necessary as already described.

The calling subscriber is connected to the operator through the talking circuit controlled by the *Bsr* relay in the satellite. The talking circuit to the operator, however, is extended by the operation of the *Bsr* relay of the tandem exchange over the (b) wire in series with the grounded *Br* relay of the satellite; the *Asr* retard coil holding the *Ar*

relay of the satellite operated over the (a) wire.

If the subscriber restores his receiver and has to be called back, the operator performs the operations already described, operating the *Dkr*, *Dkr*₁, *Rcr* and *Rcr*₁ relays of the tandem exchange while the reproduction of the break in the (a) wire to the satellite causes the corresponding operation of the same relays at the satellite. When the subscriber answers, both sets of *Olr* and *Olr*₁ relays operate, releasing the *Dkr*, *Dkr*₁, *Rcr* and *Rcr*₁ relays, reclosing both talking loops and the operator inquires the number.

It will be noted that in dialing, the impulses are not reproduced at the satellite for the reason that when the operator operates the dialing key, and both sets of *Dkr* and *Dkr*₁ relays are operated, the operation of the *Dkr*₁ at the tandem exchange opens the circuit of the *Jor*, *Jpr* and *Pr* relays. The release of the *Jor* relay closes the pulsing lead through to the counting relays of the tandem exchange. The dialing of the called subscriber then proceeds in the manner already described.

It is also to be noted that the calling subscriber is not connected to the calling side of the local connecting circuit until after dialing, as contrasted with the previous type of call where, as a result of the operator depressing the dialing key, the *Cor* relay of the calling subscriber operated. In this case the *Tlr* relay does not operate in the usual way, as the operating path is held open by the operated *Jcr* relay. When relay *Dsr* releases after the digit has been dialled, closing a ground to relay *Btr*, this ground passes over a back contact of relay *Btr* to the *Jcr* relay which, being operated, closes the circuit through the back contact of the *Lbr* relay to relay *Tlr* instead of the *Otr* relay. The *Jcr* relay also holds the circuit open for the operating winding of the *Btr* relay, thus preventing the operation of the *Cor* relay of the called subscriber until the calling junction has been connected to the local connecting circuit and the *Cor* relay of the junction releases. The operation of relay *Tlr* closes a circuit to the satellite junction relay *Cor* which operates from battery on the back contact of relay *Lbr*, breaking the locking circuit of the satellite junction relay *Cor* and presenting battery to the calling side of the local connecting circuit. The release of the satellite junction relay *Cor* releases relay *Jkr*, in turn releasing relay *Jcr* and closing the circuit through to the *Cor* relay of the called line. It will be noted also that the *Cor* relay of the calling line at the satellite remains locked to ground, since none of the above operations are repeated at the satellite, closing through the subscriber's loop over to the junction in the way already described.

In case the local connecting circuit is busy, the *Lbr* relay will have been operated from the previous call and the ground from the front contact of the *Jcr* relay will be passed through the front contact of relay *Lbr* and operates relay *Lor* which locks and prepares the circuit to transmit busy tone to the operator as previously described.

10 *Establishing a call between two subscribers in one of the satellites (Figs. 5 and 6) but connected to a junction point (Figs. 3 and 4)*

When a subscriber in one of the satellites 15 asks for a connection to a subscriber in the same satellite, the calling party rings up the *Lr* relay in the usual way and is rung back by the operator in the same manner as previously described. The operator in this case 20 must dial two digits, as is the case of dialing any subscriber in a satellite, the first to operate a pair of counting relays in the tandem exchange to select the *Cor* relay of the junction extending to the satellite in which the 25 called subscriber terminates and the second to operate a pair of counting relays in the satellite to operate the *Cor* relay of the called subscriber. It will be remembered, however, that when a calling subscriber is in the satellite, the *Cor* relay of the satellite was operated when the junction was connected to the 30 operator and held locked until the calling subscriber was connected to the local connecting circuit. The *Cor* relay was then reoperated from the operated pair of counting relays. Since, in this case, the originating and terminating *Cor* relay is the same at the tandem exchange, the *Cor* relay is not released 35 after the first digit is dialed. When the *Dsr* relay releases after the first digit, the ground from its back contact is closed through the front contact of relay *Djr* and front contact of relay *Jcr*, operating the *Jor* relay. The 40 operating ground for the *Jor* relay passes over a back contact, operating the *Jpr* and *Pr* relays, giving a break in the (a) wire of the junction operating the *Dkr* and *Dkr₁* relays in the satellite exchange. The operation of relay *Dkr* causes the operation of relay *Tlr* 45 and results in the calling party being connected to the local connecting circuit in the manner already described. The operation of the *Jor* relay releases the counting relays in the tandem exchange and transfers the (b) 50 wire of the junction from the manual exchange direct through to the (b) wire of the junction of the satellite. The (b) wire is the impulse wire so that when the second digit is dialed, the *Br* relay of the satellite follows 55 the impulses and operates the proper pair of counting relays at the satellite.

The called subscriber is connected to the local connecting circuit after ringing in the same manner as previously described. The 65 *Olr* and *Olr₁* relays in the satellite are held

operated by the *Tlr* relay, thus connecting the satellite to the listening position on the local connecting circuit, it being remembered that the *Olr* and *Olr₁* relays of the tandem are released at this time.

A ground from a front contact of the *Olr₁* 70 relay in the satellite is connected through a winding of the *Br* relay to the (b) wire of the junction to the tandem exchange, operating the *Bsr* relay in the tandem exchange. 75 The operation of the *Bsr* relay in the tandem exchange operates the *Sr* relay, releasing the *Olr* and *Olr₁* relays, thus preventing the operator from being connected to the listening connection of the tandem local connecting 80 circuit and connects the junction from the manual exchange to the satellite exchange over the normal condenser and impedance talking circuit.

The operator can now listen to the beginning of conversation and then remove the 85 plug from the jack of the junction releasing the *Ar*, *Hr* and *Hbr* relays in the tandem exchange. This releases the satellite *Cor* relay at the tandem exchange, opens the (a) and 90 (b) wires to the satellite and causes the release of the *Ar*, *Hr*, and *Hbr* relays at the satellite. The junction from the manual exchange to the tandem junction and the junction 95 from the tandem exchange to the satellite are now free.

Should the called party not answer, or if the local connecting circuit is busy, the operator receives the busy tone from the satellite 100 exchange and so informs the calling party as previously described.

Establishing a connection between a subscriber in one satellite (Figs. 5 and 6) and a subscriber in another satellite (having equipment similar to that shown in Figs. 5 and 6) and connected by a common rural tandem exchange (Figs. 3 and 4) 105

The method of operation for a calling subscriber in a satellite to signal the operator is 110 the same as already described and the manner of connection to the called subscriber in another satellite is the same. In this type of call there will be two satellite *Cor* relays involved at the tandem exchange. In this 115 case the operation of ringing the calling subscriber in the satellite is the same as previously described and the connection to the called subscriber in another satellite is established in the same manner as was the case 120 for the called subscriber in Figs. 5 and 6, the calling subscriber being connected to the calling side of the local connecting circuit in the tandem exchange over the junction of the calling satellite after the first digit has 125 been dialed, and the called subscriber being connected to the answering side of the local connecting circuit in the tandem exchange over the junction from the called satellite in the manner as previously described. 130

When the operator withdraws the plug after observing the beginning of the conversation, the junction from the manual exchange to the tandem exchange is liberated in the usual manner and leaves the junctions of the respective satellites connected to the local connecting circuit in the tandem exchange. Either subscriber restoring his receiver removes the ground from the (b) wire of the junction from its respective satellite to the tandem exchange which releases itself from the local connecting circuit in the usual manner.

Establishing a connection from a subscriber in the manual exchange (as for example, subscriber S in exchange A, Fig. 1 to a subscriber in a tandem rural exchange (Figs. 3 and 4) or a statellite exchange, Figs. 5 and 6

When a subscriber in the manual exchange calls a subscriber in a rural exchange, the operator dials the number of the wanted subscriber. However, due to the fact that the *Sr* relay is not operated when the dialing key is operated, the *Tlr* relay will not operate. When the operator produces a break in the (a) wire after ringing, causing the *Olr* and *Olr₁* relays to operate, the called subscriber is not connected to the local connecting circuit but operates the *Bsr* relay which in turn operates the *Sr* relay, releasing the *Olr* and *Olr₁* relays and connecting the subscriber's line through a condenser and impedance talking circuit to the junction.

If the called subscriber is busy on the local connecting circuit, the operator receives the busy tone after dialing in the same manner as previously described.

Toll connections

When the operator receives a toll call for some subscriber in the area controlled by the main exchange, she dials the wanted number.

If the called subscriber and the local connecting circuit are idle, the connection is established in the usual way. If, on the other hand, the subscriber is busy, the operation of the dialing key and the consequent operation of the *Dkr* and *Dkr₁* relays causes the *Otr* relay only to operate, since the *Tlr* relay cannot operate because the *Lbr* relay is operated. Also the *Lor* relay cannot operate because, as there is no calling subscriber signaling the operator, the *Sr* relay is not operated. The operator then operates the listening key to ascertain if the line is busy and gets the tone induced in the secondary winding of the *Tr* relay which is placed across the trunk. Provision is now made whereby the operator is connected to the busy local connecting circuit to inform the subscriber that a toll call is awaiting him and also to disrupt the previous connection and

extend the toll call to the wanted subscriber. This is accomplished as follows.

When the operator receives the busy tone after dialing, she operates the ringing key and then restores both the ringing and listening keys, whereupon the breaks in the (a) wire cause the operation of the *Dkr*, *Dkr₁*, *Rcr*, *Rcr₁*, *Olr* and *Olr₁* relays. The operation of the *Olr₁* relay causes the release of relays *Dkr* and *Dkr₁* and which, in turn, causes the release of the *Rcr* and *Rcr₁* relays. Since the line is busy, the *Lbr* relay is operated and prevents the *Tlr* relay from being operated. As soon as the *Olr* and *Olr₁* relays are operated, a circuit is closed to operate relay *Lor* from ground through the front contacts of relays *Olr* and *Olr₁*, front contacts of the *Lbr* relay, front contacts of relay *Dkr*, back contacts of relay *Jcr*, front contacts of the transfer set on relay *Lbr*, back contacts of relay *Tbr* to battery through the *Lor* relay. This relay, in operating, locks itself to a ground on the *Dkr* relay and also transfers the holding circuit of relays *Olr* and *Olr₁* to the same ground so that, when the *Dkr* and *Dkr₁* relays release, the *Olr* and *Olr₁* relays release also. Relay *Lor* is slow in releasing to make sure that the *Olr* and *Olr₁* relays are unlocked before the *Lor* relay releases; otherwise these relays would remain locked through a back contact of relay *Lor* to ground on the back contact of relay *Sr*. The operator then operates the dialing key and restores it, producing two breaks in the (a) wire of the junction, causing the operation of the *Dkr*, *Dkr₁*, *Rcr*, and *Rcr₁* groups of relays and then operates the listening and ringing keys, producing another break in the (a) wire and causing the operation of the *Olr* and *Olr₁* relays. The operation of the *Olr₁* relay again releases the *Dkr* and *Rcr* groups of relays as before, but relay *Lor*, being released at this time, leaves the normal holding circuit for the *Olr* and *Olr₁* relays closed, causing these relays to remain energized and connect the operator to the listening position on the local connecting circuit.

The operator now informs the subscriber on the local connecting circuit that a toll call is waiting and proceeds thereafter to break down the local connection in order to set up the toll call. The operator operates the dialing key and dials the number of the wanted party. The operation of the dialing key again operates the *Dkr* and *Dkr₁* relays to prepare the circuit for dialing. When the *Dkr* relay operates, it connects the ground through the *Br* relay to the (b) wire of the junction, operating the *Br* relay and when the *Dkr₁* relay operates, a path is closed for the *Bdr* relay from battery through its winding, front contact of relay *Olr*, front contact of relay *Br*, back contact of relay *Rcr*, to ground on the front contact of the *Dkr₁* relay.

Relay *Bdr* operates and locks to holding ground.

Relay *Bdr* closes a circuit to operate the *Sr* relay through a front contact of relay *Olr*, and since relays *Olr* and *Olr*₁ are both locked to ground through a back contact of relay *Sr*, the operation of relay *Sr* will release the *Olr* pair of relays and the release of relay *Olr* opens the circuit for the *Sr* relay. The *Bdr* relay locks to the holding ground of relay *Dkr* but opens the holding path of these relays—they now holding from a back contact of relay *Rcr*₁. Therefore, when the *Rcr*₁ relay operates, the *Dkr* and *Dkr*₁ relays will release. The operation of relay *Bdr* also breaks the holding ground for the local connecting circuit as well as for the *Cor* relay. The operator then proceeds to dial the wanted number. When the *Dsr* relay releases after the digit is dialed, the ground from the operated pair of counting relays is closed through relay *Btr* and the *Cor* relay of the wanted line.

When the operator restores the dialing key, causing the operation of the *Rcr* and *Rcr*₁ relays, the *Dkr* and *Dkr*₁ relays release as already explained. The operation of relay *Rcr*₁ also unlocks relay *Bdr* which releases at this time. The release of relay *Bdr* also releases relays *Rcr* and *Rcr*₁ which were held by relay *Bdr*. The *Bdr* relay is also in releasing in order to hold relay *Rcr*, operated long enough to insure the release of the *Dkr* and *Dkr*₁ relays. The release of relay *Bdr* recloses the locking ground for the *Cor* relay before the operating path is broken by the release of the counting relays.

The operated *Cor* relay puts the *Bsr* relay and *Asr* retard coil across the subscriber's loop, causing the operation of the *Bsr* and *Sr* relays, closing the line to the junction for talking.

Faulty junction

If the (b) wire of the junction from the manual exchange to the tandem exchange becomes grounded, it operates the junction line relay giving the operator a permanent junction line lamp. If the (a) wire becomes grounded, it operates the *Ar* relay, in turn operating the *Hr* and *Hbr* relays, closing a ground through the back contact of the *Sr* relay, back contact of the *Dkr*₁ relay, back contact of the *Dkr* relay, back contact of the *Olr* relay to the thermal heat relay *Thr*. If this circuit is not broken within a period of approximately one minute, the thermal heat relay *Thr* closes a circuit for the *Pgr* relay which locks to the front contact of the *Ar* relay and breaks the circuit to the *Hr* relay, thus releasing the *Hr*, *Hbr* and *Thr* relays. The *Pgr* relay connects a ground to the (b) wire of the junction to the manual exchange, operating the junction line relay, giving a permanent line lamp. If the fault becomes

cleared, releasing the *Ar* relay, the *Pgr* relay is released and the circuit is restored to normal.

Disabling a faulty satellite exchange from a junction

If a junction from a satellite exchange (Figs. 5 and 6) to the tandem exchange (Figs. 3 and 4) becomes faulty on either the (a) or (b) wire, the ground on the (b) wire operates the *Jlr* relay in the tandem exchange, connecting ground through the *Br* relay on to the (b) wire of the manual exchange, thus causing a permanent line lamp in the manual exchange. The operator will ascertain whether a subscriber is on the line and on getting no response will recognize it to be a faulty line by successfully ringing on it, there being a ground return on the (b) wire, and will know that it is a junction to a satellite since the line relays of the local subscribers' lines are connected to ground and do not become operated from a faulty line.

In order to ascertain which junction is faulty, the operator makes a test call on each junction until the faulty junction is found.

The operator then disables the junction by dialing zero, followed by the junction number and then removes the plug from the jack. When the digit "0" is dialed, the *Or* relay is operated from the front contact of the *Adr*₁ relay and the front contact of the *Tcr*₁ relay. The *Or* relay, in operating, closes a circuit from the *Jr* relay to the back contact of the *Tcr*₁ relay so that when the second digit is dialed, releasing the *Cor*₁ relay, the *Jr* relay will operate. The operation of the *Jr* relay transfers the *Cor* relay operating leads from the *Tcr*₁₋₄ relays to the respective *Jdr* relays, so that when the *Dsr* relay releases after the second digit, the ground is connected to the *Jdr* relay of the junction which was dialed. The *Jdr* relay in operating opens the (a) and (b) wires of the junction and locks itself to the (b) wire. When the fault becomes clear, the *Jdr* relay is released and the junction is restored to service.

Fuse alarm

The circuit is fused with the *Ar*, *Otr*, *Lor* and *Tr* relays on a separate fuse back of the main fuse so as to give a tone to the operator when any fuse is blown except this one.

A blown fuse connects battery to the fuse panel alarm bar, operating the *Far* relay which connects ground through the *Br* relay to the (b) wire of the junction operating the junction line relay, giving a permanent junction line lamp. When the operator plugs into the jack of the junction operating the *Ar* relay, it connects ground through the make contact of the *Far* relay, operating the *Lor*, *Otr* and *Tr* relays, connecting the busy tone to the junction. This tone makes a distinction between the permanent line lamp for a blown

fuse and a permanent line lamp for a faulty junction. When the operator removes the plug from the jack of the junction, the *Ar* relay is released, thus releasing the *Lor*, *Otr* and *Tr* relays, so that the busy relays are operated only while the operator is on the junction.

Charging battery

10 The battery charging equipment consists of the *Chr*, *Cjr* relays, D resistance and Y wiring. When the battery is charged via the junction, from the manual exchange, the polarized relay *Chr* is connected between the
15 (a) wire of the junction and the *Ar* relay. A negative battery of 48 volts or higher potential is connected through the back contact of the junction line relay and the junction cut-off relay in the manual exchange
20 to the (a) wire of the junction, which flows through the operating winding of the *Chr* relay through the *Ar* relay to the battery of the rural exchange by way of the Y wire. When the battery is
25 fully charged, the potential is reversed and the polarized relay *Chr* operates on the reversed flow of current, disconnecting the ground from the armature spring of the *Ar* relay, so as to prevent the *Hr* and *Hbr* relays
30 from operating. When the operator plugs into the jack of the junction applying a ground to the (a) wire, the flow of current is reversed through the polarized relay which operates in the opposite direction,
35 restoring the ground to the armature spring of the *Ar* relay so that the circuit will function in the normal manner. The holding winding of the *Chr* relay is energized whenever the circuit is in operation, so as to aid the
40 operating winding in maintaining a firm contact for the ground to the armature spring of the *Ar* relay.

When the junction is seized by a call incoming to the manual exchange, the operation of the junction line relay removes the charging current and likewise when the junction is seized by the operator plugging into the jack of the junction, the operation of the junction cut-off relay removes the
50 charging current from the line.

The batteries in the satellite exchange are charged in the same manner by connecting the charging battery to the (a) wire of the junction to the satellite in parallel and in
55 parallel with the battery of the tandem exchange through the (D) resistance.

The operation of the *Chr* relay in the tandem exchange operates the *Cjr* relay connecting the charging battery through the D resistance in parallel with the C resistance. The value of these resistances depends upon the resistance of the junction from the manual exchange to the tandem exchange and the
60 resistance of the junction to the various satel-

lites in the charging current required for each of them.

What is claimed is:

1. In a telephone exchange system comprising a main exchange, a plurality of tandem
70 rural exchanges each connected by a trunk line to said main exchange, a plurality of rural exchanges each connected by a trunk line to either said tandem rural exchanges or to said main exchange, a local connection
75 trunk at each of said tandem rural exchanges and at each of said rural exchanges, a register sender at each of said tandem rural exchanges, means at said main exchange for
80 controlling said sender at each of said tandem rural exchanges to interconnect lines at said tandem rural exchanges over said local connection trunk in each of said tandem rural
85 exchanges or to connect lines at said tandem rural exchanges with any of said rural exchanges connected thereto, a register sender at each of said rural exchanges and means
90 for controlling said sender at each of said rural exchanges through said respective tandem rural exchanges in which said rural exchanges terminate, for further extending a
95 connection from a line in any tandem rural exchange over the local connection trunk of said tandem rural exchange or for interconnecting lines of any of said rural exchanges over the local trunk thereof.

2. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural
100 exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural
105 exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for
110 controlling said sender to interconnect lines at said tandem exchange over said local trunk or to connect lines at said tandem rural exchange with said rural exchange over said
115 outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange and means at said main exchange and at said tandem rural exchange for
120 controlling the sender at said rural exchange for further extending a connection from a line in said tandem rural exchange over the local connection trunk of said tandem rural
125 exchange to a line in said rural exchange or for interconnecting lines of said rural exchange over the local connection trunk thereof.

3. In a telephone exchange system, a main
125 exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a
130 trunk line extending from said tandem rural exchange to said main exchange, a register

sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local trunk or to interconnect lines at said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange, means at said main exchange and at said tandem rural exchange for controlling the sender at said rural exchange for further extending a connection from a line in said tandem rural exchange over the local connection trunk of said tandem rural exchange to a line in said rural exchange or for interconnecting lines of said rural exchange over the local trunk thereof, and means for releasing the trunk line from said main exchange to said tandem rural exchange and the trunk outgoing from said tandem rural exchange to said rural exchange for establishing other calls when such trunk lines are not used as part of an established talking connection.

4. In a telephone exchange system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local connection trunk, and means for thereafter releasing the said trunk line from said main exchange to said tandem rural exchange for establishing other calls at said tandem rural exchange.

5. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange, and means at said main exchange and at said tandem rural exchange for controlling the sender at the said rural exchange for interconnecting lines at said rural exchange over the local connection trunk thereof, and means for thereafter releasing the trunk line from the said main exchange to said tandem rural exchange and the trunk outgoing from said tandem rural exchange to said rural exchange for establishing other calls at said rural exchange.

6. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local connection trunk thereof or to interconnect lines at said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange and means at said main exchange and at said tandem rural exchange for controlling the sender at said rural exchange for further extending a connection from a line in said tandem rural exchange over the local connection trunk of said tandem rural exchange to a line in said rural exchange or for interconnecting lines of said rural exchange over the local connection trunk thereof, and means at said main exchange, at said tandem rural exchange and at said rural exchange for enabling the operator at said main exchange to listen to the commencement of conversation on the established connection at said tandem rural exchange or on the established connection at said rural exchange or on the established connection between said tandem rural exchange and said rural exchange.

7. In a telephone exchange system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local connection trunk, and means at said main exchange and at said tandem rural exchange for enabling the operator at said main exchange to listen to the commencement of conversation on the established connection at said tandem rural exchange.

8. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, means at the said main exchange for controlling said sender to interconnect said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural

exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange, means at said main exchange and at said tandem rural exchange for controlling the sender at said rural exchange for interconnecting lines at said rural exchange over the local connection trunk thereof, and means at the said main exchange and at the said tandem rural exchange and at the said rural exchange for enabling the operator at said main exchange to listen to the commencement of conversation on the established connection at said rural exchange.

9. In a telephone exchange system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines and a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange and means at the said main exchange and at said tandem rural exchange to ring the called subscriber at the said tandem rural exchange from said main exchange.

10. In a telephone exchange system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange, a trunk line extending from said tandem rural exchange to said main exchange a register sender at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange, means at said main exchange and at said tandem rural exchange for controlling the sender at said rural exchange for interconnecting lines at said rural exchange over the local trunk thereof, and means at said main exchange, at said tandem rural exchange and at said rural exchange to ring the called subscriber at said rural exchange from said main exchange.

11. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange and each equipped with a cut-off relay, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, and means at said main exchange for controlling said sender to select and operate the cut-off relay of a desired subscriber's line to cause the connection of said line to said local connection trunk or to operate the cut-off relay of said outgoing trunk for causing the

interconnection of said rural exchange with said tandem rural exchange.

12. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange and each equipped with a cut-off relay, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange and means at said main exchange, at said tandem rural exchange and at said rural exchange for controlling said sender at said rural exchange to operate the cut-off relay of a desired subscriber's line at said rural exchange to cause the connection of said line to said local connection trunk.

13. In a telephone exchange system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines each provided with a cut-off relay, a trunk line extending from said tandem rural exchange to said main exchange, a register sender and a local connection trunk at said tandem rural exchange, said sender comprising a plurality of pairs of recording relays, means at said main exchange for transmitting impulses to said register sender to operate said pairs of relays successively, means operative upon the operation of each pair of relays for releasing the next preceding operated pair of relays, and means controlled by the pair of relays operated by the last impulse transmitted to operate the cut-off relay of a desired subscriber's line to cause the connection of that line to the local connection trunk.

14. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local trunk or to interconnect lines at said tandem rural exchange with said rural exchange over said outgoing trunk, subscribers' lines terminating in said rural exchange, a register sender at said rural exchange, comprising a plurality of pairs of recording relays, means at said main exchange for transmitting impulses to said last mentioned sender to operate said pairs of relays successively, means

operative upon the operation of each pair of relays for releasing the next preceding operated pair of relays, and means controlled by the pair of relays operated by the impulse last transmitted to select a desired subscriber's line terminating in said rural exchange.

15. In a telephone system, a main exchange, a tandem rural exchange, a plurality of subscribers' lines, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local connection trunk, and means in said tandem rural exchange for connecting said trunk line to said sender, to a subscriber's line or to said local connection trunk.

16. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect lines at said tandem rural exchange over said local connection trunk or to interconnect lines at said tandem rural exchange with said rural exchange over said outgoing trunk, a register sender at said rural exchange, lines terminating in said rural exchange, a local connection trunk at said rural exchange, means at said main exchange and at said tandem rural exchange for controlling the sender at said rural exchange for interconnecting lines of said rural exchange over the local connection trunk thereof, and means at the said tandem rural exchange and at said rural exchange for connecting said trunk outgoing to said rural exchange to said sender in said rural exchange, to a subscriber's line or to the local connection trunk thereof.

17. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem exchange, means at said main exchange for controlling said sender at said tandem rural exchange to interconnect said rural exchange with said tandem rural exchange and means at said main exchange and at said tandem rural exchange and at said rural exchange to disable at said tandem rural exchange the said

trunk line extending from said tandem exchange to said rural exchange.

18. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, means at said main exchange for controlling said sender at said tandem rural exchange to interconnect said rural exchange with said tandem rural exchange, means for charging the battery in said tandem rural exchange, and means at the said tandem rural exchange for disconnecting the charging current when the trunk from said main exchange to said tandem rural exchange is seized in either direction.

19. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, means at said main exchange for controlling said sender to interconnect said rural exchange with said tandem rural exchange over said trunk outgoing to said rural exchange, means at said main exchange, at said tandem rural exchange and at said rural exchange for charging the battery at said tandem rural exchange and the battery at said rural exchange over said trunk line connecting the main exchange with said tandem rural exchange and over said outgoing trunk to said rural exchange, and means at said rural exchange and at said tandem rural exchange to disconnect the charging current when the said trunk lines are seized in either direction.

20. In a telephone exchange system, a main exchange, a tandem rural exchange, a rural exchange, a plurality of subscribers' lines and a trunk outgoing to said rural exchange terminating in said tandem rural exchange, a trunk line extending from said tandem rural exchange to said main exchange, a register sender at said tandem rural exchange, a local connection trunk at said tandem rural exchange, a local connection trunk and register sender at said rural exchange, means at said main exchange for controlling said senders to establish local connections at said tandem rural exchange, at said rural exchange or between said tandem rural exchange and said rural exchange, and means at said main exchange to connect with a desired subscriber's line, at the time engaged in a local connection, release the

local connection and connect said line with the main exchange for the establishment of a toll connection.

In witness whereof, we hereunto subscribe
5 our names this 20th day of January, 1930.

LIPA POLINKOWSKY,

By EDOUARD FRUM,

Administrator of the Estate of Lipa Polinkowsky, Deceased.

10 OWEN C. FROM.

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