May 25, 1926. 1,585,652

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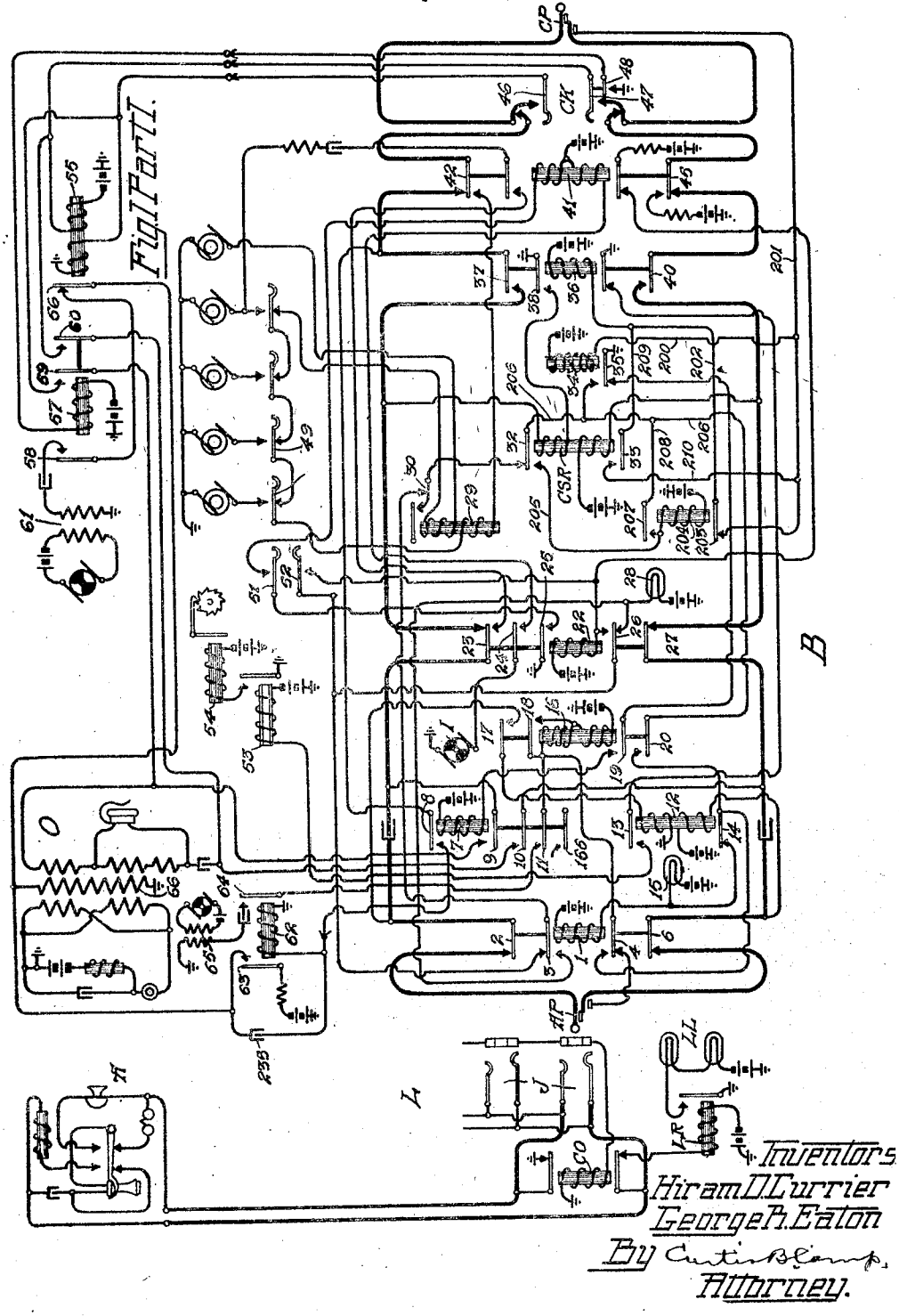
TELEPHONE SYSTEM

Filed April 27, 1921 3 Sheets-Sheet 1



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TELEPHONE SYSTEM

Filed April 27, 1921 3 Sheets-Sheet 2

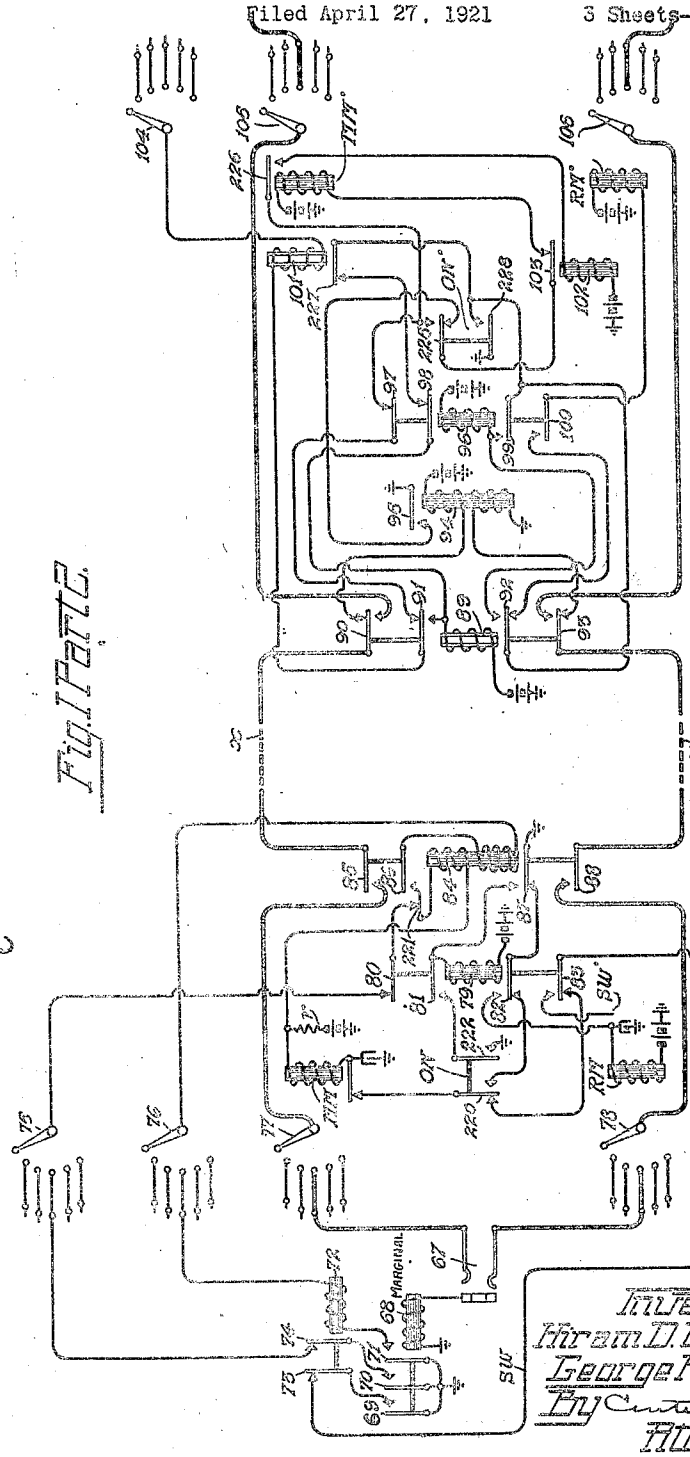

Fig. II Part 2.

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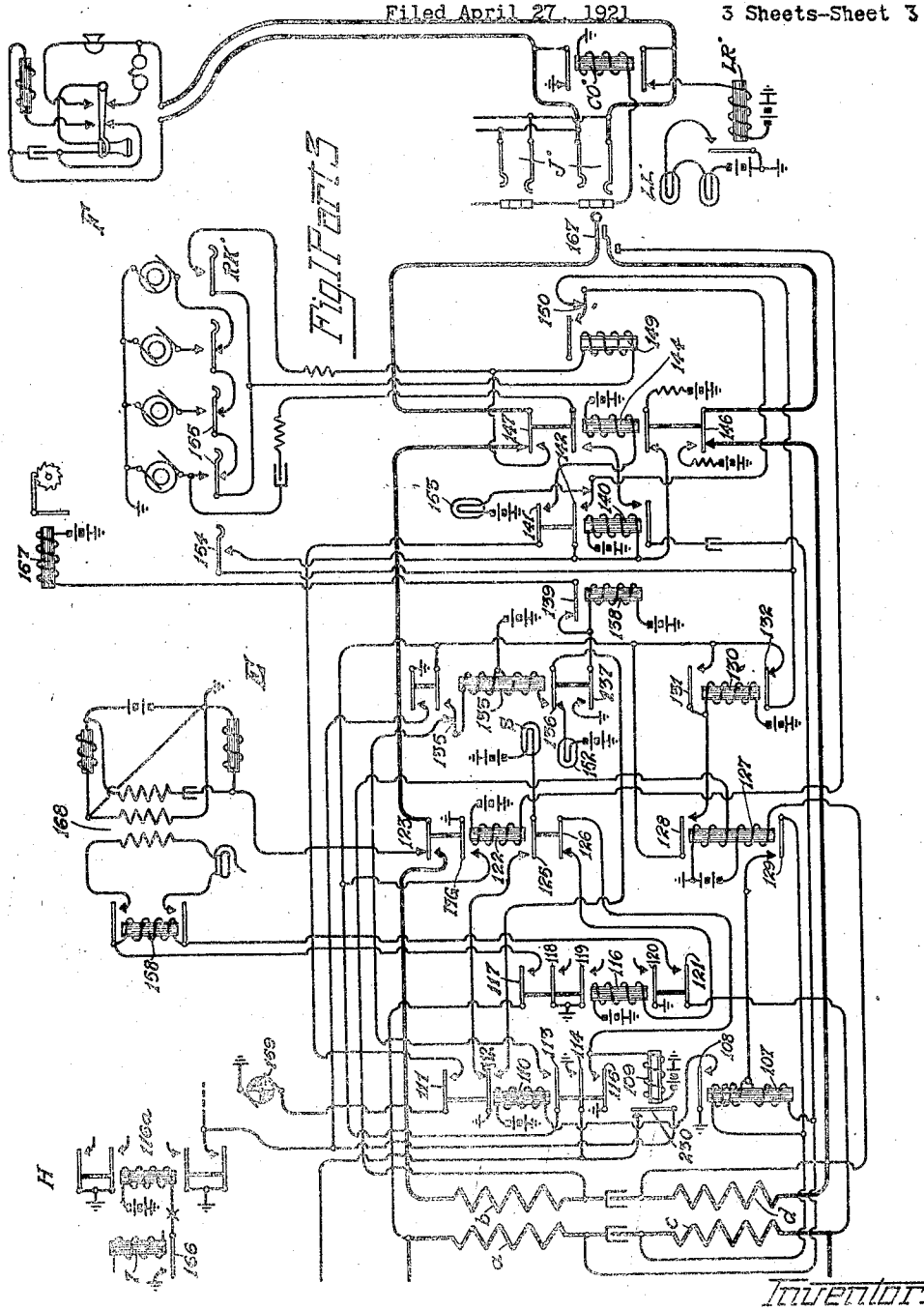
TELEPHONE SYSTEM

Filed April 27, 1921 3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE.

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TELEPHONE SYSTEM.

Application filed April 27, 1921. Serial No. 464,814.

Our invention relates to multi-office systems, that is, systems in which two or more exchanges are interconnected by means of trunk lines, and trunking calls between exchanges are handled over these wires by operators in the originating exchange, who pass the calls to the operators in the distant exchange, which latter complete the connections to the called subscribers' lines.

In the system of our invention we have abandoned the former practice which involved A operators who would place themselves in communication with a B operator's head set over an order wire to transmit the wanted number. An A operator at the originating office would then receive the assignment of the trunk being used by the B operator at the distant exchange and would insert the calling plug of her cord pair into the trunk thus assigned to her, the B operator in the meantime having inserted the plug of the trunk into the jack of the called line.

In the system embodying our invention, the A operator reaches the B operator by inserting the calling plug of her cord pair into a trunk jack, which insertion starts switching mechanism that automatically extends the call to an idle operator at the distant exchange, and when this has taken place the A operator is in direct connection with the B operator. This arrangement permits us to do away with B operators in the sense of operators who handle trunk connections only, and all the operators in the system put up local connections and also serve as B operators, as they also receive calls extended from distant exchanges and complete the connections required for such calls.

A feature of our invention is the provision of means such that when a trunking call has been completed from a calling subscriber in one exchange to a line of a called subscriber in a distant exchange, the inter-office trunk is released so as to render it available for use immediately upon the conclusion of conversation due to the replacement of the receivers at the respective substations.

Another feature of our invention is the provision of means whereby the replacement of the receiver at the calling substation immediately operatively disconnects his line from the connected cord, and the replacement of the receiver at the called substation will then operate means to bring about the restoration of the switching mechanism used in extending the connection from the exchange originating the call to the distant exchange. This gives the subscriber at the calling substation instantaneous disconnect, and the replacing of the receiver at the called substation instantly disconnects the trunk from the cord at the originating exchange, thus preventing the trunk that was used from being tied up.

The above features as described, as well as others, will be more fully hereinafter described in the ensuing specification.

Referring now more in detail to our invention as illustrated in the accompanying drawings, we show

A circuit diagram consisting of parts 1, 2 and 3, which diagrammatically illustrate our invention.

Referring first to part 1, we have illustrated a subscriber's telephone substation terminating in a line circuit L and a cord circuit B suitable for interconnecting local subscribers' lines within one exchange. The said cord circuit B may also be used for trunking calls to distant exchanges, and when its calling plug CP is inserted in a trunk switch jack 67 (referring now to part 2), the automatic selecting switches C and D are set into operation to extend the call over the inter-office trunk wires x and y, and extend it to the distant exchange E (part 3), and also directly connect the operator at the originating exchange with some operator at the distant exchange who is not busy at the time, that is, one who is not busy at the time establishing either a local or a trunk connection, for it is to be understood that at exchange E the operator will be provided with local cord circuits B in addition to a number of trunk circuits E.

The system as a whole, therefore, may consist of two exchanges B and E, at which the operators will have identical equipment, that is, a suitable number of local cord circuits B, such as shown in part 1, and also a suitable number of trunking cord circuits E, such as shown in part 3. Furthermore, before each operator will be suitable trunk jacks 67 connected with switch pairs, such as C and D, so that any operator at any

exchange can in addition to establishing local connections pass trunk calls to distant exchanges, as well as receive trunk calls from such distant exchanges.

To describe the various instrumentalities in a general way, at A we have shown a common battery subscriber's local substation connected at the exchange with a usual form of line circuit L comprising a line relay LR, a cut-off relay CO, together with multiple line lamps LL and jacks J. The operator's cord circuit B shown in part 1 comprises an answering plug AP and a calling plug CP connected by talking wires, which are indicated by the heavily marked lines. It is provided with answering and calling supervisory signals and the necessary relays for controlling them, and with suitable relay apparatus for providing the various features now considered necessary to a modern manually operated telephone switchboard, such as secret service, automatic ringing, instantaneous disconnect, line lamp recall, etc.

The apparatus for transferring trunking calls from one exchange to another includes a number of spring jacks 67 at each operator's position which terminate in multiple contacts located in a number of finder switches as C, and one of these will automatically select a jack 67 in which an operator has inserted a plug, such insertion serving to initiate the travel of an idle switch C. When the switch C has completed its operation, the switch D at the distant exchange will be set in motion, and it comprises suitable magnets, relays and off-normal springs to effect the automatic selection of an idle trunk cord of the kind shown at E in part 3.

The latter has but a single plug 167, to which extend the talking conductors indicated by the heavily marked lines, and suitable relay instrumentalities and circuits for testing, ringing and supervising at the exchange E, and also for extending the required signals back over the trunk line to the originating exchange B.

A more complete understanding of the precise arrangement of the parts and their operation, one with the other, will be obtained from the following description of operation.

We will first assume that a subscriber at A desires to converse with a called subscriber at F, the latter's line terminating in an exchange distant from exchange B to which the calling subscriber belongs. The removal of the receiver at A energizes relay LR, lighting lamps LL, which lamps are distributed at various positions in the switchboard. An operator seeing the lamp at her position displayed, will insert the answering plug AP in a jack J of the calling line, and relay 16 instantly energizes by current through its two windings, normal contact 4, the sleeve contacts of the connected plug and jack and through cut-off relay CO to ground, the latter also energizing and clearing the line for talking, as well as putting out the lamps LL by de-energizing the line relay LR. The relay 16 upon energization closes its contact 18 to shunt out its high resistance upper winding so that if another operator has plugged into another jack of the line of A, such other operator's relay 16 will fail to energize because of the shunt established by the low resistance winding at the first operator's relay 16, and the second operator will get no response when she asks for the number and will withdraw her plug. The operating relay 16 of the first cord by its closure of contact 19 energizes listening relay 7 by current flowing to ground at contact 35 of relay 34 and relay 7 upon energization closes its contacts 9 and 10 to connect the operator's telephone set O to the calling line, and she now inquires and learns the number of the wanted subscriber. Furthermore, by the operation of relay 16, due to the closure of its alternate contact 17, the supervisory relay 12 has been cut across the calling line, supplying talking current thereto, and by the opening of its contact 14 prevents the premature display of supervisory signal 15, while the closure of contact 13 actuates counter relay 53, resulting in the actuation of magnet 54 to count a call as answered by the operator. The operator at B learning that the line of the wanted subscriber terminates at the exchange E, will now insert calling plug CP into spring jack 67, such spring jack being assigned for calls to be extended to E, and she will first have actuated her cut-out key CK to close its contacts 46 and 47. The insertion of the calling plug CP into the trunk jack 67 has established an energizing circuit for the sleeve relay 34 traced from battery through the winding of relay 34, conductors 200 and 201, the sleeve contacts of connected plug CP and trunk jack 67, through the winding of relay 68 to ground. A parallel circuit is also established for relay 36 over which circuit the said relay 36 energizes. The circuit may be traced from battery through the winding of relay 36, conductor 202, normal contact 203 of relay 204, and over conductor 201, sleeve contacts of the plug CP and jack 67, to ground through relay 68. As a result the relay 68 energizes and sets in travel the switch at C by closing its contact 69, which grounds starting wire SW (which extends from switch C as a common wire to all relays 68 connected with spring jacks 67 adapted to be selected by the switch C). Current will now flow from battery through the resistance r, the winding of motor magnet MM, normal contact 220 of off-normal

contacts ON, normal contact 83 of relay 79, conductor SW, normal contact 73 of relay 72, and to ground through contact 69 of relay 68. The magnet MM will energize and de-energize over this circuit to step the switch wipers 75, 76, 77 and 78 a step from normal into engagement with the first set of contacts in search of terminals of the spring jack 67, in which the plug CP has been inserted. On the first step the off-normal springs ON are shifted to their alternate positions and successive actuations of magnet MM are produced by its armature over a circuit through the alternate contact 220 of off-normal contact ON, through contact 82 to ground at normal contact 87 of relay 84. Such actuations of magnet MM will continue, each actuation causing a step of the wipers 75, 76, 77 and 78 until they engage multiple jacks in their banks connected to a jack 67 in which a plug CP has been placed, and which has not been already selected. As soon as this occurs the motor magnet MM will be shunted, preventing its further actuation, and this shunt may be traced from battery through the resistance r, the low resistance upper winding of relay 84, its normal contact 221, normal contact 80 of relay 79, through wiper 75, its engaged bank contact and through normal contact 74 of relay 72, and alternate contact 70 of relay 68 associated with the spring jack 67, to ground. The relay 84 attracts its armature to open its normal contact 87, and to close alternate contact 87, thereby opening the circuit of magnet MM, and the closing of alternate contact 87 energizes relay 79, and the closing of alternate contact 86 of relay 84 connects the high resistance lower winding of said relay 84 in series with its upper winding and the said relay 84 locks to ground at 71, the circuit being traced from battery through resistance r, the upper winding of relay 84, its alternate contact 86, through the lower winding of relay 84, wiper 76, through relay 72, to ground at alternate contact 71 of relay 68. The relay 72 energizes over this circuit and opens its contact 74 so that no other switch whose wiper 75 engages a multiple of the seized contact will stop, while the opening of contact 73 keeps ground off the starting wire SW, so that when relay 79, which is now energized, closes its alternate contact 83, the starting wire SW is extended to starting wire SW′, which extends to another finder switch in the usual manner. The relay 79 having energized as above described, locks itself to ground at alternate contact 222 of off-normal contacts ON through its alternate contact 81.

By the closure of contacts 85 and 88 of relay 84, the relay 94 in the distant exchange has had its windings connected across the trunk wires x and y, and current flows from battery through the upper winding of 94, normal contact 90 of relay 89, over the heavily marked talking conductor via the tip contacts of the jack 67 and plug CP, the alternate contact 46 of key CK, over the common wire to ground through the winding of the relay 55, while another circuit is established from battery through the other winding of relay 55, the alternate contact 47 of key CK, through the ring contacts of the plug CP and jack 67, over the talking conductor, and through normal contact 93 of relay 89 and through the lower winding of relay 94 to ground, it being remembered that at the time the operator at B inserted the calling plug CP into the jack 67, she actuated her cut-off key CK to close contacts 46, 47 and 48. As a result the relays 94 and 55 both energize, and it is to be understood that the relay 55 is common to all cords of a position. When the operator first actuated her cut-out key CK, the closure of contact 48 energized the relay 57, with the result that a tone from the constantly operating interrupter mechanism 61 was transmitted via contacts 58 and 56 into the operator's head telephone through the winding 66 of her induction coil, and she thus had an audible indication which was terminated when the relay 55 was energized as just described, because the opening of contact 56 interrupted the tone circuit. By the cutting off of this signal she knows that the switch C has properly performed its function and has extended the call over the wires x and y to the distant exchange and that the switch D is starting its travel.

The starting of D is effected by the energization of relay 94, which by closing its alternate contact 95 energizes motor magnet MM′ by current from battery through the winding of magnet MM′, normal contact 103 of relay 102, normal contact 225 of off-normal contacts ON′ to ground at alternate contact 95 of relay 94, and said magnet by a suitable pawl and ratchet mechanism steps the wipers 104, 105 and 106 one step from normal to engage the first set of contacts leading to a trunk circuit, such as that shown at E. Upon this first step the contacts ON′ are shifted to their alternate position, and if the first contact engaged by wiper 104 is a busy contact, it will be grounded, the manner of such grounding to be later explained. The result is that in the case of such grounded contact a circuit will be established from battery through relay 102, the alternate contact 226 of magnet MM′, contact 97 of relay 96, contact 91 of relay 89, through the winding of relay 101, and the wiper 104 to the engaged busy contact and to ground. Consequently, relays 102 and 101 energize, and the latter is of slow release construction so that rapid interruptions of its circuit as the switch

travels are not effective to cause its armature contact to restore. The opening of normal contact 103 of relay 102 de-energizes magnet MM', whose retracted armature opens contact 226, which in turn de-energizes relay 102, whereupon magnet MM' instantly is again energized by current through the now closed contact 103 of relay 102, the alternate contact 225 of ON', contacts 97 and 91 of relays 96 and 89, through the relay 101, through the wiper 104 and the engaged grounded contact, whereupon magnet MM' steps the wipers another step, and by the closure of its alternate contact 226 will again energize the relay 102 over the previously described circuit to wiper 104 and now to ground at the next engaged contact, if it is busy. Thus a seesaw action between relay 102 and magnet MM' is produced, the slow relay 101 being in the circuit of whichever one of the other two is energized, and this seesaw action will continue until the wiper 104 engages a contact in its bank which leads to a trunk line in the exchange E which terminates before an operator who is not busy, that is, who is not busy establishing either a trunk or local connection. When an idle contact is engaged by the wiper 104 the seesaw action terminates because the engaged contact of such a trunk line will be characterized by a freedom from ground. When this occurs the circuit will remain open through the slow relay 101, whose armature will retract, and the closing of its normal contact 227 closes an energizing circuit for the slow release relay 89 from battery through the winding of relay 89, normal contact 98 of relay 96, normal contact 227 of relay 101, to ground through the shifted off-normal contact 228. Upon energization of relay 89 its contacts 90 and 93 assume their alternate position, closing a circuit from battery through relay 55 at B, over the lower heavily marked talking conductor to the right through wiper 106 and its engaged idle contact, through winding *c* of the induction coil at E, in series through the two windings of relay 107, through winding *a* of the induction coil, to the left over the heavily marked talking conductor, and through the left-hand winding of relay 55 to ground. This energizes relay 107, and the closure of its alternate contact 108 energizes relay 110 from battery through relay 110 to ground at alternate contact 108 of relay 107, which relay 110 closes its contact 114 and grounds the contact engaged by the wiper 104 of the switch B, the result being that relay 89 at D by its alternate contact 91 locks to ground via relay 101 at contact 114. When relay 89 first operated the closure of its contact 92 energized the relay 96, which was immediately locked to ground to the off-normal contact 228, via its alternate contact 99, and said relay 96 by opening its normal contact 98 opens the initial energizing circuit of relay 89, but the latter's slow release construction causes it to hold its armature in operated position until the substitute circuit for it was established, as just described. The opening of normal contact 97 of relay 96 has effectively prevented any reoperation of motor magnet MM' until the relay 96 is de-energized, which can only happen after the switch D is restored to normal, and the contacts ON' are consequently shifted to their original or normal position.

Referring now to the apparatus at E, the relay 110 (which energized as the result of the closure of contact 108) closes an energizing circuit for relay 109 from battery through relay 109 to ground at alternate contact 115 of relay 110, and also closes a circuit for relay 116 from battery through relay 116, normal contact 126 of relay 122 to ground at alternate contact 115 of relay 110, and the closure of alternate contacts 117 and 121 of relay 116 connects the operator's relay 158 across the talking conductors, and said relay 158 energizes by current through the windings of relay 55 at B, over a path which is obvious from the preceding description. Thus the operator's talking set at 168 is directly connected in circuit with that of the operator at B through the alternate contacts 59 and 60 of relay 55 at B. The operator at B now tells the operator at E the number of the subscriber wanted, and the latter plugs into a spring jack of the wanted line, having first tested it in the usual way and found it idle.

It will be observed that upon the energization of relay 110, the signal lamp 152 was lighted by current flowing through said lamp 152, normal contact 136 of relay 133, to ground at alternate contact 112 of relay 110, so that the operator at E knows which of her trunk circuits is to be used in establishing the connection. The relay 116, in addition to cutting the operator's telephone relay 158 into circuit, closes its armature contacts 118, 119, 120 to ground, and it is to be understood that the short wires indicated at its alternate contacts are connected to the private terminals of all trunks belonging to the operator's position whose head telephone is now cut into use, so that as long as the relay 116 remains energized, no other switch D can connect effectively with any trunk assigned to the said operator.

Furthermore, we have illustrated at H a relay 116^a which, it is to be understood, is a relay corresponding to 116 but belonging to another cord of the same operator's position, and this in conjunction with 116 shows clearly the exact wiring of this part of the system, as well as an additional local cord feature which will now be briefly described.

It has been already stated that the operator at B is provided with incoming trunks like that illustrated at E, and the operator at E not only has incoming trunks but is provided with local cord circuits like the one shown at B, and it is to be understood that the wiring and inter-relation of the local cord circuit and trunk cord circuits at the various operators' positions in both exchanges are exactly alike. Now, the relay 7 shown at H is to be understood to be the relay 7 of a local cord circuit such as shown at B but located at E. Its switch contacts 166 are omitted for convenience in B, but it will be understood from this diagram at H that whenever the listening relay 7 of any local cord circuit is energized to cut in the operator's head telephone its contact 166 is closed to ground and places ground upon a common wire. This common wire has branches extending to battery through all the relays 116, 116[a], etc., of the trunk circuits at this particular operator's position, and the result is that when the operator's telephone set is cut in on a calling line by means of any relay 7 of any of her local cords, all the relays 116, 116[a], etc., of the trunk circuits of her position will necessarily be energized and will guard the private contacts of her trunks at the switches D from being selected so that it is quite impossible for her telephone set to be connected in on two different calls at the same time. Thus, it is made sure that a trunk call will only land at the position of an operator whose telephone set is idle at the time the switch D engages the trunk.

We left the operator at E just having received the number of the called subscriber from the operator at B. The latter now restores her cut-out key CK, with the result that the windings of the calling supervisory relay CSR are substituted in the circuit with relay 107 in place of the windings of the relay 55, and the relay 57 is de-energized by the opening of contact 48, cutting off the operator's head telephone, and it is to be observed that when plug CP was first inserted in jack 67 the operation of relay 34 de-energized the listening relay 7, disconnecting the operator's head telephone at that point, so that it is now entirely free of the connection.

The relay CSR, although it now has current flowing through its windings, is not energized sufficiently to shift its contacts 32 and 33, due to the high resistance of the windings of the relay 107 at E, so that at this time the calling supervisory lamp signal 28 remains operated by current from battery through said lamp 28, normal contact 26 of relay 22, normal contact 3 of relay 1, contact 30 of relay 29, contact 32 of relay CSR, to ground at alternate contact 35 of relay 34.

The operator then having found the called line idle, inserts her plug 167 in a multiple jack J' of the wanted line, thus closing an energizing circuit for relay 122 in the trunk circuit and of cut-off relay CO' of the called line circuit, from battery through relay 122, sleeve contacts of the plug 167 and jack J', to ground through the winding of relay CO', and relay CO' energizing clears the line. Relay 122 upon energization opens its normal contact 126 to de-energize relay 116, whose retracted contacts 117 and 121 disconnect the operator's head telephone 168, while its other contacts 118, 119 and 120 unground the terminals of the other idle trunks at the position, rendering them selectable by switches D. The master ground contact MG at 122 in now closed energizing the relay 133 by current from battery through the upper winding of relay 133, its normal contact 135, alternate contact 113 of relay 110, to the master ground at relay 122, and the opening of contact 136 of relay 133 puts out the signal at 152 and closes a locking circuit for relay 133 through the lower winding from battery through its lower winding, alternate contact 136 to ground at alternate contact 112 of relay 110. A locking circuit is also closed through the upper winding of relay 133 from battery through the upper winding, its alternate contact 135 to ground at the master ground MG of relay 122. The closure of contact 137 of relay 133 operates the countermagnet 157 through contact 139 of relay 138, to count a complete trunk call for the operator at E and relay 138 is immediately energized to ground at alternate contact 137 of relay 133 and thereafter opens its contact 139 to prevent any possible reoperation of the counter magnet.

Assuming that the substation F has a harmonic bell, the operator will now actuate one of the ringing key buttons of the ringing key RK' to close the contact 155 of the ringing key button, and will select the one connected to the generator of proper frequency, and in so doing will momentarily close the end spring contact 154, which latter spring will energize relay 140 by current from battery through said relay 140, end spring 154, normal contact 132 of relay 130, to ground at MG of relay 122, and the relay 140 by the closure of its contact 142 closes a locking circuit for itself from battery through relay 140, its alternate contact 142, normal contact 150 of relay 149, through normal contact 132 of relay 130 to ground at MG of relay 122. The closing of contact 141 of relay 140 connects the constantly rotating interrupter 159 in circuit with relay 144, from battery through relay 144, alternate contact 141, alternate contact 111 of relay 110 to ground through the interrupter 159, and relay 144 will be alternately ener-

gized and de-energized, alternately closing and opening its contacts 146 and 147 to connect and disconnect the generator from the called line to periodically ring the bell at the substation, the path of the ringing current being traced through a contact 155 (the contact remaining closed after being once operated, although the end contact 154 restores as soon as the operator removes her hand from the button), the winding of the relay 149, alternate contact 147 of relay 144, tip contacts of the plug 167 and jack J′, through condenser and call bell at the substation, back through the ring contacts of the jack J′ and plug 167 and to battery at alternate contact 146. Should the called subscriber at substation F remove his receiver during a ringing interval, the slow release relay 149 will receive enough current to actuate its armature to open its normal contact 150, and this will de-energize relay 140 by opening its locking circuit, and the relay 144 will have its connection with interrupter 159 opened at contact 141 of relay 140 and will remain de-energized so that ringing current will no longer be applied to the called line. As soon as normal contacts 146 and 147 of relay 144 are closed after the subscriber removes his receiver, or if they are closed at the time he does so (the contacts being in this position during a silent interval), the relay 127 is energized by current from battery through its lower winding, through winding *d* of the induction coil, normal contact 146 of relay 144, through the ring contacts of the plug 167 and jack J′, the closed switchhook contacts at F, back through the tip contacts of the plug 167 and jack J′, normal contact 147 of relay 144, alternate contact 123 of relay 122, winding *b* and through the upper winding of said relay 127 to ground. The closure of contact 128 of relay 127 now energizes relay 130 by current from ground at MG of relay 122, alternate contact 128 of relay 127 and through relay 130 to battery, and said relay 130 by its contact 131 locks itself to said ground at MG of relay 122, and the opening of contact 132 of relay 130 cuts off all the ringing key apparatus and relays definitely from the ground MG of relay 122. The closure of contact 129 of relay 127 has short-circuited the high resistance upper winding of the relay 107, so that the resistance in the path of the current flowing through the windings of relay CSR at B is very substantially reduced, and the result is that said relay CSR now actuates its armature, and the opening of its contact 32 puts out lamp 28 at B so that the operator in the originating exchange is thus signaled that the called subscriber at the distant exchange has answered his call.

Relay CSR upon energization closes its alternate contact 32 to establish an energizing circuit for the relay 204, traced from battery through the winding of said relay 204, conductor 205, alternate contact 32 of relay CSR, conductor 206 to ground at alternate contact 35 of relay 34. The relay 204 upon energization closes a locking circuit for itself which may be traced from battery through the winding of relay 204, its alternate contact 207, conductors 208 and 206 to ground at alternate contact 35 of relay 34. The relay 36, as will be remembered, was energized over a parallel circuit with relay 34 upon the insertion of the calling plug CP into the trunk jack 67 and said circuit of relay 36 although in parallel with relay 34 passed through the normal contact 203 of relay 204 and was therefore initially controlled by the calling plug CP. The relay 204 upon energization opens its normal contact 203, opening the initial energizing circuit of the relay 36, but as relay CSR is energized as soon as the called subscriber answers, a substitute circuit is established for the said relay 36 which is traced from battery through the winding of relay 36, conductors 202 and 209, alternate contact 33 of relay CSR, conductors 210 and 201, to ground through relay 68 over the path previously described. The control of the relay 36 is now under the called subscriber, for purposes as will presently be described.

The subscribers at A and F are now in conversational circuit, the talking circuit being traced from A to F over the heavily marked conductors, the transmitter of the substation at A receiving its current through the windings of relay 12, while the transmitter at F receives its current through the windings of relay 127.

When the subscribers have finished conversation, they replace their receivers, and we will assume that the subscriber at substation A of exchange B does so first. He consequently opens the circuit of his answering supervisory relay 12, and the lamp 15 is displayed by current through normal contact 14, alternate contact 20 of relay 16, to ground through alternate contact 35 of relay 34. Furthermore, the link disconnect relay 1 is operated by current through it and traced from battery through relay 1 to ground at contact 35 over the path just described for lamp 15, and relay 1 upon energization closes its alternate contacts 2 and 6, thus opening up the talking conductors of the cord strands; and the opening of its alternate contact 4 places the sleeve contact of the plug on open circuit, thus removing the busy test from the multiple jacks J of the line of A, and in so doing the cut-off relay CO is de-energized to again place the line relay LR under the control of the substation. The closure of alternate contact 4 of relay 1 maintains the relay 16 operated, however, a substitute

locking circuit for said relay 16 being traced through contacts 18, 4, 20 and 35 to ground.

The called subscriber replacing his receiver brings about the de-energization of relay 127 and the relay upon restoring to normal opens its alternate contact 129 to remove the shunt from about the upper high resistance winding of relay 107, and this shunt removal again connects the two windings of relay 107 operatively in series with the relay CSR at B. Due to the high resistance of the windings of relay 107, relay CSR now does not receive sufficient current, and therefore restores. The relay CSR upon restoration opens its alternate contact 33, which interrupts the circuit of relay 36, thus wholly disconnecting the said relay 36 from the sleeve strand of the cord circuit. The relay 36 upon restoration opens its alternate contacts 37 and 40, interrupting the talking conductors of the cord circuit.

Should the called subscriber at substation F at the distant exchange have been the first to replace his receiver, the operation of the circuit under his control would be the same as just described, and the later replacing of the receiver at the calling substation A would operate as already described.

It will be seen that as soon as the relay 36 is cut off from the sleeve strand of the cord, the only battery connection to said cord strand is through the winding of relay 34, which relay is of very substantial resistance, for instance, 7000 to 7500 ohms. Current continues flowing through said relay and through the sleeve contacts of the plug CP and jack 67 to ground, through relay 68 at C, and this current is sufficient to maintain the relay 34 operated, but the relay 68 owing to its relatively inefficient construction and the adjustment of its armature, allows its armature contacts to be opened, and this results in the restoration of the switches C and D as follows: The opening of contact 71 of relay 68 opens the locking circuit of relay 84, which de-energizes and in so doing opens the talking wires extending to wipers 77 and 78 at its contact 85 and 88, and by closing of its normal contact 87 energizes release magnet RM by current from battery through RM through alternate contact 82 of relay 79, to ground at normal contact 87, and said release magnet RM withdraws the retaining pawl of the switch and the wipers are spring-restored to normal. The opening of contact 71, of course, has de-energized relay 72, while the restoration to zero of the switch has placed contacts ON in their normal position, and all the mechanism at C is now at normal.

On the opening of contacts 85 and 88, the relay 107 at E has its circuit opened, and consequently is de-energized. The retraction of the armature of relay 107 opens the circuit of relay 110 at contact 108, which de-energizes relay 110, the latter relay 110 in opening its alternate contact 115 de-energizing the relay 109. The opening of contact 114 of relay 110 removes ground from wiper 104 at E, and as the relay 109 is relatively sluggish to restore, it will keep its contact 230 open long enough to insure the restoration of relay 89 at D to allow its armature to fall back, whereby its contacts 90 and 93 place the talking wipers 105 and 106 on open circuit, while the closing of normal contact 92 closes an energizing circuit for the release magnet RM′ traced from battery through said magnet, contact 100 of relay 96, normal contact 92 of relay 89, to ground at alternate contact 228 of off-normal contacts ON′, and said magnet RM′, upon energizing, withdraws the retaining pawl and the wipers 104, 105 and 106 of the switch D are spring-restored to their zero point, at which time the contacts ON are restored to normal, and the opening of contact 228 opens the circuit of relay 96 and magnet RM′, whereupon said relay 96 and magnet RM′ de-energize and the apparatus of the switch is restored to normal.

It is thus seen that when the two subscribers have finished conversation, the replacing of the receiver at the calling substation instantly disconnects his line from the cord circuit due to the energization of relay 1, as already described, irrespective of the withdrawal of the plug AP. The replacing of the receiver at the called substation F at the distant exchange, irrespective of the replacing of the receiver at the calling substation A caused relay CSR to de-energize, and the relay CSR in turn opens the circuit of relay 36, which relay upon restoration severs the cord conductors at the calling end irrespective of the withdrawal of the plug CP, thus instantly disconnecting the conductors from the trunk jack 67, which brings about the release of the two switches C and D. This is very important inasmuch as it frees the trunk wires x, y, which extend from one exchange to another (usually involving a very substantial investment in capital), so that the freeing of them and the rendering of them promptly available for another connection is an item of the greatest importance in the economical operation of a telephone system.

The operator at B seeing the signal lamps 15 and 28 displayed, withdraws the plugs AP and CP from the respective jacks J and 67, and the withdrawal of plug CP de-energized relay 34 and the opening of its contact 35 de-energizes relay 1, and the apparatus and cord circuit are at normal.

The de-energization of relay 110 at E, as above described, results in the lighting of the supervisory lamp S, from battery through the lamp S, alternate contact 125 of relay 122, to ground at normal contact 112 of relay 110, and the operator at E observing the signal withdraws the plug 167 to de-energize relay 122 of the trunk cord E, and the relay 122 now restoring opens its master ground contact MG, and the apparatus of the trunk cord is placed at normal, while the withdrawal of the plug 167 has restored the line circuit of called substation F by de-energizing cut-off relay CO'.

It will be observed that in the preceding description of the operation of the cord circuit B when used for a trunking call, the signal lamp 28 remained lighted while the called for subscriber was being rung, the circuit of said lamp being traced through contacts 26, 3, 30, 32, 35 to ground at relay 34. This was effective because of the high resistance of the two windings of relay 107 then in circuit with the windings of relay CSR, such resistance being so great as to prevent the actuation of the armature of relay CSR. The cord circuit at B thus operated on the light key shelf principle, so-called, in which the calling supervisory lamp is maintained lighted until the called subscriber answers, and the originating operator through said lamp 28 has an indication of such response.

Returning now to the point at which the conversation was finished, if the subscriber at F was to replace his receiver first, he would obviously, whether the dotted circuit in E was wired or not, by the de-energizing of relay 127, cause the display of the lamp 28 before the operator at B. When the calling subscriber at A replaces his receiver this act brings about the de-energization of relay 12, which de-energization would effect the energization of relay 1 and cause the display of lamp 15, and the closing of alternate contact 3 of relay 1 will permit the continued display of lamp 28.

Lamp 153 in the trunk circuit E is merely a guard lamp which is lighted as soon as master ground MG of relay 122 is closed, the said lamp being lighted, indicating to the operator that she has not actuated her ringing key lever to ring the called subscriber, As soon as she does so, closing contact 154, the relay 140 energizes and locks, and the opening of normal contact 142 puts out the lamp 153.

Let it be assumed that although the called substation bell was rung, the called subscriber did not answer the call. In such case the calling subscriber will replace his receiver and denergize relay 12 to energize relay 1. The relay 1 upon energization brings about the lighting of the lamp 15 and the operator at B noting the two lighted signals 15 and 28 withdraws the answering and calling plugs AP and CP, and the withdrawal of the plug CP brings about the restoration of switches C and D, as is obvious from the previous description.

Switches C and D upon restoring, the circuit of relay 107 will be opened and said relay 107 will de-energize, and as a consequence relay 110 will also de-energize.

Let it be assumed now that a calling subscriber at A removes his receiver to initiate a call for a subscriber in his own exchange. The operation of the line circuit and cord circuit of Figure 1, part 1, would be the same as that already described until after the operator has received the number of the called subscriber. In this case she will not actuate the key CK, but as usual she will test a multiple spring jack of the called subscriber's line whose line circuit and substation would have exactly the same arrangement as that of the subscriber A. To make the test the operator touches the tip of the plug CP to the sleeve of a jack of the called line, and if this sleeve of the jack is busy because a plug of another cord circuit has already been placed in a multiple of the jack tested (provided always that the subscribers have not effected the automatic disconnect), there will be a potential above ground at the tested sleeve contact and an impulse of current will flow through the tip of plug CP, normal contact 46 of key CK, normal contact 42 of relay 41, the closed contact 8 of relay 7, and to ground through the test relay 62 which is common to an operator's position. The relay 62 will close its alternate contact 63 to close battery through the tertiary winding of the operator's induction coil, giving her the cutomary busy click.

Moreover, the test arrangement provides means for giving the operator a revertive tone test, if she tests a spring jack of the line in which she has already inserted the answering plug of the cord, that is, if the calling subscriber wants another subscriber on his own line, the system thus providing for the case in which there are a number of substations connected to a single line as a party line. In making such a revertive test the operator will receive the click as usual, but in addition the closure of alternate contact 64 of relay 62 will connect the revertive tone test apparatus 65 to the operator's head telephone, the circuit being traced from the tone 65 through alternate contact 64, alternate contact 11 of relay 7, normal contact 4 of relay 1, through the sleeve contacts of plug AP and jack J in which that plug AP is inserted, thence to the sleeve of the jack being tested, and over the tip of the plug CP which is testing the multiple jack of the wanted line, through contact 46 of key CK, contact 42 of relay 41, alternate contact 8

of relay 7, through the condenser 235 and through the tertiary winding of the operator's induction coil to ground. The operator hearing the buzz will know it is a reverting call, tell the calling subscriber to momentarily replace his receiver, and she will then withdraw plug AP, inserting the calling plug CP and ring in the usual manner.

But assuming now that the substation called for is on an idle line entirely independent of that of the subscriber at A, the operator receiving no click upon her test, inserts the calling plug CP in the tested jack, thus placing the relays 36 and 34 of her cord circuit in connection with ground through the winding of cut-off relay CO of the called line, and said relays 36 and 34 are both operated with results to the switching instrumentalities of the calling end of the cord circuit, as previously described herein, and the cut-off relay CO of the called line will, of course, energize to clear the line circuit for talking and ringing, the line relay LR being disconnected. The operator at B now actuates whichever ringing key lever 49 will impress current of the proper frequency to ring the bell of the called substation, the contact 49 staying in its closed position while the end springs 51 and 52 of the ringing key are shifted to close their contacts, but only as long as the operator holds the ringing button down. By the closing of contact 52 the relay 22 energizes over a circuit which may be traced from battery through relay 22, end spring contact 52, normal contact 3 of relay 1, contact 30 of relay 29, normal contact 32 of relay CSR to ground at alternate contact 35 of relay 34, and relay 22, due to the closure of its contact 26, locks itself to ground at contact 35, over the just described path. By the closure of contact 51 of the end springs, the upper winding of the ringing relay 41 receives current from battery through the upper winding of relay 41, contact 51 of the end springs to ground at contact 25 of relay 22, so that the called substation is instantly rung and will continue to be rung as long as the operator keeps the contacts 51 and 52 closed. When she releases the button, said end spring contacts 51 and 52 restore to normal, and the upper winding of relay 41 is disconnected, but the lower winding of said relay, due to the closing of alternate contact 24 of relay 22, has been connected with the constantly operating interrupter I and will be alternately energized and de-energized, connecting and disconnecting the selected ringing generator. The flow of ringing current is to be traced from ground through the selected generator, the closed contact 49 of the ringing key, lower winding of relay 29, alternate contact 42, of relay 41, contact 46 of key CK, the tip contacts of the plug CP and jack of the wanted line, through the call bell at the called substation, back through the ring contacts of the plug CP and jack of the called line, and to battery at alternate contact 45 of relay 41. If the subscriber answers during a ringing interval, the reduced resistance at the substation caused by the removal of his receiver will allow sufficient current to flow through the lower winding of relay 29 to energize it (it having previously remained inert because of the high resistance call bell circuit at the substation), and the said relay 29 upon energization opens its normal contact 30 to de-energize the relay 22 by opening its locking circuit that extends to ground at alternate contact 35 of relay 34, and the said relay 22 restoring does not reoperate because the contact 52 of the end spring is now open. Its retracted armature contacts 23 and 27 re-establish the talking circuit at these points, and the opening of its contact 24 prevents any further operation of ringing relay 41, which relay de-energizes, and the contacts 42 and 45 of relay 41 complete the talking circuit between the subscribers. The closing of contacts 42 and 45 also connects the two windings of calling supervisory relay CSR to the called for line and it energizes, since the substation receiver has been removed. The relay CSR upon energization closes an energizing circuit for the relay 204 and the said relay in turn closes a locking circuit for itself, as previously described. The relay 204 by the opening of its normal contact 203 opens the initial energizing circuit for the relay 36, but the said relay 36 has a substitute circuit established upon the closing of alternate contact 33 of relay CSR, thus placing the said relay CSR under the control of the called subscriber, for purposes as will presently be described.

If the called subscriber had removed his receiver during a silent interval, the relay 41 would be in a de-energized condition and its contacts 42 and 45 would be closed and relay CSR would instantly have energized over the called-for line, and by the opening of its normal contact 32 the relay 22 is de-energized with results as before.

The calling and called subscribers are now in conversation, and when they have finished they replace their receivers. It will be assumed that the called-for subscriber does so first. The opening of the transmitter circuit at the called substation de-energized relay CSR and the closing of its contact 32 will cause the lamp 28 to be lighted over a circuit from battery, through the lamp 28, normal contact 26 of relay 22, normal contact 3 of relay 1, normal contact 30 of relay 29, normal contact 32 of relay CSR, to ground at alternate contact 35 of relay 34. The relay CSR upon de-energization opens its alternate contact 33, opening

the energizing circuit of the relay 36, and the relay 36 upon de-energization opens its alternate contacts 37 and 40, interrupting the talking conductors of the cord circuit connected to the called line. The sleeve relay 34 is now the only relay remaining connected to the sleeve strand of the cord, but due to the high resistance of relay 34 the cut-off relay CO of the called line does not receive enough current to permit its armature to remain attracted, and the result is that relay CO de-energizes and allows its contacts to restore, and again places the line relay LR of the line circuit associated with the called line under the control of the called substation switchhook. The multiple jacks of the called line will also test idle at this time due to the high resistance of the relay 34, which reduces the potential upon the said multiple jack so as to make the operator's test ineffective if some operator tests that line again as a called line, irrespective of the withdrawal of the plug CP. The calling subscriber in replacing his receiver upon its switchhook opens the energizing circuit of the relay 12 and the resulting de-energization of relay 12 by the closing of its normal contact 14, energizes the relay 1 by current flowing to ground at alternate contact 35 of relay 34, and by the opening of its normal contacts 2, 4 and 6 all three contacts of plug AP are placed on open circuit so that the line of the calling subscriber is restored to its normal condition as far as signaling and testing purposes go. It will be observed that the closing of alternate contact 4 of relay 1 establishes a substitute locking circuit for the relay 16 before said relay 16 has time to retract, said substitute circuit being traceable through alternate contact 4 of relay 1, normal contact 14 of relay 12, its contact 20 and to ground at alternate contact 35 of relay 34. The closing of normal contact 14 of relay 12 closes a circuit for the supervisory lamp 15 to ground at alternate contact 35 of relay 34, and both lines are now free and the lamps 28 and 15 are both lighted, and the operator noting the two lighted signals withdraws the two plugs, and restores all apparatus of the cord circuit to its normal condition.

It will be noted that the circuit of the calling supervisory lamp 28 extends through the back contact 26 of relay 22, and as the said relay is energized when the operator depresses her ringing button, said circuit will be opened at back contact 26 to efface the lamp 28 at this time and will remain effaced until the called for subscriber replaces his receiver whereupon the lamp 28 will light, either through its original energizing circuit, namely, via the normal contact at 26, or if the calling subscriber has already replaced his receiver, the said lamp 28 will be lighted by current through alternate contact 3 of relay 1. We thus have what is known as the dark keyshelf method of operation.

While we have illustrated and described a particular embodiment of our invention, it is to be understood that it is of considerable scope, and we do not intend to be limited to the particular devices and connections herein shown and described, but intend to include all such modifications as will suggest themselves to those skilled in the art, and to claim the invention in its general aspects.

What we claim as new and desire to secure by United States Letters Patent, is:

1. A telephone system comprising telephone lines terminating in operators' positions, subscribers' cord circuits and trunk circuits at each of said positions for interconnecting said lines for conversational purposes, an operator's telephone set for each of said positions and normally disconnected from said cord circuits, a relay having a high and a low resistance winding, means for connecting an operator's set to a line through a cord circuit, said relay preventing another operator from connecting her operator's set to a cord circuit when connected to said line subsequent to the connection of said first cord circuit to said line, and means controlled by the subscribers to operatively free both lines from said cord circuit and said trunk circuit when applied to the terminals of said lines, the freeing of said lines from the said cord circuit being individually under the control of each subscriber.

2. A telephone system comprising calling and called telephone lines terminating in a plurality of operator's positions, a subscriber's cord circuit, for connecting said lines in conversational circuit, automatic means including a relay having a high and a low resistance winding for preventing more than one operator from connecting to said calling line at the same time, means controlled by the said calling and called subscribers to free said lines from said cord circuit, a pair of relays included in said first means and responsive to a connection of a cord circuit to a called line for connecting said pair of relays in parallel circuit, and a supervisory relay controlled by said called subscriber for placing one of said relays under the control of said called subscriber for freeing said called line from the connected cord circuit.

3. A telephone system comprising calling and called subscribers' lines connected for conversation by a subscriber's cord circuit, relay controlled means under the control of each subscriber for individually freeing his line from the connected cord circuit, including a pair of relays responsive to a connection of said cord circuit to a called line for connecting said pair of relays in parallel circuit, a relay, a supervisory relay, and means under the control of the answering called for subscriber for energizing said supervisory

relay to energize said last relay for placing one of said pair of relays under the control of the said called subscriber for freeing said called line from said connected cord circuit for disconnect purposes.

4. A telephone system comprising calling and called subscribers' lines connected for conversation by a subscriber's cord circuit, relay controlled means under the control of the connected subscribers for individually freeing their lines from the connected cord, including a pair of relays responsive to a connection of said cord circuit to a called line for connecting said pair of relays in parallel circuit one of said relays being initially under the control of the said operator, a supervisory relay electromagnetic means, means under the control of the answering called for subscriber for energizing said supervisory relay to actuate said electromagnetic means for removing one of said pair of relays from the control of the operator and placing it under the control of the said called subsciber for freeing said called line from the said connected cord circuit while said connected cord circuit remains connected to said lines.

5. A telephone system comprising a calling subscriber's line and a called subscriber's line, cord circuits and trunk circuits for interconnecting said lines, means controlled by the subscribers and applied to the terminals of said lines to operatively free both lines from said cord circuit and said trunk circuit, the freeing of said lines from said cord and trunk circuits being individually under the control of each subscriber, automatically selecting switch mechanisms for selecting said cord and trunk circuits and adapted to be connected in circuit intermediate of said cord and trunk circuit during conversation and means for releasing said switch mechanisms effective on the operative freeing of the called line.

6. A telephone system comprising calling and called telephone lines connected for conversation by a subscriber's cord circuit, means controlled by the said calling and called subscribers to free said lines from said cord circuit, a pair of relays responsive to a connection of said cord circuit to a called line for connecting said pair of relays in parallel circuit, a supervisory relay, means under the control of the answering called for subscriber for energizing said supervisory relay to place one of said relays under the control of said called subscriber for freeing said called line from the connected cord circuit, automatic selecting switch mechanism connected in circuit with said cord circuit during conversation, and means for releasing said mechanism effective on the operative freeing of the called line.

7. A telephone system comprising calling and called subscribers' lines connected for conversation by a subscriber's cord circuit, relay controlled means under the control of each subscriber for individually freeing his line from the connected cord circuit, including a pair of relays responsive to a connection of said cord circuit to a called line for connecting said pair of relays in parallel circuit, a supervisory relay, means under the control of the answering called for subscriber for energizing said supervisory relay to energize one of said relays under the control of the said called subscriber for freeing said called line from said connected cord circuit for disconnect purposes, automatic selecting switch mechanism connected in circuit with said cord circuit during conversation, and means for releasing said mechanism effective on the operative freeing of the called line.

8. A telephone system comprising calling and called subscribers' lines connected for conversation by a subscriber's cord circuit, relay controlled means under the control of the connected subscribers for individually freeing their lines from the connected cord, including a pair of relays responsive to a connection of said cord circuit to a called line for connecting said pair of relays in parallel circuit, one of said relays being initially under the control of said operator, other means, a supervisory relay, means under the control of the answering called for subscriber for energizing said supervisory relay to actuate said other means for removing said one of said relays from the control of the operator and placing it under the control of the said called subscriber for freeing said called line from the said connected cord circuit while said connected cord circuit remains connected to said lines, automatic selecting switch mechanism connected in circuit with said cord circuit during conversation, and means for releasing said mechanism effective on the operative freeing of the called line.

9. A telephone system including a pair of telephone lines and a central office link circuit having a pair of terminals connected one to each line, automatic selecting switch mechanism intermediate said pair of terminals for controlling talking contacts in said telephone system, means controlled over each line independently of the other for placing the talking contacts of the associated terminal on open circuit (between said terminals) while they remain connected to said lines.

10. In a telephone system a calling and a called line having terminals, link circuit means including terminals connected to said first terminals interconnecting said lines for conversation, an automatic selecting switch mechanism also included in said link circuit means intermediate said second ter-

minals for controlling talking contacts in said telephone system, and means independently controlled over each line to operatively free it from said link circuit means and to permit restoration of said automatic switch while said link circuit terminals remain connected to said first terminals.

11. A telephone system including a calling line and a called line and link circuit means interconnecting them including a link circuit terminal connected to a terminal of the called line, an operator's telephone set normally disconnected from said circuit, means solely controlled over the called line for operatively freeing said line from said circuit while said terminals are connected, said means including a pair of single wound relays in energized condition before and during conversation, means effective to deenergize the one relay only when the called subscriber replaces his receiver, and means for preventing connection of said operator's set to said circuit so long as said link circuit terminal is connected to the terminal of said called line.

12. A telephone system including a calling and a called line connected for conversation by link circuit terminals connected to them respectively, automatic switches intermediate said link circuit terminals operable for extending and closing contacts in the talking conductors of said telephone system, means controlled by the calling and called subscribers to free their lines from the link circuit and to permit said automatic switches to restore while said terminals remain connected, said means including a pair of relays responsive to a connection of said link circuit to a called line for connecting said pair of relays in parallel circuit, a third relay, and means under the control of the answering called for subscriber for energizing said third relay to place one of said relays under the control of the called subscriber for freeing said called line.

13. A telephone system including a calling and a called line connected for conversation by link circuit terminals connected to them, a pair of relays responsive to a connection of said link circuit to a called line, the called line, a third relay actuated on the response of the called subscriber to place one of said relays under control of said subscriber, and switching means thereon controllable by said one of said relays to operatively free said called line while the link circuit terminal remains connected to said line.

14. A telephone system, comprising telephone lines, subscribers' cord circuits for interconnecting said subscribers' lines for conversational purposes, a sleeve relay for said cord circuit responsive to a connection of said cord circuit to a called line, a second relay energized in parallel with said sleeve relay extending through contacts of a third relay and initially under the control of the operator, a supervisory relay, means under the control of the answering called for subscriber for energizing said supervisory relay to energize said third relay and open said initial circuit of said second relay and to close a substitute circuit for said second relay, placing it under the control of said called subscriber and placing its substitute energizing circuit under the control of the called subscriber.

15. A telephone system comprising telephone lines, subscribers' cord circuits for interconnecting said subscribers' lines for conversational purposes, a high resistance sleeve relay responsive to a connection of said cord circuit to called lines, a second relay, a relay initially energized in parallel with said sleeve relay extending through contacts of said second relay, a supervisory relay, and means under the control of the answering called for subscriber for energizing said supervisory relay to energize said second relay for opening said initial circuit of said third relay and for closing a circuit for said first relay under the control of said supervisory relay.

Signed by us at Chicago, in the county of Cook and State of Illinois, this 25 day of April, 1921.

HIRAM D. CURRIER.
GEORGE R. EATON.