Jan. 14, 1941. F. J. SINGER 2,228,890

TELEGRAPH EXCHANGE SYSTEM

Filed July 31, 1937 4 Sheets-Sheet 1

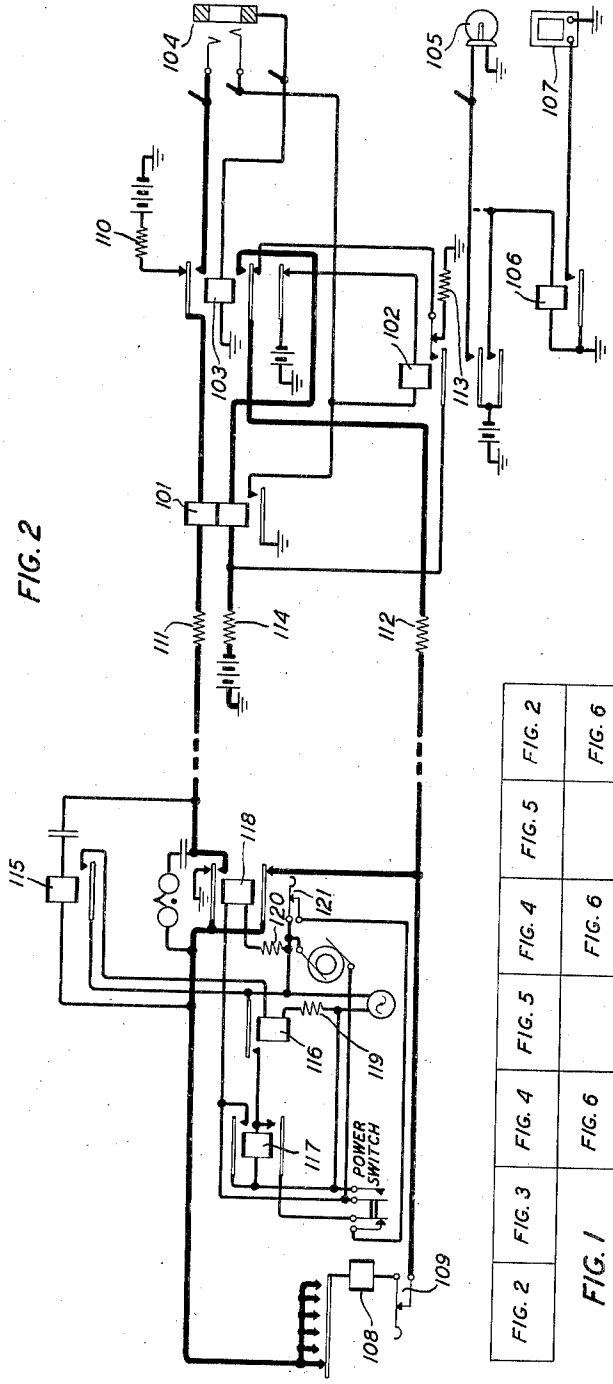

FIG. 2

FIG. 2	FIG. 6	
FIG. 5		
FIG. 4	FIG. 6	FIG. 2
FIG. 5		
FIG. 4	FIG. 6	FIG. 2
FIG. 3		
FIG. 2		

FIG. 1

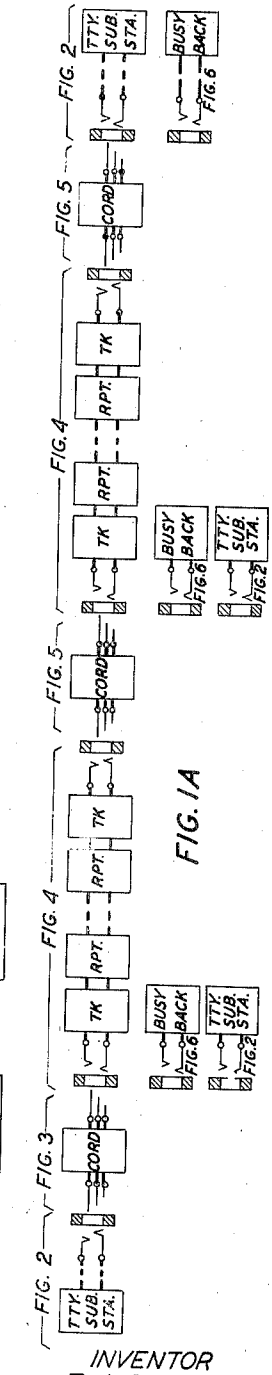

FIG. 1A

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TELEGRAPH EXCHANGE SYSTEM

Filed July 31, 1937 4 Sheets-Sheet 2

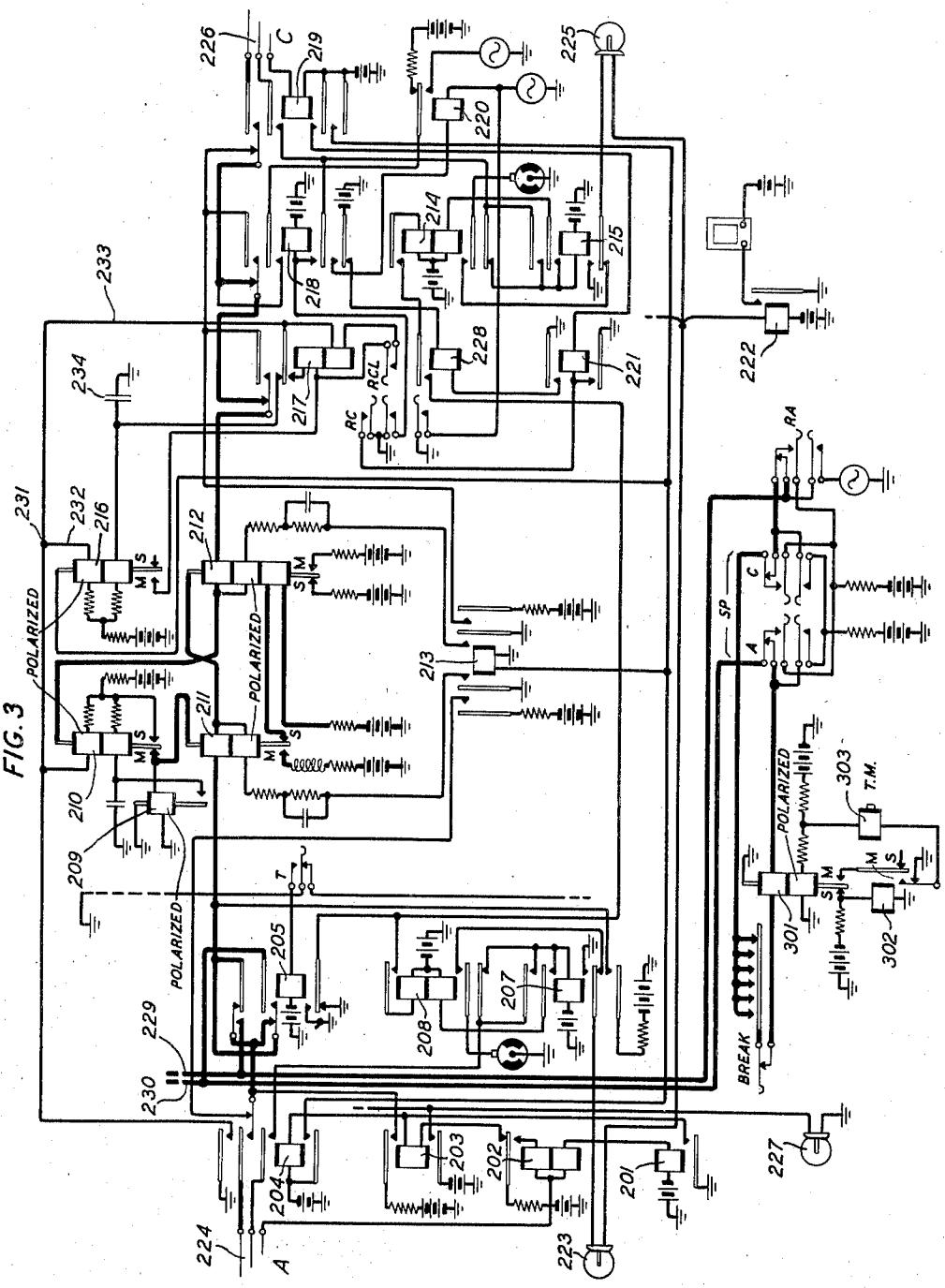

FIG. 3

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TELEGRAPH EXCHANGE SYSTEM

Filed July 31, 1937 4 Sheets-Sheet 3

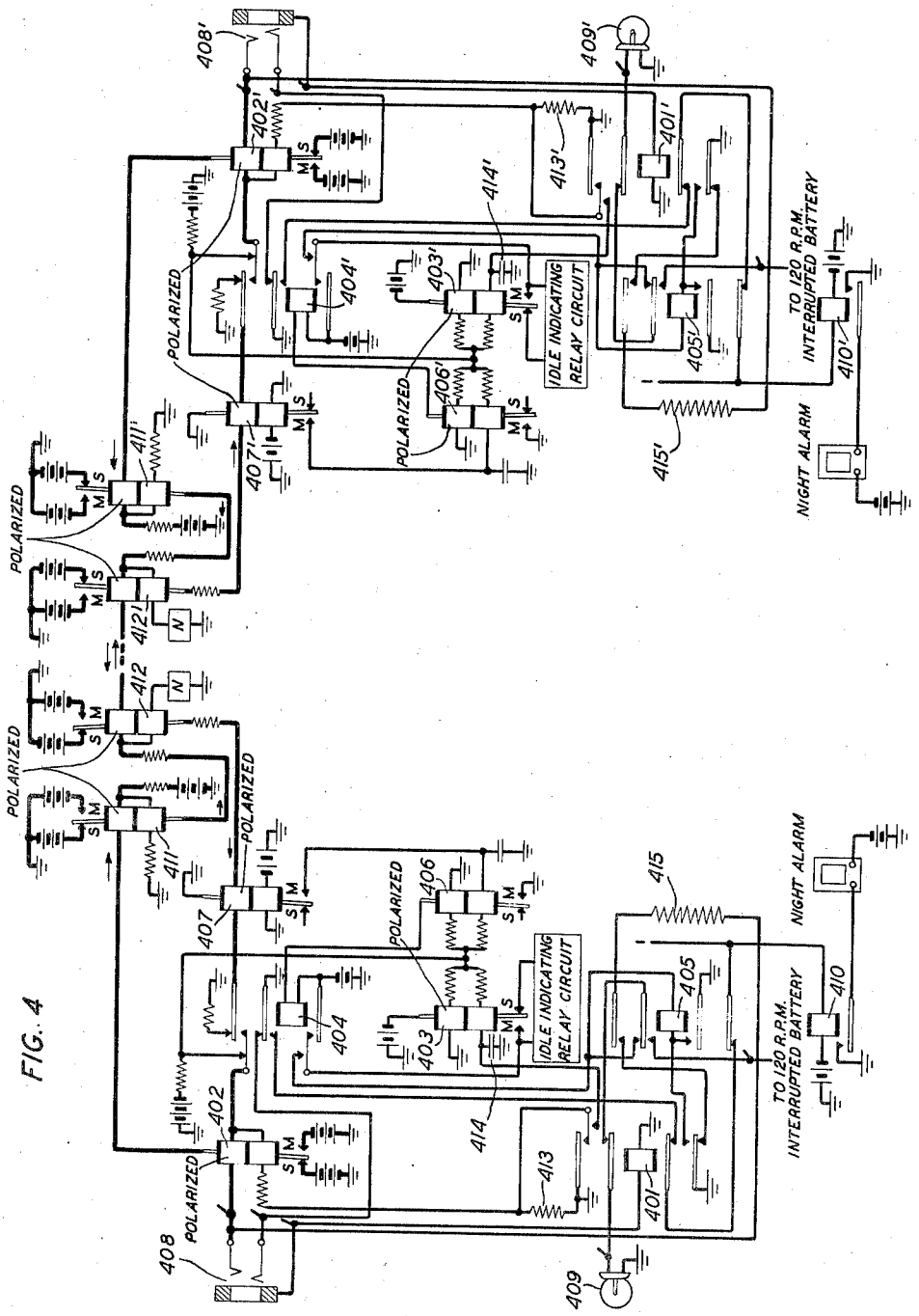

FIG. 4

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TELEGRAPH EXCHANGE SYSTEM

Filed July 31, 1937 4 Sheets-Sheet 4

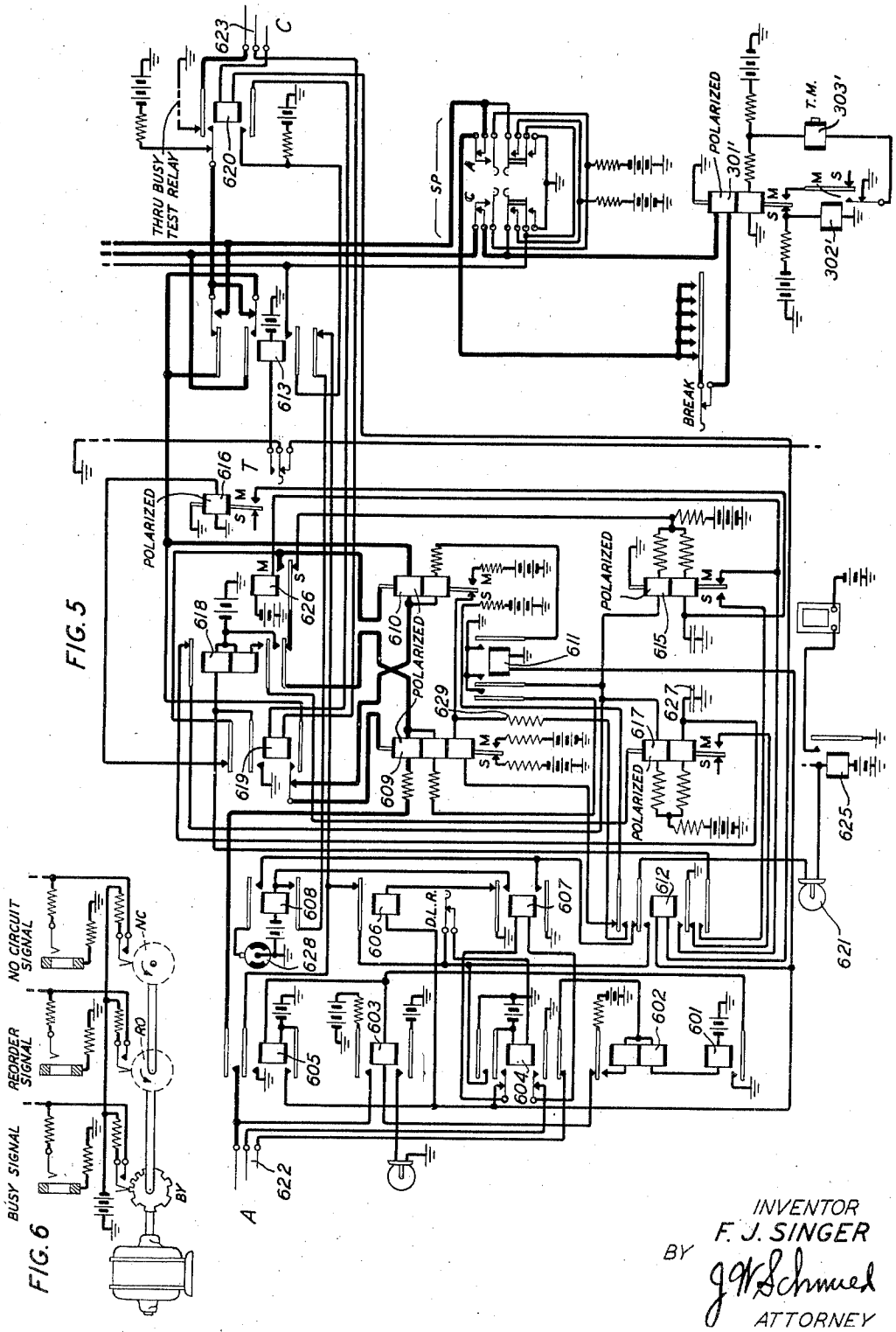

FIG. 5

FIG. 6

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UNITED STATES PATENT OFFICE

2,228,890

TELEGRAPH EXCHANGE SYSTEM

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Application July 31, 1937, Serial No. 156,684

54 Claims. (Cl. 178—2)

This invention relates to telegraph exchange systems generally and more particularly to printing telegraph exchange systems wherein any two of a plurality of subscribers or signaling stations in the same or distant exchange areas can be connected together by switching operations at a plurality of central interconnecting stations by the straightforward trunking method.

The novel features and principles of making connections of this invention are described herein as applied to a straightforward manual printing telegraph exchange system. The application of these principles is not necessarily limited to such an exchange system, but may be applied also by certain adaptations to mechanical and semi-mechanical straightforward telegraph or equivalent impulse transmission systems.

The service provided by this telegraph system corresponds in general to straightforward toll telephone exchange system service.

A feature of this invention is the arrangement of the straightforward circuits to provide through supervision.

A further feature of this invention is the operation of the facilities interconnecting the originating, herein called "outward," and completing, herein called "inward," toll central stations, through intermediate, herein called "through," toll central stations when required, and including the calling portion of the outward central office cord and the answering portion of the inward central station cord on a full duplex basis.

A further feature of this invention is the maintenance at all times while a connection is established, between an outward and inward toll central station, involving through central stations when required of one independent channel in each direction, over which both supervisory and communication signals are transmitted on a full duplex basis through the interconnecting facilities including the portions of the cords mentioned in the foregoing paragraph.

A further feature of this invention is the extension of the full duplex central station interconnecting facilities abovementioned to local stations on a half-duplex basis.

A further feature of this invention is the arrangement whereby supervisory signals, indicating the progress of the call and control of ringing, recall and disconnect are localized in the cord circuit of the outward toll central station.

A further feature of this invention is that disconnect signals to the through and inward operators are controlled by the outward operator.

A further feature of this invention is an arrangement whereby all supervisory signals originated by the called and calling subscribers appear only in the outward board.

A further feature of this invention is an arrangement whereby the outward operator can send recall signals to the inward operator.

A further feature of this invention is an arrangement whereby identical cord circuits, that is to say, circuits similar in every respect to those used in the through central station for extending a toll call are used at the inward toll central station and vice-versa.

A further feature of this invention is an arrangement whereby the cord used in the outward toll central office to answer a call may be used either to extend a toll call or to complete a call to a local subscriber and the supervisory features in the cord at the outward toll central station are essentially the same in either instance.

A further feature of this invention is that all subscriber-to-subscriber communication and all signals necessary to the establishing of a connection between two subscribers' stations as well as break, recall and disconnect signals are transmitted over the telegraph facilities in the system without the aid of call circuits or order wires or other auxiliary facilities.

A further feature of the invention is the provision of equipment for increasing the speed with which break, recall and disconnect signals are transmitted over the system.

A further feature of the invention is the location of the apparatus responsive to break signals in the cord circuits of the outward and inward toll offices, respectively, and their disposition in such manner that break signals do not interfere with the full duplex operation of the facilities interconnecting the outward and inward toll offices, including the calling portion of the outward cord and the answering portion of the inward cord.

A further feature of the invention is the limited participation of through and inward toll central station operators in a call. Their participation is restricted to answering the toll line signals, extending the call, and disconnecting and, in the case of the inward toll operator, answering recall, all in response to supervisory signals and information from the outward toll operator who alone is concerned with subscriber signals.

A further feature of this invention is a means whereby an outward operator may start an unattended called station motor and have an indication when the station has been started.

A further feature of this invention is that code

signaling devices to indicate various line conditions are located at each central station to facilitate operation by reducing operating time.

A further feature of this invention is that each end of each interoffice trunk is arranged to automatically signal the operator when a cord is removed from a trunk in error.

A further feature of this invention is that if any cord is removed from any trunk in error, the operator, upon noting the error signal, may reinsert the cord removed in error in the jack without losing the connection.

A further feature of this invention is that at the completion of a call a connection involving one or more through boards will be automatically broken down when the operator at the outward board removes the completing cord from the trunk jack regardless of whether the cords at the through and inward boards are removed from the respective trunk jacks at these officers. Furthermore, a visual indication is registered in these cords and remains until the operators pull down. The trunks may therefore be used for new calls regardless of when the inward and through operators act on the disconnect signals.

A further feature of this invention is the complete provision of guarded busy intervals on the trunks, which prevent an outward operator from completing to a trunk until both ends are prepared to receive the call.

The invention has been illustrated in the accompanying drawings.

A diagram, Fig. 1, on page 1 shows how Figs. 2 to 6 comprising the circuit arrangements of this invention are disposed with relation to each other.

Fig. 1A shows in block form an elaboration of the diagram, Fig. 1, to include plug and jack symbols to convey the figure relationships more graphically. The indicated connections are arranged from left to right in sequence of operation. The top line of this figure shows a telegraph toll connection involving one through toll central station. The invention, however, is not limited to one such through toll central station but may be, and in practice quite frequently will be, extended through a number of such stations.

The teletypewriter subscriber station and busy-back symbols in the lower portions of Fig. 1A indicate terminating connections with cords above at the respective points. The lower left-hand Fig. 2 indicates that the cord in the outward toll central station may be terminated in a subscriber station circuit as in the case on a local call.

The teletypewriter subscriber's station in the lower center indicates that the through and inward cord is universal and may be used to complete a connection to a subscriber's station and further, that a through toll board is not needed in certain toll calls.

The three busy-back symbols in Fig. 1A indicate that connections may be made to a source of teletypewriter code signals generally at the various offices as a time saver to facilitate operation.

The various symbols shown in Fig. 1A are not intended to represent individual units only. They represent an unlimited number of subscribers' stations interconnected through an unlimited number of central stations, links, trunks, etc., in a flexible straightforward, toll-telegraph system.

Fig. 2 shows a subscriber's station line circuit. The apparatus and wiring shown at the left is located at the subscriber's station. The apparatus and wiring shown at the right is located at the outward central station. The two points are interconnected by the subscriber's loop. The subscriber's station portion of the circuit includes apparatus and wiring for unattended as well as attended operation. It is to be understood that the station arrangement may be simplified by eliminating the apparatus and wiring for unattended service when this feature is not required.

Fig. 3 shows the cord circuit used at the originating central station. The left-hand portion in general is used in association with the subscriber's line, Fig. 2. The right-hand portion in general is used in extending a toll call through a trunk, Fig. 4, or it may be used to complete a local call directly to a called subscriber's line in which case the right-hand portion would be used with a second Fig. 2.

A central station operator's printer circuit, common to all the cords at an operator's position and selectively connected to and disconnected from a particular cord, through the operation of the cord typing key, is shown at the bottom of Fig. 3.

Fig. 4 shows the trunk circuit used on calls other than local, for interconnecting the various central stations. The circuit may be considered as comprising two identical units. The left-hand portion is located at one office and the right-hand portion at another connecting office. The circuit shows two full duplex telegraph line repeaters, one at each office. A single wire ground-return circuit is shown interconnecting the two full duplex telegraph line repeaters. It is understood that this is typical, as the invention is not so limited, but will function on all types of full duplex telegraph circuits, including carrier telegraph circuits. It is also understood that, although only one section of line facility is shown, there may be two or more in tandem made up of direct current or carrier full duplex facilities.

Fig. 5 shows a universal toll cord circuit. It may be used for two purposes: First, at an intermediate toll central station for extending a toll call in conjunction with two Figs. 4, one on each end of the cord; second, at an inward toll central station for completing a call to a called subscriber's line in conjunction with one Fig. 4 on one end of the cord and one Fig. 2 on the other end.

In Fig. 5 is shown also, as in Fig. 3, a central station operator's position printer circuit, common to all the cords at an operator's position and arranged to be selectively connected to or disconnected from a particular cord through the operation of the cord typing key.

Fig. 6 shows the arrangement whereby busy-back, reorder and no-circuit signals may be sent back over the circuit to indicate these conditions at boards to which the call has been extended. Since the subscribers' printers and the printers at the various stations are arranged so that they can be directly interconnected over the circuit to pass information by teletypewriter, the circuit shown in Fig. 6 is not necessary to the operation of the system but is used as an operating time-saving device.

The detailed description of the operation of the circuits involved in this invention follows:

1. Built-up Connection With One Intermediate Central Station

A straightforward toll call will now be described involving the use of an outward board, a through board and an inward board. Although but one through board is considered in this con-

nection it is to be understood that the circuit might be extended through a number of through boards, Figs. 3 and 4 being repeated as necessary and functioning as described herein for the case involving but one through board.

A. *Calling subscriber calls—Fig. 2*

To signal an operator at an outward board, the calling subscriber closes the power switch at the subscriber's station, whereupon the associated station line lamps in the multiple at the outward board light. The detailed operation may be understood by reference to Fig. 2.

When the calling subscriber closes the power switch, alternating current is supplied to the station teletypewriter motor from a power source at the station through the power switch make contact, starting the motor. Closing the switch also supplies alternating current from the same source through resistance **120**, relay **118** winding, armature and make contact of the power switch, to the alternating current source. Relay **118** operates, removing ground from the ring of the subscriber's loop at its upper armature and back contact and closing the loop through the same armature and front contact. The station ringer is short-circuited. Normal current flows through the loop which may be traced from positive battery, resistance **110**, upper back contact and armature relay **103**, upper winding relay **101**, resistance **111**, upper front contact and armature relay **118**, teletypewriter contacts, teletypewriter magnet **108**, break-key **109**, resistance **112**, lower inner armature and back contact relay **103**, break contact relay **102**, resistance **113** to ground. At the central office, differential relay **101** operates since current passes through its upper winding. Operation of relay **101** closes a circuit from ground through armature and front contact relay **101**, winding relay **102**, lower outer back contact and armature relay **103** to negative battery. Relay **102** operates and lamp **105** lights. Night alarm relay **106** operates.

A1. *Calling subscriber abandons call—Fig. 2*

To abandon a call, the calling subscriber opens the power switch at the subscriber's station, extinguishing the line lamp at the outward board and restoring the circuit to normal. Reference to Fig. 2 will show the operation in detail.

The power switch at the subscriber's station which has been operated to close the right-hand make contact is now reoperated to its normal position. The circuit from the power source for the operation of the teletypewriter motor and relay **118** is broken. The teletypewriter motor stops. Release of relay **118** breaks the circuit loop and grounds the ring at its upper armature. The circuit through the upper winding of relay **101** is broken and it releases. The circuit through relay **102** is broken when relay **101** releases. Relay **102** releases. Lamp **105** is extinguished and relay **106** is released.

B. *Outward operator answers—Figs. 2 and 3*

Prior to answering the operator awaits a call by operating a typing key T, associated with an idle cord to associate the position printer with that cord. She plugs her answering cord into the jack associated with the lighted subscriber's line lamp, extinguishing the lamp. The operator then communicates with the calling subscriber.

The detailed functioning of the circuit may be understood from reference to Figs. 2 and 3.

In Fig. 3, the typing key T, is operated to its upper contact. Relay **205** operates from ground through the key armature and upper contact, winding relay **205** to battery, connecting the operator's position circuit to the cord. The transmission circuit is open, however, since relays **204** and **213** are not operated. Relay **301** is on its S contact under control of current through its lower winding. Relay winding **302** is short-circuited and the teletypewriter magnet **303** is closed, preventing the teletypewriter mechanism from "spinning." Since the transmission circuit is open, operating the teletypewriter keyboard contacts has no effect on the mechanism.

The operator inserts the answering cord plug **242** into the station line jack **104** of Fig. 2, to answer the call. Relays **201** and **202** in the answering cord and relay **103** in the station line circuit are connected in series and operate over a circuit from battery through relay **201** winding, lower winding relay **202**, sleeve plug **224**, sleeve jack **104**, winding relay **103** to ground. Operation of relay **103** causes relay **102** to release by breaking its circuit at relay **103** lower outer armature and back contact. Relay **102** released, extinguishes line lamp **105** and releases relay **106**. Operation of relay **103** connects negative battery through resistance **114**, lower winding of differential relay **101** to the loop ring conductor, releasing relay **101** and removing ground from the ring conductor of jack **104**. Operation of relay **201** in the cord closes a circuit to relay **204**, which operates. Operation of relay **202** removes battery from relay **203** winding, preventing it from operating even though relay **201** has operated.

When relay **204** operates, the ring circuit of jack **104** is connected through the lower break contact of relay **208** to relay **207** winding. Relay **207** does not operate since relay **101** has released and the ring is not grounded.

The operation of relay **204** also connects the tip circuit of jack **104** through tip of plug **224**, make-before-break contact relay **204**, top outer make-before-break contact relay **205**, conductor **229**, break contacts ringing key, RA, break contacts of C portion of splitting key, SP, teletypewriter keyboard contacts, break key, upper winding relay **301**, break contact of A portion of splitting key, SP, conductor **230**, top inner armature and front contact relay **205**, upper winding relay **211** to positive battery through M contact relay **212**. The transmission circuit to the station is therefore closed from negative battery at winding relay **101** to positive battery on the contact relay **212**. The station and operator's teletypewriters are in series. Relay **301** operates to M and relay **302** operates. The operator's keyboard is no longer locked and the magnet is under control of relay **301**. The operator and station subscriber may now communicate.

Relay **204** also closes a circuit from battery through its bottom armature and front contact, through relay **213** winding to ground, operating relay **213**. Relay **204** also closes a circuit from ground through its top outer armature and front contact, through the top winding relay **210**, to positive battery. It also closes a circuit from ground through the same top outer armature and front contact to both windings of relay **216**, the circuit through the top winding being extended from junction point **231**, over conductor **232**, through the top winding to positive battery, and the circuit to the bottom winding being extended from junction point **231**, over conductor

233, through the top inner armature and back contact of relay 217, through relay 216 bottom winding to positive battery. Relay 209 operates when relay 211 operates to M and connects ground to the bottom winding of relay 210. Since the ampere turns through the bottom winding of relay 210 are greater than those through its top winding, relay 210 operates to M, even though the current through the top winding is in a direction to operate the relay to S. Relay 216 operates to M since the ampere turns through its top winding are greater than through the bottom winding.

Operation of relay 213 connects ground to the bottom winding of relay 211 and the middle winding relay 212 through the left and right-hand inner armatures and front contacts, respectively. Relay 213 also connects negative battery through its right-hand outer armature and front contact, upper outer break contacts relay 219, upper outer break contacts of relays 218 and 217 to the top winding relay 212. The current through the bottom winding relay 211 and middle winding relay 212 are in a direction to cause these relays to operate to S. The currents through the top windings of these relays are in a direction to hold the relays on M and since the effective ampere turns in the top windings are twice as great as those in the bottom winding of relay 211 and middle winding of relay 212, the armatures of relays 211 and 212 remain on their M contacts.

Since the station line circuit is multipled throughout the switchboard, there may be several operators attempting to answer the call when the line lamp lights. The cord relays 202 and 203 in the cord which establishes the connection prevent this from happening. When several cords are plugged in simultaneously, one cord makes the connection and relays 201 and 202 operate as described above. As soon as relay 202 has operated, a low resistance battery shunt through the top winding relay 202 is connected to the sleeve of jack 224. This shunt raises the potential of the sleeve to a value that prevents the 202 relays of other cords from operating. The 201 and 202 relays in the cord which has become connected remain operated. In each of the other cords relay 201 only operates and its operation causes relays 203 and 204 to operate. Relay 204 operates over a path from ground, through the armature and front contact relay 201, through 204 winding to battery. Relay 203 operates from ground through the same armature and front contact relay 201, through the winding relay 203, back contact and armature relay 202 to battery. In each of these cords positive battery is therefore connected to the tip circuit through the upper armature and front contact relay 203 and the upper middle armature and front contact relay 204. This potential is equal to that established from the M contact relay 212. The top winding relay 301 in each of these operators' position circuits is therefore shunted and does not operate to M. Relay 302 does not operate and the keyboard is locked. The positive battery connected to the tip circuit in each of the locked-out cords also shunts out the 301 relay in the operator's position circuit of the cord that has obtained the connection and that operator cannot communicate. Since relay 203 is not operated in the cord that establishes the conenction, but is operated in all other cords in the multiple, the position pilot lamps 227 of the interfering cords are lighted. These operators then remove their cords. When all interfering cords have been removed, the remaining cord can be used by the operator to communicate with the subscriber.

C. *Outward operator completes to interoffice trunk—Figs. 3 and 4*

The outward operator now extends the call by plugging her calling cord into the trunk jack at the outward board. The call cord lamp at the outward board and the trunk lamp at the through-board light and the trunk is made busy at both points. The manner in which this is performed may be seen in detail through reference to Figs. 3 and 4.

Using the calling cord 226 and with the typing key T operated, the outward operator plugs into the jack 408 of an idle trunk to the distant city containing the through-switchboard or the inward switchboard required for the call. Relays 219 and 401 are connected in series over a circuit which may be traced from negative battery, winding of relay 219, sleeve of plug 226, sleeve of jack 408, winding relay 401 to ground. Relays 219 and 401 operate. Operation of relay 401 furnishes ground through its upper outer armature and lower front contact, through the lower winding relay 403 to negative battery. Relay 403 has been held on its S contact by current through its upper winding. With ground connected to its lower winding, the relay operates to M. This makes the trunk busy and the idle trunk indicating relay circuit, shown by a block, functions to indicate the next idle trunk. The operation of relay 401 also removes connections to the lamp 409 at its top inner armature and back contact and to relay 410 at its lower inner armature and back contact, so that neither is energized. The high resistance 413 in series with the bottom winding of relay 402 which reduced the current drain for the idle condition, is shunted at the upper outer armature and front contact relay 401 and a circuit is prepared for the operation of relay 405 at the lower outer armature and front contact relay 401. Relay 405 does not operate, however, since relay 404 is not operated, as the armatures of relays 406 and 407 are held on their S contacts. This is so because relays 411' and 412 in the trunk from the distant city are on S, or spacing.

Negative battery is applied to the apex of relay 402 through the upper outer break contact relay 404. Current flows through the upper winding relay 402, jack tip 408, plug tip 226, upper outer armature and make contact relay 219, upper outer break contact relay 218, upper outer break contact relay 217, upper winding relay 212, M contact relay 210, M contact relay 211 to positive battery. Relay 212 is held on M and relay 402 operates to M since the ampere turns through the upper windings of these relays are twice the value of the ampere turns through the lower windings. When relay 402 operates to M, relay 411 operates to M and at the distant office relay 412' operates to M. Operation of relay 412' to M causes 407' to operate to M over a circuit which may be traced from negative battery through the armature of relay 412', upper winding relay 407' to ground, through the upper outer armature and make contact relay 404'. Operation of relay armature 407' to its M contact operates relay 406' over a circuit from ground through relay 407' armature and M contact, bottom winding relay 406' to negative battery.

Operation of relay 406' operates relay 404' over a circuit from ground through the M contact and armature relay 406', through relay 404' winding to battery. Operation of relay 404' causes the multiple line lamps 409' to light over a circuit from battery through the lower armature and upper front contact relay 404', upper inner armature and back contact relay 405', upper inner armature and back contact relay 401', through lamp 409' to ground. The idle indicating relay circuit, shown as a box, is also energized from battery through the lower make contacts of relay 404' and the circuit is made busy in the multiple at that point. Night alarm relay 410' is operated over a circuit from ground, upper inner armature and front contact relay 404', lower inner back contact and armature relay 401', lower outer back contact and armature relay 405', winding relay 410' to battery, operating the night alarm. When relay 404' operates the ground applied to the upper winding of relay 407' is momentarily removed and later replaced by a ground through the lower winding of relay 402' and resistance 413'. Relay 407' therefore momentarily operates to S and then returns to M after relay 404' is fully operated. This does not cause the ground from the M contact of relay 406' to be removed, however, since during the short interval relay 407' has left its M contact a high surge current flows in the lower winding of relay 406' in a direction to hold that relay on M although the current through the upper winding tends to operate it to S.

In the outward cord ground is supplied to the ring of jack 226 from the upper inner armature and back contact relay 404. This ground causes relay 215 to operate over a circuit from ground, through the upper inner armature and back contact relay 404, ring jack 408, ring plug 226, upper inner armature and front contact relay 219, lower outer armature and back contact relay 214, winding relay 215 to battery. Operation of relay 215 lights lamp 225 over a circuit from ground, through the lower front contact and armature relay 215, through the lamp filament, through relay winding 222 to battery. Relay 222 operates, providing an audible signal. The lamp and audible signal furnish an indication to the outward operator that the distant through-operator has not yet answered the call. Operation of relay 215 operates relay 214 from battery through relay 214 lower winding, upper inner armature and front contact relay 215, lower outer back contact and armature relay 214 to the same ground that operated relay 215 on the upper inner armature of relay 404. The 60 I. P. M. ground used for recall, to be explained herein later, is not applied to the lamp since relay 215 remains operated.

D. *Through-operator answers call—Figs. 3, 4 and 5*

The operator at the through-board answers the incoming call by plugging her answering cord into the jack associated with the lighted line lamp, having her typing key T operated. The call cord lamp at the outward board and the line lamps at the through-board are extinguished. How this is accomplished may be seen in detail through reference to Figs. 3, 4 and 5.

With the typing key operated, the through-operator plugs her answering plug 622 into multiple jack 408'. Relays 601, 602 and 401' operate in series over a circuit from battery, through relay 601 winding, lower winding relay 602, lower outer armature and back contact relay 604, sleeve of plug 622, sleeve of jack 408', winding relay 401' to ground. Operation of relay 401' releases relay 410' and extinguishes multiple line lamps 409'. Relay 405' operates from ground through the lower outer armature and front contact relay 401', winding relay 405', make contact combination and lower armature relay 404' to battery. Relay 405' locks to ground through its lower armature and front contact. Operation of relay 401' furnishes direct ground to relay 402' lower winding by shunting resistance 413' through its upper outer armature and front contact. The current through the bottom winding relay 402' is raised to normal for transmission purposes. Operation of relay 401' also furnishes ground to the bottom winding relay 403' through relay 401', upper outer armature and lower of the two front contacts. Relay 403' operates to its M contact to hold the trunk busy even though relay 404' subsequently releases, as will be described later under recall and disconnect.

In the cord, operation of relay 601 closes a circuit for the operation of relay 605, from ground, through the front contact and armature relay 601, through relay 605 winding, to battery. In case more than one operator answers the call, the 602 relay in the first cord operates but in the other cords relay 603 operates, causing the transmission circuit of all cords to be locked until, all but the first operator retire in a manner similar to that described for Fig. 3.

Operation of relay 605 operates relays 611 and 606. The path for the operation of relay 611 may be traced from battery, through the lower armature and front contact relay 605, relay 611 winding to ground. The path for relay 606 may be traced through the same contact, winding relay 606, to ground, through the upper armature and back contact relay 607. Relay 607 does not operate, since there is no ground on the ring of plug 622 as relay 404' is operated before the through-operator answers. Operation of relay 611 connects ground to the middle winding relay 609, through relay 611, left-hand outer make contact and armature. Ground is furnished to the bottom winding relay 610, through the right-hand front contact and armature relay 611. Ground is furnished through the left-hand inner front contact and armature relay 611 to the upper windings relays 615 and 617. Current through the upper windings of relays 615 and 617 tends to hold these relays on S but since ground is also applied to the lower windings these relays operate to M. Ground is applied to the bottom winding relay 617 from the left-hand inner make contact and armature relay 611 through the upper armature and back contact relay 613. Ground is applied to the lower winding of relay 615 through the make contact of relay 616 which has also operated as will be described below. Relay 626 operates from ground, through the armature and right-hand M contact relay 615, through relay 626 winding to battery.

Operation of relay 605 also closes the transmission circuit. This circuit may be traced from negative battery on the M contact relay 412', Fig. 4, top winding relay 407', upper outer armature and front contact relay 404', top winding relay 402', tip of jack 408', tip of plug 622, upper outer front contact and armature relay 605, top winding relay 609, lower outer armature and back contact relay 613, armature and front contact relay 626, armature and M contact relay 610 to positive battery.

Relay 610 is under control of the through-operator's teletypewriter. This transmission circuit may be traced from positive battery, M contact and armature relay 609, break contact relay 619, top winding relay 610, upper inner front contact and armature relay 613, (as relay 613 was operated from ground through the upper contact of the typing key) left-hand upper break contact of the call portion C, of the split key, SP, top winding relay 301', break key, teletypewriter contacts, right-hand upper break contact of the answering portion, A, of split key, SP, upper outer make-before-break contacts relay 613, upper break contact relay 620 to negative battery.

The transmission circuit is closed through Figs. 4 and 5. On the right side of the cord, Fig. 5, relays 301', 302', 616, 626, 610 and 615 are operated to M. On the left side of the cord relays 607 and 617 are operated to M and in the trunk circuit, Fig. 4, relays 402', 403', 406', 407', 611', 412', 412, 411, 407, 406, 403 and 402 are operated to M. Relay 404 operates from ground on relay 406 M contact, through relay 406 armature, relay 404 winding to battery. Operation of relay 404 removes ground at its upper inner armature from the ring of jack 408 and cuts the transmission circuit through from negative battery through the M contact of relay 412 through the top winding relay 407, upper outer armature and make contact relay 404 to the apex of relay 402. Relay 405 operates from negative battery on the lower armature and upper front contact relay 404, winding relay 405, lower outer front contact and armature relay 401 to ground. Relay 405 locks to ground through its lower front contact and armature.

In the outward cord, Fig. 3, relay 215 now releases since ground has been removed from the ring of plug 226. Relay 214 also releases since its locking ground has not yet been applied as relays 221 and 228 have not yet operated. The cord lamp 225 is extinguished, as ground is removed at the lower armature and front contact relay 215, indicating to the outward operator that the through-operator has answered.

The outward operator may now type the information required to permit the through-operator to complete the connection to a trunk to the inward board. Operation of the outward keyboard, Fig. 3, causes the current through the top winding relay 301 to be intermittently made and broken. The relay therefore follows these signals and, in turn, operates the magnet 303, causing the teletypewriter to record a copy of the message sent. Relay 302 being slow to release remains operated during this time. In the outward cord, relays 209 and 211 also follow these signals. Relay 210, being a slow release relay arranged to release in about one-half second, remains operated. Relay 211 repeats the signals to the circuit containing the relays 212 to 402. Relay 212 does not follow the signals, since when relay 211 is on M, the top winding of relay 212 holds that relay on M, even though the middle winding tends to operate it to S. When 211 is on S, the current through the middle winding of relay 212 has reversed and holds that relay on M. The current through the top and bottom windings is zero since negative battery is applied in the cord and meets negative battery from the M contact of relay 412 in Fig. 4. Relay 402, however, follows the signals sent by the outward operator and these signals are also followed by relays 411 and 412'. Relay 407' and relay 609 in Fig. 5 also follow these signals. Relay 406' does not release since it is arranged to remain operated for one second after relay 408' leaves its contact. During normal teletypewriter or "break" signaling, relay 407' does not leave its contact that long.

In the through cord, relay 609 applies positive and negative battery intermittently to the apex circuit of relay 610 and to the loop containing the through-operator's teletypewriter. Relay 610 does not follow the signals, since when relay 609 is on M, the current through the upper winding of relay 610 is sufficiently large to overcome the effect of the current in the lower winding. When relay 609 is on S the current through the upper winding of relay 610 is zero but the current through the lower winding has reversed and 610 remains on M. Relay 301' in the position circuit, however, repeats these signals. Magnet 303' follows the signals and the teletypewriter records the message sent by the outward operator. Relay 302' operates and remains operated during this period.

E1. *Through-operator completes call—Figs. 3, 4 and 5*

After the through-operator receives the necessary information from the outward operator, she plugs her calling cord into the interoffice trunk jack to the inward board. The call cord lamp at the outward board and the interoffice trunk line lamps at the inward board are lighted. The through-operator then releases the cord typing key which removes the position circuit from the through-operator's cord. The trunk between the through and inward board is made busy and the trunk between the outward and through board remains busy. How the circuit functions in detail to perform this may be seen on reference to Figs. 3, 4 and 5.

When the completing cord 623 is inserted in jack 408 of the trunk toward the inward board, relays 612 and 620 in Fig. 5 operate in series with relay 401, Fig. 4, over a circuit which may be traced from ground, through relay 401 winding, sleeve of jack 408, sleeve of plug 623, winding relay 620, winding relay 612, lower front contact and armature relay 605 to battery. Relay 612 operates in this instance, since the resistance of relay 401 winding is low enough in value to permit such operation. If plug 623 had been connected to a station jack 104, Fig. 2, relay 612 would not have operated, since the station sleeve relay 103 has a relatively high resistance.

The operation of relay 612 prevents a flashing lamp appearing as a recall signal from the outward board and also removes the "break" feature from the cord by substituting an impedance 629 for the lower winding of relay 609. These features will be described in more detail later.

Since ground is applied to the ring of plug 623 when the through-operator completes the connection, relay 619 operates over a circuit from ground, through the upper inner armature and back contact relay 404, ring of jack 408, ring of plug 623, winding relay 619, lower armature and front contact relay 620 to negative battery. Operation of relay 619 causes the transmission circuit toward the inward board to be cut and closed. This circuit may be traced from positive battery through the M contact and armature relay 609, make-before-break contact and armature relay 619, upper inner break contact and armature relay 613, upper make-before-break contact and armature relay 620, tip of plug 623,

tip of jack 408, Fig. 4, top winding relay 402, upper outer break contact of make-before-break combination relay 404 to negative battery. Relay 404 remains released until the inward operator answers since the transmission circuit from the inward board is in a spacing condition and relays 406 and 407 are on their spacing contacts. With the closure of the transmission circuit toward the inward board, relay 402 operates to M and, in turn, relays 411, 412', 407', 406' and 404' operate in the same manner as was described previously for the through-board to light the multiple line lamps 409' and to make the trunk busy at the inward board.

The transmission circuit toward the outward switchboard is opened when relay 619 operates as relay 618 operates from ground, through the upper front contact and armature relay 619 upper winding relay 618 to battery. With relay 618 operated, negative battery is supplied through its lower outer front contact and armature to the apex of relay 609, and thence through the upper outer armature and front contact relay 605 to the tip of plug 622. This space signal causes relay 402', in Fig. 4, associated with plug 622, to operate to S and relays 411' and 412 in the interoffice trunk toward the outward board to operate to S. In the trunk terminating circuit at the outward board, relay 407 operates to S and after one second relay 406 also operates to S. Relay 404 releases and connects ground to the ring circuit of the outward cord, reoperating relay 215 and causing the outward completing cord lamp to light as previously described. This lighted lamp gives the outward operator an indication that the through-operator has completed the connection to the inward board.

E2. *Through-operator sends busy back, reorder or no-circuit signals back to outward operator—Figs. 3, 4, 5 and 6*

In case the through-operator finds all trunks to the inward board busy, she will complete to one of the three jacks shown in Fig. 6, depending on the traffic circumstances. Busy back, reorder or no-circuit signals will thereupon be transmitted to the outward board to be recorded on the outward position teletypewriter. Reference to Figs. 3, 4, 5 and 6 will show this operation.

Plug 623, Fig. 5, is inserted into either one of the three jacks, busy back, reorder or no-circuit, Fig. 6. Ground is furnished in each instance over the sleeve of the jack to operate relay 620 as heretofore described. The operation of relay 620 closes the cord tip circuit. Relays 612, 619, and 618 do not operate. Battery interrupted to give the proper code signal by the interrupters in Fig. 6 will be transmitted over the tip of the jack to cause relay 610 in the cord to repeat this signal through the transmission circuit to the outward board. The outward operator receives the corresponding signal over trunk, Fig. 4, on her teletypewriter in Fig. 3.

The sleeve resistance on the jacks in Fig. 6 is relatively high, equivalent to that of relay 401 in Fig. 4. This is the reason that when an inward or through cord plug 623 is connected to it relay 612 in the cord is not operated. The cord is therefore arranged to receive either a recall or disconnect signal from the outward board. As the details of recall and disconnect signal operation will be described in later sections, they will be omitted here.

F. *Inward operator answers call—Figs. 3, 4 and 5*

The inward operator answers the call incoming to the inward board. To do this, with the cord typing key T, operated, she inserts her answering cord plug into the jack associated with the lighted line lamp in the interoffice trunk multiple. The call cord lamp in the outward board and the line lamp in the interoffice trunk multiple at the inward board are extinguished.

The inward cord with the operator's teletypewriter equipment and the trunk circuit function for this operation as for the case when the through-operator answered the call incoming to the through board from the outward office. Reference to Figs. 3, 4 and 5 will disclose these operations.

At the through office the 406 and 407 relays in the through-inward interoffice trunk circuit operate to M when the inward operator plugs in to answer. The operation of relay 406 at the through office causes relay 404 to operate over a circuit from ground through relay 406 armature, relay 404 winding to battery. Relay 405 operates from battery through the lower armature and upper front contact relay 404, relay 405 winding front contact and lower outer armature, relay 401, to ground. The operation of relay 404 removes ground from the ring of jack 408 at its upper inner armature and back contact. This causes relay 619 of the through cord to release and when relay 619 releases relay 618 also releases. With relay 618 released, the transmission circuit of the through cord is cut through and the marking signal from the inward board is extended over the trunk to the outward board. In the outward office, relays 407 and 406 again operate to M. Relays 404 and 405 then operate and the call cord lamp at the outward board is again extinguished as previously described. The outward operator, noting this extinguished lamp, then types the number of the called station. This number is received on the teletypewriter at the inward board over a transmission circuit which has been described before up to the through switchboard. Relay 609 in the through switchboard repeats the signals to the tip of the call cord and the signals are then repeated to the teletypewriter at the inward board in a manner similar to that described previously for the case where the outward operator communicated with the through operator.

G1. *Inward operator completes to called station line—Figs. 3, 4 and 5*

The inward operator now makes a tip busy test on the sleeve of the called station jack and, upon noting that the line is idle, plugs the calling cord into the jack. This makes the station line busy and lights the calling cord lamp at the outward board. The detailed operation of the circuits to perform these functions may be seen by referring to Figs. 2, 3, 4 and 5.

Before plugging in to the called station jack 104, Fig. 2, of the called subscriber line, the inward operator determines whether or not that line is busy. This operation is performed by making a tip busy test with the calling cord plug 623, Fig. 5. If the line is busy, another cord is in the multiple and there is a potential on the sleeve due to the battery from the sleeve of the answering cord of an outward cord pair, Fig. 3, or from the sleeve of the calling cord of another inward cord, Fig. 5. When the tip test is made, a relay common to all cords in the position operates if the line is busy and its operation causes

a position busy lamp to light. The relay and lamp are not shown in Fig. 5 but the relay winding is connected to the upper back contact relay 620.

Assuming the line is idle, the inward operator completes the connection by inserting plug 623 into jack 104 of the called station line. Relays 103, 612 and 620 are thereby connected in series over a circuit from battery through the bottom armature and front contact relay 605, winding relay 612, winding relay 620, sleeve plug 623, sleeve jack 104, winding relay 103, to ground. Since relay 103 has a relatively high resistance, there is insufficient current to operate the marginal relay 612 but relays 103 and 620 operate.

In the station line circuit, operation of relay 103 causes positive battery to be removed from the tip of the loop at its upper armature and back contact, and connects negative battery through the lower winding of relay 101, front contact and lower inner armature of relay 103 to ground at the upper armature and break contact of relay 118. Battery is also removed from relay 102 at the lower outer armature and back contact of relay 103 so that relay 102 cannot operate. Relay 101 operates since its lower winding is energized and ground is thereby connected to the ring of jack 104.

In the inward cord, Fig. 5, operation of relay 620 removes negative battery from the transmission or tip lead at the break contact of the upper make-before-break combination of relay 620 and extends this circuit to an open at the upper make contact of relay 118, at the subscriber station. Since the transmission circuit is now open and relay 610 operates to S under control of its bottom winding, causing a spacing signal to be applied to the apex of relay 609 over a circuit from negative battery through the upper back contact of relay 612, lower winding of relay 609, S contact and armature relay 610, front contact and armature relay 626, back contact and lower outer armature relay 618, to apex circuit relay 609. This spacing signal is sent over the circuit to the distant outward switchboard. Relay 609 remains on its M contact because the currents through its middle and lower windings from negative battery at the S contact of relay 610 are in a direction to hold relay 609 on that contact. At this time the current through the upper winding of relay 609 is zero. After one-half second the break-limiting relay 615 also operates to its S contact and causes relay 626 to release but the operation is ineffective since before this time has elapsed relay 619 operates from battery through the front contact and lower armature relay 620, winding relay 619, ring of plug 623, ring of jack 104 to ground at relay 101 armature. The operation of relay 619 operates relay 618 from ground through the front contact and upper inner armature relay 619, top winding relay 618 to battery. Relay 618 remains operated until the called subscriber answers or the cord connection is broken. Operation of relay 619 transfers the armature of relay 609 to the tip circuit of plug 623 through its lower armature and front contact for subsequent use when the outward operator rings. Operation of relay 618 removes the armature of relay 610 from the transmission circuit and connects negative battery to the apex of relay 609, which causes the spacing signal which was started when relay 610 operated to S to be continued as a permanent signal. Relay 609 remains on S because current is still applied to its middle winding. Operation of relay 618 also breaks the ground connection from the left-hand inner armature and make contact relay 611 to the lower winding relay 617. After one and one-eighth seconds, relay 617 operates to S, removing the locking circuit through the bottom winding relay 618 so that relay 618 is held operated only by its top winding under control of relay 619.

The spacing signal sent from the apex of relay 609 through the lower make contact of relay 618 in the inward cord causes relay 402′ in Fig. 4 at the inward office to operate to S. The signal then operates relays 411′ and 412 of the interoffice trunk to S and at the through office relays 407, 610, 616 and 402′ also operate to S. The signal is then propagated toward the outward office since relays 411′ and 412 in the through outward switchboard interoffice trunk circuit also operate to S. Finally at the outward office relay 407 operates to S.

One-half second after relay 616 in the through cord operates to S the 615 relay also operates to S. However, this operation is ineffective since relay 612 is operated and ground is held on relay 626 through the lower inner make contact of relay 612. Relay 626 therefore remains operated and the transmission circuit between the armature of relay 610 and the apex of relay 609 is not broken. One second after the 407 relays in Fig. 4 at the through and outward switchboards operates to S, the corresponding 406 relays also operate to S and in turn the 404 and 405 relays release, causing ground to be applied to the ring of plugs 623 and 226, respectively, at the upper inner armature and back contacts relays 404.

At the through switchboard relays 619 and 618 then operate but during the operating time of relay 618 and after it has operated, relay 402′ in the trunk terminating circuit toward the outward board remains on S under the influence of current through its lower winding from battery at the M contact of relay 412′. After relay 618 in the through cord has operated, the windings of relay 610 are no longer in the transmission circuit toward the inward board but the armature of relay 610 is also removed from the transmission circuit toward the outward board so the outward switchboard operator can send ringing pulses through the through switchboard without affecting the permanent spacing signal which is still being transmitted to the outward board. At the outward switchboard the application of ground to the ring of plug 226 causes relay 215 to operate as has been heretofore described. With relay 215 operated the cord lamp 225 again lights, indicating to the outward operator that the inward operator has completed to the called station line.

It is to be noted that in tracing the spacing signal that was propagated from the inward to the outward board, the transmission circuit of the calling station and outward operator's teletypewriters was broken for about one second; that is, until relay 404 in Fig. 4 at the outward switchboard released.

Thereafter the circuit was cut and closed from negative battery through the upper break contacts of relay 404 so that the calling subscriber and outward operator could communicate and so that the outward operator had complete control of the transmission circuit toward the called station.

G2. *Inward operator sends busy back, reorder or no-circuit signal—Figs. 5 and 6*

Facilities per Fig. 6, such as were provided at

the outward board, are also provided at the inward board in order to inform the outward operator of similar conditions existing at the inward board. The operation of Fig. 6 under these circumstances is similar to that described under E2.

H. *Outward operator rings called station—Figs. 2, 3, 4 and 5*

To ring the called station the outward operator operates her ringing key, RC, momentarily. The calling cord lamp remains lighted. The detailed operation of the circuits under the circumstances may be observed from references to Figs. 2, 3, 4 and 5.

Upon noting the relighting of lamp **225**, Fig. 3, after having ordered the connection to be established to the called station line, the outward operator operates the ring-called-station, RC, key momentarily.

Operation of this key operates relay **221** from ground through the upper left-hand armature and front contact of the key, winding relay **221**, front contact and lower inner armature relay **219** to battery. Relay **221** locks from ground through its lower armature and front contact. With relay **221** operated, a circuit is prepared for the operation of relay **228**, but this relay does not operate until later, as explained below. Operation of the ring-called-station key, RC, also operates relay **218**, from ground through the lower armature and front contact of the key through relay **218** winding to battery. Relay **218** locks from battery through its winding, front contact and lower inner armature relay **218**, front contact and upper inner armature relay **219**, ring or plug **226** to ground through the back contact and top inner armature relay **404**.

With relay **218** operated and locked, relay **228** is prevented from operating. The transmission circuit of the cord is cut and closed toward the calling station and a circuit is established for the operation of relay **220**.

Ringing relay **220** is connected to a machine ringing generator which applies ground to the circuit for two seconds and then opens the circuit for four seconds. With relay **218** operated, relay **220** remains operated for two seconds out of every cycle of six seconds duration. During the two-second period when relay **220** is operated, a source of twenty cycles alternating current voltage is applied from ground through the twenty-cycle alternating current source to the front contact and armature of relay **220**, top inner armature and front contact relay **218**, front contact and top outer armature relay **219** to the tip of plug **226**. During the four-second period while **220** is released the positive battery is supplied through the back contact of the relay over the same path to tip of plug **226**. Relay **402**, Fig. 4, follows these signals. It sends a series of ± signals having a period of twenty cycles per second for two seconds and then remains on M for four seconds. These signal patterns are transmitted over the line to the through office by relays **402**, **411** and **412'** and in the through cord, Fig. 5, relay **609** repeats them directly to the next trunk since relay **619** in the through cord is still operated. Relays **610** and **616** also follow these signals but are ineffective since relays **612** and **618** are also operated.

From the through office to the inward office the signals are repeated by the corresponding relays to those described for the outward through trunk case and are repeated to the called station line by relay **609** of the inward cord. As in the through cord relays **616** and **610** follow these signals but these relays are disconnected from their normal circuits so that their operation causes no interference.

As relay **609** transmits the ringing signal patterns to the tip of the inward cord plug **623**, the signals pass over the tip of the station line, through the station ringer to ground. In the station line circuit, relay **101** remains operated since the current through its lower winding is larger in value than the peak values of the signaling current flowing through its upper winding.

At the outward switchboard the operator may retire from the circuit by releasing the typing key since the called cord lamp **225** acts as a ringing cord lamp and is extinguished when the called subscriber answers.

I1. *Called subscriber answers—Figs. 2, 3, 4 and 5*

To answer, the called subscriber operates the power switch at the called station to the right. The calling cord lamp at the outward switch is thereupon extinguished. The operation of the circuit in detail may be understood from reference to Figs. 2, 3, 4 and 5.

Operation of the power switch to the right at the called station, Fig. 2, starts the teletypewriter motor and operates relay **118**. Operation of relay **118** closes the loop and removes ground from the ring conductor. Relay **101**, being a differential relay, releases during the first four-second closed period of the ringing signaling pulse since current now flows from negative battery through its lower winding over the station loop through the upper winding and to positive battery on the M contact of relay **609** in the inward cord.

Relays **616**, **615** and **626** in the inward cord operate to M and as soon as relay **101** releases, relay **619** in the inward cord releases and it in turn causes relay **618** to release. Release of relay **618** causes relay **617** to reoperate to M and also removes negative battery from the apex of relay **609** and replaces it with positive battery from the armature of relay **610**. Relay **610** is operated to M, because relay **609** is marking and current flows from positive battery through the M contact of relay **609**, through the upper winding of relay **610** and over the called station loop to negative battery connected to the lower winding of relay **101**. The permanent spacing signal which had been applied to the channel toward the outward board before the calling subscriber had answered is, therefore, now replaced by a marking signal. This marking signal causes the relays **407** and **406** at the through and outward offices to operate to M and relays **404** and **405** to reoperate. With relay **404** at the through switchboard reoperated, relays **619** and **618** in the through cord release and the connections to relays **609** and **610** are restored to normal transmitting condition.

With the **404** and **405** relays at the outward switchboard reoperated, ground is removed from the ring of plug **226** and relay **218** releases. Release of relay **218** causes the circuit to relay **220** to be broken at its lower-outer armature and front contact. Release of relay **218** also connects the transmission circuit from the winding of relay **212** to the tip of plug **226** so that the calling and called subscribers can communicate. The release of relay **218** also operates relay **228**, from battery through the lower-outer armature and

back contact of relay 218, winding relay 228 to the front contact and upper armature of relay 221 to ground. Meanwhile relay 215 released since its operating path was broken when the ground was removed from the ring of plug 226 and relay 214, which was also operated, released before its locking path through the now made contact of relay 228 was closed.

The lamp 225, therefore, is extinguished and the circuit is ready for communication to start.

12. *Outward operator starts called station teletypewriter for unattended service*

To start the teletypewriter at an unattended called station, the "ring-called-station" key RC, in the outward board is operated for five seconds. The teletypewriter at the unattended station is started and the calling cord lamp in the outward board is extinguished. Reference to Figs. 2, 3, 4 and 5 will show the operation in detail.

Under H above, ringing the called subscriber for attended called station operation was described in detail. To start a teletypewriter at an unattended station, the "ring-called-station" key RC in Fig. 3 is operated as was the case for ringing an attended station. In this instance, however, the key is held operated by the outward operation for five seconds. Relays 218 and 220 operate and lock, and ringing is impressed on the subscriber's station circuit over the tip lead as described under H in detail, except in this instance relay 220, is held operated during the five seconds while the key is operated over an obvious circuit, and the ringing is continuous.

The ± signals repeated from the 609 relay in Fig. 5 over the tip of the subscriber's line pass through alternating-current relay 115 winding, upper armature and back contact relay 118 to ground. Relay 115 operates, closing a path from the alternating-current source, resistance 119, relay 116 winding, armature and front contact relay 115 to the alternating-current source.

When the ± signal has persisted for five seconds, relay 116, a slow-acting thermal relay, operates. With the operation of relay 116, a path is closed from ground on one side of the alternating-current source through the armature and front contact relay 116, winding relay 117, to the other side of the alternating-current source. Relay 117 operates and locks over a circuit from the right-hand conductor from the alternating-current source, through the teletypewriter motor control contacts 121, break contact and armature of the power switch, lower armature, front contact and winding relay 117 to the left-hand conductor of the alternating-current source. Operation of relay 117 also closes a path at its upper armature and front contact in parallel with the open power switch contact, starting the teletypewriter motor and operating relay 118 over obvious circuits. Operation of relay 118 removes the ring ground at its upper armature and back contact and closes the subscriber's loop through the same armature and front contact. Relays 115 and 116 release as soon as relay 118 operates since relay winding 115 is then short-circuited. Relays 117 and 118 remain operated while the station is in operation and until, at the conclusion of the communication, an upper case H character is transmitted, opening the motor control contacts 121 momentarily. This opens the locking path of relay 117 releasing it, which in turn releases relay 118, again opening the subscriber's loop and grounding the ring, and stops the teletypewriter motor, restoring the circuit to normal.

J. *Calling and called subscribers communicate—Figs. 2, 3, 4 and 5*

The calling and called subscribers are now in position to communicate with each other. Figs. 2, 3, 4 and 5 show the operation in detail.

During normal communication between the calling and called subscribers, marking and spacing signals are sent to and fro between the stations. The spacing impulses never exceed a small per cent of one second. The break-limiting relays 210 and 615 remain on M. Furthermore, the recall relays 216 and 617 and the trunk relays 406 and 406' all remain on M.

When signals are sent from the calling station, the following relays respond to the signals:
Outward cord—relays 209 and 211.
Outward-through trunk—relays 402, 411, 412' and 407'.
Through cord—relay 609.
Through inward trunk—relays 402, 411, 412' and 407'.
Inward cord—relay 609.

When signals are sent from the called station, the following relays respond to these signals:
Inward cord—relays 610 and 616.
Inward-through trunk—relays 402', 411', 412 and 407.
Through cord—relays 610 and 616.
Through-outward trunk—relays 402', 411', 412 and 407.
Outward cord—relay 212.

If the called subscriber wishes to "break" the calling subscriber while the latter is sending, the called subscriber holds his break key 109 operated for about one second. This causes relays 610 and 616 in the inward cord to operate to S as soon as relay 609 has operated to M. It is to be noted that with relay 610 on its S contact a circuit is established from negative battery through the lower winding of relay 609 to the S contact of relay 610, lower make contact of relay 626, lower break contact of relay 618, apex of relay 609, center winding of relay 609, resistance, left make contact of relay 611 to ground. Currents therefore flow through the center and lower windings of relay 609 from the negative battery associated with the spacing contact of relay 610. These two windings are connected in an aiding direction and are of sufficient magnitude to hold relay 609 on its M contact, regardless of whether a spacing or marking signal is being received from relay 412' in Fig. 4. Relay 609 therefore remains on M as long as the break key 109, at the called station is held operated and relays 610 and 616 remain on S causing an interrupted space to be sent into the trunk circuit. Relays 402', 411', 412 and 407 in the inward-through trunk, relays 610 and 616 in the through cord, and relays 402', 411', 412 and 407 in the through outward trunk, then operate successively to spacing. The spacing signal finally reaches relay 212 in the outward cord and as soon as the calling subscriber sends the next mark signal, relay 211 operates to M and the current through the top winding of relay 212 is reduced to zero. Since the current through the middle winding still persists, relay 212 operates to S before relay 211 has had time to leave its M contact. With relay 212 on S, the calling station loop current is reduced to zero, relay 211 is prevented from operating to S and the calling subscriber's sending is broken.

If the called subscriber holds his break key, 109,

operated for more than one-half second, the 615 relay in the inward cord and possibly also in the through cord will operate to S since ground is removed from its bottom winding when relay 616 releases. This operation in the inward cord will cause the trunk toward the through switchboard to be cut and closed by release of the 626 relay and since this occurs in considerably less than one second after the space signal is started, the 406 relays in the trunk-terminating circuits will not operate to S and there will be no false supervisory signals. If the 615 relay in the through cord releases, its release will be ineffective since relay 626 is held operated through the lower inner make contact of relay 612. When the called subscriber releases the break key 109, the transmitting relays in the inward and through cords and trunks restore to marking and relays 616 and 615 in the inward through cords and relay 626 in the inward cord reoperate and the called subscriber may then send.

When signals are being sent to the calling subscriber, he too may stop this sending by operating his break key, 109, for more than one-half second. In the outward cord, signals are at this time being repeated by relay 212, and relay 209 is following these signals. Regardless of whether a marking or spacing signal is being received, when the break key, 109, is operated, the current through the top winding of relay 211 is permanently reduced to zero and when relay 212 reaches its M contact, the current through the bottom winding of relay 211 causes it to operate to S. As soon as relay 211 reaches S, relay 209 releases and the currents through the bottom and middle windings of relay 212 hold that relay on M, regardless of the current through its top winding. The permanent S signal from relay 211 is therefore propagated over the trunks to the called station.

One-half second after the break key 109, at the calling station is operated, relay 210, Fig. 3, operates to S and cuts and closes the transmission circuit to the inward board, thereby limiting the break and preventing the 406' trunk relays from operating to S and causing false supervisory signals.

It is to be noted from the foregoing that the "break" feature in this complete network is located in the outward and inward cord circuits only and that either teletypewriter or supervisory signals may be sent over the trunks and through the through cord in both directions at the same time without interference. In the through cord the lower winding of relay 609 is open because relay 612 is operated when a connection is established and the "break" feature, lower winding of relay 609, is disconnected. It is this full duplex feature of the system that permits the through supervision to be unaffected by the various teletypewriter transmission conditions of the system.

K1. *Calling subscriber recalls and outward operator answers recall—Figs. 2 and 3*

To recall, the calling subscriber operates the power switch at the subscriber's station to the left or off-position and then again to the right or on-position. The answering cord lamp at the outward board flashes. The operator answers by operating the typing key, which extinguishes the flashing lamp. Reference to Figs. 2 and 3 will show this in detail.

If the calling subscriber for any reason wishes to send a recall signal to the outward operator, it may be done, regardless of whether or not the teletypewriter is receiving a marking signal. In case of trunk failures or troubles of other sorts, the communication signal received at the calling station may be either a marking or spacing signal or a succession of marking and spacing signals. For any of these conditions a momentary operation of the power switch, Fig. 2, to the off-position, followed by restoration to the on-position will cause a flashing recall signal to be received at the outward cord.

When the power switch is off, the differential relay 101 will operate from negative battery through its lower winding, front contact and lower inner armature relay 103, resistance 112, lower back contact of relay 118, and upper back contact of relay 118 to ground. When relay 101 operates, it applies ground to the ring of jack 104 and plug 224, Fig. 3. Relay 207 operates. With relay 207 operated, relay 208 operates over a circuit from battery through the upper inner armature and front contact relay 207, front contact and upper outer armature and front contact relay 207, front contact and upper outer armature relay 207 to the same ground over the ring circuit. When relay 207 operates, negative battery is furnished through its lower outer armature and front contact to the transmission lead at the winding of relay 211. Relay 211 operates to its M contact and in turn reoperates relay 209. The length of spacing signal sent to the trunk by relay 211 when the power switch at the station is off, is therefore relatively short, being the sum of the operate times of relays 101 and 207. This period is considerably less than one-half second and the break-limiting relay 210 remains on its M contact. The operation of relay 207 also applies ground to cord lamp 223 and the common night alarm relay 222 over a circuit from ground through the front contact and lower inner armature relay 207, filament lamp 223, relay winding 222 to battery. Lamp 223 therefore lights and the night alarm sounds.

After the short period required at the station to release and reoperate the power switch, relay 101 releases again and then relay 207 releases. Relay 208 remains operated, however, since it is locked to ground over a circuit from battery through top winding relay 208, upper armature and front contact relay 208, lower armature and front contact relay 205 to ground. A source of interrupted ground is therefore applied to lamp 223 and relay 222 as soon as relay 207 releases over a circuit from ground through the interrupter, lower inner armature and front contact relay 208, back contact and lower inner armature relay 207, filament lamp 223, winding relay 222 to battery. The lamp therefore flashes at a 60 I. P. M. rate indicating a recall.

The outward operator answers the recall by operating the typing key, T, to its upper contact, operating relay 205. During the travel time of the relay ground is momentarily removed from the locking winding of relay 208 at the lower armature of relay 205 and relay 208 is released. The operator may then challenge and communicate with the calling subscriber. If a permanent space is being received from the trunk, the operator may operate the position split key to close the circuit and to permit the communication.

If during the time the position circuit is connected to the cord, such as when a toll connection is being established, the calling subscriber recalls, the station and outward cord circuits function in the same manner as described above. In this case, however, relay 208 is locked op-

erated from ground through the lower armature and front contact of relay 205. To release this circuit and extinguish the lamp the operator restores the typing key momentarily, again releasing and unlocking relay 203. After reoperating the key to connect the position printer again to the cord the operator challenges the subscriber.

K2. *Called subscriber recalls and outward operator answers recall—Figs. 2, 3, 4, and 5*

To recall, the called subscriber operates the power switch to the left or off-position and then again to the right or on-position. The calling cord lamp at the outward board flashes, the operator answers by operating the typing key, T, which extinguishes the flashing lamp. Reference to Figs. 2, 3, 4 and 5 will show the operation in detail.

If, after a connection has been established in accordance with the plan described in A to J above, the called subscriber wishes to recall the operator, he may do so by momentarily releasing the power switch in the same manner as described for the calling station in K1 above. This recall signal is translated in the inward cord, Fig. 5, to a code signal, 1⅛ seconds timed open, by relay 617, and this signal is transmitted over the interoffice trunks to the outward switchboard where it causes lamp 225 to flash and relay 222 to operate. This recall signal does not appear as a lamp signal at the inward and through switchboards and may be transmitted even though the calling station is transmitting a marking or spacing teletypewriter signal, a "break" signal, or a recall or disconnect signal.

Referring to Fig. 2, relay 101 is momentarily operated and released as heretofore described, causing ground to be applied momentarily to the ring of plug 623, Fig. 5. Relay 619 operates and its operation causes relay 618 to operate through its top winding. When relay 618 operates, negative battery is applied to the apex of relay 609 at the lower outer armature and front contact, and the spacing signal is propagated over the trunks to the outward board in the same manner as described under G above. This spacing signal persists until relay 617 releases. Relay 619 remains operated for a short period, that is, during the release time of the station power switch. This time is sufficient to allow relay 618 to operate. When relay 618 operates, its lower winding is energized through its bottom inner armature and front contact, relay 617 armature and M contact to ground at the lower inner armature and back contact of relay 612, and is held operated over this path even though relay 619 releases. With relay 618 operated, ground from the left-hand inner armature and front contact of relay 611 is removed from the bottom winding of relay 617 and after condenser 627 is charged from positive battery through the lower winding, the current dies down to a low enough value to permit the current through the top winding to operate relay 617 to S. As soon as relay 617 operates to S, relay 618 releases since its holding path, above described, is open. Release of relay 618 again closes the transmission path toward the outward board at its lower outer armature and back contact to positive battery from the M contact of relay 619.

At the through and outward offices, relay 406 in the trunk circuits toward the inward board are slow-release relays, but their time of release is sufficiently less than that of relay 617 to insure that the respective 404 and 405 relays in the trunk terminating circuits and relays 619 and 618 in the through cord, and relays 215 and 214 in the outward cord operate.

When the spacing signal from the inward cord is started through the through cord, relays 610 and 616 in the through cord release. The release of relay 610 causes negative or spacing battery to be applied to the apex of relay 609 and the signal is propagated on to the outward board. Release of relay 616 removes ground from the lower winding of relay 615 which operates to S after one-half second. When relay 615 operates to S, ground is applied to the top winding of relay 618 over a path from ground through relay 615 armature and S contact, lower outer front contact and armature relay 612, top winding relay 618 to battery. Relay 618 therefore operates and during its operation time the negative battery is temporarily removed from the apex of relay 609. This does not cause relay 402′ in Fig. 4 to leave its S contact, however, since the current in the bottom winding of relay 402′ holds it on S. The timed space signal toward the outward board is therefore not interrupted. Soon relay 618 is completely operated and negative battery is again applied to the apex of relay 609 and the space signal toward the outward board still persists.

A fractional part of a second after relay 618 in the through-cord is operated, relay 406 in the interoffice trunk toward the inward board releases, since the space signal sent out from the inward board has been long enough to cause it to release.

Release of relay 406 causes relay 404 to release. With relay 404 released, ground is applied to the ring of plug 623, causing relay 619 in the through-cord to operate. With relay 404 released, negative battery is applied to the apex of relay 402 and relays 616 and 610 in the through-cord reoperate to M. The reoperation of these relays will not cause the spacing signal sent toward the outward board to be interrupted, however, since relay 618 which was previously operated now has control of this signal and with relay 619 now operated relay 618 remains operated, even though relay 615 again reoperates under control of relay 616.

As explained above, the timed space signal sent from the inward board is not broken at the through-switchboard, due to release of relays 406 and 404 in the through-inward interoffice trunk terminating circuit. This space signal therefore is long enough to allow relays 406, 404 and 405 in the interoffice trunk at the outward board to release. With relay 404 released, ground is applied to the ring of plug 226 in the outward cord. This ground causes relays 215 and 214 to operate and cord lamp 225 to light, as heretofore explained.

A fraction of a second later, relay 617 in the inward cord operates to S, causing relay 618 to release and a marking signal to be reestablished on the trunk. This signal causes the ground to be removed from the ring of plug 226 at the outward board. Relay 215 therefore releases, but current through the lower winding of relay 214 holds it operated and 60 I. P. M. ground is therefore now connected to lamp 225 and it flashes, giving the outward operator an indication that the called subscriber has recalled.

The reestablishment of this marking signal on the trunk at the inward board, which ultimately causes the flashing at the outward board men-

tioned in the preceding paragraph, is started when relay 617 operates to S under control of its top winding. When relay 617 leaves its M contact, the locking circuit through the lower winding of relay 618 is broken and relay 618 releases, because relay 619 is at that time released, as the calling subscriber has completed the operation of sending the recall signal. Release of relay 618 removes negative battery from the apex of relay 609. Previously when the called station loop was reclosed, relays 610 and 616 were operated to M. With relay 616 operated to M, relay 615 operated to M and relay 626 operated to M. Positive battery is therefore applied to the apex of relay 609, through the M contact of relay 610, armature and front contact of relay 626 and the lower outer back contact and armature of relay 618.

Relay 609 in the inward cord remains on M when positive battery is applied to its apex, but relay 402' in the inward through-office trunk terminating circuit connected to plug 622 of the inward cord operates to M, causing negative battery to be applied to the top winding of relay 411' (Fig. 4). Relay 411' operates to M and relay 412 at the through-office then operates to M. With relay 412 on M, relays 407 and 406 at the through-office operate to M. Relay 404 then operates and removes ground from the ring of plug 623 of the through-cord. Relay 619 in the through-cord then releases, causing relay 618 to release immediately. As soon as relay 618 releases, positive battery is again applied to the apex of relay 609, through the M contact of relay 610, make contact of relay 626 and lower outer back contact and armature of relay 618.

In the interoffice trunk toward the outward board (Fig. 4) relays 402' and 411' at the through-office and relays 412, 407 and 406 then operate to M. Relay 404 at the outward office reoperates, removing ground from the ring of plug 226 (Fig. 3) and releasing relay 215. The cord lamp then flashes as pointed out above.

Upon noting the flashing cord lamp the outward operator answers the recall by operating the typing key, T, to associate the position teletypewriter circuit with the cord. This operation causes relay 205 to operate, removing ground from the top winding of relay 214. Relay 214 therefore releases and lamp 225 is extinguished. Relays 228 and 221, however, remain operated, as sleeve relay 219 is still operated.

L. *Outward operator recalls and inward operator answers recall*

The outward operator may send a recall signal to the inward operator by momentarily operating the send-recall key, RCL, in the outward cord. The answering cord lamp at the inward board flashes. The corresponding answering cord lamp at the through board does not flash. The inward operator answers the recall by operating the typing key and challenging. Operation of the typing key extinguishes the flashing cord lamp. Reference to Figs. 2, 3, 4 and 5 shows this operation.

When the send-recall key, RCL, in the outward cord, Fig. 3, is operated momentarily, relay 217 is operated over a circuit from battery through the lower outer armature and front contact of relay 219, M contact and armature of relay 216, contacts RCL key, lower winding of relay 217 to ground through the upper outer front contact and armature of relay 204. Operation of relay 217 cuts and closes the transmission circuit toward the top winding of relay 212 to negative battery through the right-hand armature and front contact of relay 213. It also causes the transmission lead to the tip of plug 226 to be opened. As soon as relay 217 operates, it is held operated through its upper winding under control of the M contact of relay 216. Operation of relay 217 also removes ground from the lower winding of relay 216. This causes condenser 234, also connected to this winding, to charge. After 1⅛ seconds, this condenser is charged, and relay 216 then operates to S under control of its top winding. Relay 217 is then released and the transmission circuit to the tip of plug 226 is again closed. The recall signal is therefore a timed open signal of about 1⅛ seconds duration.

When the transmission lead is opened at the beginning of the recall, relay 402, Fig. 4, connected to plug 226, operates to S under control of its lower winding and then relay 411 in the outward office and relays 412' and 407' in the through-office operate to S. The spacing signal is then transmitted through plug 622 to relay 609 in the through-cord. Relay 609 operates to S under control of its lower winding and applies negative battery to the tip of plug 623, which causes relays 402, 411, 412' and 407' in the through inward trunk, and relay 609 in the inward cord, to operate successively to S. The 406' relays in the trunk circuits at the through and inward boards, respectively, operate to S one second after their associated 407' relays operate to S. When the 406' relays operate to S, the corresponding 404' relays release and cause ground to be applied momentarily to the rings of plugs 622 at the two switchboards. With ground applied to the rings, the respective 607 relays in the through and inward cords operate over a path from ground through the upper inner armatures and front contacts relays 404', rings of jacks 408', rings of plugs 622, lower inner break contacts relays 604, winding of relays 607, upper inner break contacts of relays 604, lower front contacts and armatures relays 605 to battery. Operation of relays 607 causes relays 608 to operate over a path from ground through the upper armatures and front contacts relays 607, relays 608 windings, to battery. Operation of relays 607 momentarily opens the circuits from battery through the lower armatures and front contacts relays 605, windings relays 606, upper back contacts and armatures relays 607 to ground. Relays 606 do not release, however, as they are slow-release relays and relays 607 do not remain operated long enough. This is so because, although the transmission circuit was opened for approximately 1⅛ seconds, the 406 relays required approximately one second of this period to operate to S and release the 404' relays. When the transmission circuit closed approximately ⅛ second later, the 406' relays operate to M without appreciable delay reoperating relays 404'. The time during which relays 404' are released and ground is furnished for the operation of relays 607 therefore is limited to ⅛ second. This is not sufficient for the release of relays 606.

As has been explained, heretofore, relay 612 is operated at the through-cord and is not operated at the inward cord due to variations in the resistance between the sleeve circuit to which plug 623 is connected in the two cases. At the through-board, therefore, operation of relay 607 does not light lamp 621 because relay 612 is operated and the lamp circuit is opened at the upper inner back contact and armature of relay 612. At the in-

ward board, however, lamp 621 is lighted and the night-alarm relay 625 is energized.

After release of the 607 relays, the 608 relays remain locked up to ground through their lower make contacts over a path from battery through relays 608 windings, lower front contacts and armatures relays 608, lower outer armatures and front contacts relays 613, upper inner armatures and front contacts relays 605, to ground. At the inward board, the 621 lamp now flashes over a circuit from ground through interrupter 626, upper armature and front contact relay 608, upper back contact and armature relay 612, filament lamp 621, winding relay 625, to battery. The night-alarm relay 625 is operated intermittently until the operator answers the recall.

Upon noting the flashing cord lamp, the inward operator operates the typing key, T, to associate her position circuit with the cord and then challenges. Operation of the typing key operates relay 613, breaking the holding path of the flashing recall relay 608, releasing the relay and extinguishing lamp 621.

Since the through operator did not receive a flashing recall lamp, she does not operate her typing key, T, and relay 608 in the through cord remains operated until plug 622 is disconnected and relay 605 releases.

M. *Splitting and ring-answering keys*

The split SP key in the outward cord Fig. 3 and in the through and inward cord Fig. 5 is provided to enable the operators to associate the position teletypewriter with either end of a cord, while providing the proper battery condition for both ends of the cord.

In Fig. 3 operation of the right-hand portion of the key associates the printer with the calling end of the cord. The circuit may be traced from negative battery, upper right-hand armature and make contact of the split key, teletypewriter contacts, break key, upper winding relay 301, upper left-hand break contact split key, conductor 230, upper inner armature and front contact of relay 205, winding of relay 209, top winding relay 211, armature and M contact relay 212 to positive battery. Relay 211 follows the teletypewriter signals which are repeated over the tip circuit of the calling cord.

Operation of the right-hand portion of the split key also furnishes positive battery through its lower front contact and armature, break contact of the ring-answering-cord key, conductor 229, upper outer make-before-break contact of relay 205, upper middle front contact and armature relay 204 to the tip of the answering cord.

Operation of the left-hand portion of the split key, Fig. 3, associates the teletypewriter with the tip of the answering cord over a circuit from positive battery, left-hand lower make contact and armature split key, upper winding relay 301, break key, teletypewriter contacts, upper outer right-hand break contacts split key, upper break contact ring-answering-cord key, conductor 229, upper outer make-before-break contact of relay 205.

Operation of the left-hand portion of the split key also furnishes negative battery to winding of relay 209, through the split key left-hand upper armature and make contact.

The split key circuit and operation in Fig. 5 is practically identical with that in Fig. 3 and its detailed description is therefore not repeated.

In Fig. 3 a key is provided to enable an outward operator to ring on an answering cord. Operation of the ring-answering-cord key RA furnishes ringing current through its lower front contact and armature to conductor 229 and thence to the tip of the answering cord. At the same time negative battery is again furnished through its upper armature and make contact, upper right-hand break contact split key, teletypewriter contacts, break key, upper winding 301, upper left-hand break contact split key, conductor 230, upper inner armature and front contact of relay 205 to winding of relay 209.

N. *Subscribers disconnect*

In order to disconnect, the subscriber at either station operates the power switch to the left or off position. The motor stops and the associated corp lamp at the outward switchboard burns steadily.

When the calling subscriber operates the power switch Fig. 2 to the left or off position the teletypewriter motor stops and relay 118 is released. Relay 101 operates and remains operated over a circuit from negative battery, resistance 114, lower winding relay 101 inner make contact and armature relay 103, resistance 112, lower back contact and armature relay 118, upper armature and back contact relay 118 to ground. Ground is connected through the armature and front contact of relay 101 to the ring of jack 104. Relay 207 in the outward cord, Fig. 3, operates from this ground through ring of plug 224, upper inner armature and front contact of relay 204, lower outer armature and back contact, relay 208, relay 207 winding, to battery. Operation of relay 207 operates relay 208 over a circuit from battery through the lower winding relay 208, upper inner armature and front contact relay 207, lower outer front contact and armature relay 208, upper inner back contact and armature relay 204 to the same ground on the ring of plug 224. Relay 208 locks from battery through its upper armature and front contact, lower armature and front contact relay 205, to ground. Cord lamp 223 lights from ground through the lower inner front contact and armature relay 207, filament lamp 223, winding relay 222, to battery. Operation of relay 207 also applies negative battery through its lower outer armature and front contact to relay 211 winding. Relay 211 is held operated and relay 211 holds relay 209 on M.

When the called subscriber operates his power switch to the left relay 118 releases and ground is applied to the ring of plug 623 of the inward cord. Relays 619 and 618 are operated over circuits heretofore described. Since in this case the ground is left permanently on the ring of plug 623, relays 619 and 618 remain operated whereas when a recall signal was sent, relay 619 was operated for only a short interval and relay 618 remained operated only during the release time of relay 617.

A permanent spacing signal is sent over the trunks to the outward board as soon as relay 619 operates. After approximately one second, relay 406 in the interoffice trunk circuit at the outward board operates to S and relay 404 then releases. Release of relay 404 applies ground to the ring of jack 226 and relays 215 and 214 operate from this ground. With relay 215 operated, lamp 225 is lighted indicating to the outward operator that the called subscriber has disconnected.

O. *Outward operator disconnects*

To disconnect, the outward operator pulls down both cords. The answering cord lamps at

the through and inward board light. The trunks between each pair of switchboards become idle and may be used for new calls even though the inward and through operators have not disconnected their cords at the respective offices.

When the outward operator removes plug 224 from the calling station line, relays 201, 202, 204 and 103 release. Release of relay 103 restores the station line circuit to the normal idle condition. Release of relays 201, 202 and 204 in the outward cord causes the 207 and 208 lamp relays to release and the 223 lamp is extinguished. The transmission circuit through the 209 and 211 relays is held closed, however, since when relay 204 releases, negative battery is connected from the left-hand outer armature and make contact of relay 213 through the break contact of the make-before-break combination of relay 204 top winding of relay 211, armature and M contact relay 212 to positive battery. The trunks toward the through and inward boards are, therefore, held closed.

When the outward operator removes plug 226 from the interoffice trunk jack 408, relays 219 and 401 release. Release of relay 219 in the outward cord causes all relays in the cord to restore to the idle condition and lamp 225 is extinguished. Release of relay 401 in the interoffice trunk causes the current through the bottom winding of relay 402 to be reduced since the shunt around resistance 413 is removed. On the basis that a disconnect signal had been received from the called station and since the circuit through the upper winding of relay 402 was open when the plug was removed, this reduced current is sufficient to operate relay 402 to S and the S signal is started over the trunk toward the through board. Release of relay 401 also removes ground from the bottom winding of relay 403 and condenser 414 associated with the bottom winding starts charging. Relay 403 remains operated for about 1½ seconds to guard the trunk from becoming idle. If the called subscriber's disconnect had been received before the outward operator pulled down the connection, relays 407 and 406 would be on S, and relays 404 and 405 would be released.

The spacing signal sent over the trunk to the through and inward switchboard causes the 407' relays on the answering side of the connection at these points to release. One second after the release of these respective relays, the associated 406' relays release, causing the 404' and 405' relays to release. Ground is then applied to the ring of the answering cords, causing relays 607 to operate and relays 606 to start releasing. After about ⅜ second the 606 relays release. When relays 606 release, relays 604 operate over path from battery through relays 604 windings, disconnect lamp release key contacts, armature and back contacts relays 606, upper inner armature and front contacts relays 605 to ground. The 604 relays in both cords are locked over a circuit from battery through relay 604 windings, disconnect lamp release key, D.L.R., contacts, upper outer front contacts and armatures relays 604 to ground. When the 604 relays operate, relays 601 and 602 in both cords are released. Release of relays 601 releases relays 605. Release of relay 605 releases relay 608 and relay 612 in the through cord and relays 611 and 620 in both cords. Relays 608 and 612 in the inward cord were already released as heretofore explained. Lamps 621 in both through and inward cords light from ground through the lower armatures and front contacts of relay 607, back contacts and upper armatures of relay 612, filaments of lamps 621, relays 625 windings to battery. When relays 604 operate and relays 605 and 620 release in both through and inward cords, the tip, ring and sleeve connections on both sides of each cord are disconnected from the trunks. The inward and through operators upon noting the lighted lamps in each respective case, pull down both cords and extinguish the lamps by momentarily depressing the disconnect-lamp-release keys D.L.R., which open the locking circuits of relays 604 and 607.

At the outward board, a fraction of a second after the through and inward cords are automatically disconnected, relay 403, whose release was started when the cord at the outward board was pulled down and relay 401 released, finally operates to S and the trunk is made idle at that board.

At the through board, the trunk toward the inward board is held busy for slightly more than one second after the cord at the through board was automatically disconnected, since the ground was not removed from the lower winding of relay 403 until that time. In either case the trunk to the outward cord at the through office and the trunk to the through board at the inward office may be seized before the 403 relays at the outward and through boards, respectively, have operated to S, but the idle indicator under control of the 403 relays holds the trunk busy at the outward and through offices, respectively, until the 403 relays have released. This arrangement prevents the trunks from being seized before disconnect signals have registered at the same time releasing them immediately thereafter.

P. *Disconnect in error*

In case an operator pulls down a cord from a busy trunk in error after a connection has been fully established, the corresponding trunk lamps in the multiple will flash rapidly indicating to the operator that she has broken the connection. She may then restore the cord without requiring the connection to be completely built up again. At the through board pull down of the answering cord will cause the trunk lamps associated with both cords to flash even though the calling cord is still plugged up.

Referring to Fig. 4, when a connection is established relays 403 and 406 are on M and relays 401, 404 and 405 are operated. Relays 402 and 407 may be on M or S depending on the direction of transmission of communication signals and whether the particular component part of each teletypewriter character is a marking or spacing signal. In any event the 407 relay remains on its marking contact an insufficient length of time for relay 406 to remain on M as was heretofore explained. Under this condition if a cord is removed from jack 408, relay 401 releases, but since relays 404 and 405 remain operated, a source of interrupted battery is applied through the upper inner make contact of relay 405 through lamp 409, filament to ground, and the lamp flashes. Relay 402 is now under control of relay 412 since ground is applied to the tip of jack 408 through the lower back contact of relay 401, upper outer make contact relay 405 and resistance 415. The current to this circuit through the upper winding of relay 402 from battery at relay 412 M contact, in a direction to hold relay 402 on M as long as relay 412 is on M and to release 402 to S when 412 is on S. A false disconnect signal is therefore prevented from be-

ing sent over the trunk as long as relay 412 is not on S more than one second. Furthermore, relay 402 repeats the signals from relay 412 back over the circuit to relay 411 giving an indication of trouble to a sender, if at that time teletypewriter signals are being transmitted in a direction to operate relay 412.

Upon noting the flashing lamp the operator restores the cord, relay 401 operates and the connection is reestablished.

2. Local-to-Local Connection

In a local-to-local connection, a cord circuit per Fig. 3 is used in conjunction with two Figs. 2 as indicated in the diagrams per Fig. 1 and Fig. 1A. The operation will not be described in detail here as it is very similar to the operation of the same figures in the case of the built-up connection described under 1 above.

3. Direct Interoffice Connection

In a direct interoffice connection, Figs. 2, 3, 4, 5 and 6 are used as indicated in Fig. 1 and Fig. 1A. The operation will not be described in detail here as again it is very similar to the operation of the same figures in the case of the built-up connection described under 1 above.

What is claimed is:

1. In a manual telegraph system, a first manual telegraph central switching station, a second manual telegraph central switching station, a local telegraph station individual to each of said central stations, means for establishing a continuous telegraph path connecting said stations, a telegraph repeater in said path, signal and control means in the path at each station for establishing said path by the straightforward method with full through supervisory control localized in the first central station.

2. In a telegraph system, a first manual telegraph central switching station, a second manual telegraph central switching station, a local telegraph station individual to each of said central stations, at least one manual telegraph central switching station intermediate the first central station and the second central station, means for establishing a continuous telegraph path connecting said stations, a telegraph repeater in said path, signal and control means in the path at each station for establishing said path by the straightforward method with full through supervisory control localized in the first central station.

3. In a telegraph system, telegraph exchanges, each comprising a subscriber's line and an operator's position, means comprising an operator's cord in each of the exchanges, and a telegraph channel between said exchanges for transmitting messages and supervisory signals from one to the other of said exchanges, and means comprising said operator's cords and another telegraph channel between said exchanges for transmitting messages and supervisory signals from said other to said one of the exchanges.

4. In a telegraph system, a first telegraph exchange comprising a calling subscriber's line, a second telegraph exchange comprising a called subscriber's line, two telegraph channels between said exchanges, an operator's cord in the first exchange connecting said calling line to said channels, and an operator's cord in the second exchange connecting said channels to said called line, means in the first exchange for transmitting signals over one of the channels and means therein for receiving signals over the other of the channels, means in the second exchange for receiving signals over said one and means therein for transmitting signals over said other of the exchanges.

5. In a manual teletypewriter exchange system, a first central station, a second central station, a plurality of local stations associated with each central station, a telegraph line circuit connecting each local station with its associated central station, at least one central station intermediate the first central station and the second central station, a telegraph path connecting any line circuit associated with the first central station with any line circuit associated with the second central station through the intermediate central stations in tandem, means for establishing the path by the straightforward method and instrumentalities for full through supervision localized at the originating central station.

6. In a telegraph system, the combination of a first central station, a second central station, a full duplex telegraph path connecting the central stations comprising a cord circuit at each station and a telegraph trunk between stations, supervisory signal means in the cord circuits, relay means in the trunk circuits for discriminating between signals transmitted over the trunk on the basis of their duration for controlling the cord circuit supervisory signals in different manners for signals of different duration.

7. In a telegraph system, a first central station, a second central station, at least one central station intermediate the first central station and the second central station, a full duplex telegraph path between the first central station and the second central station through the intermediate central stations comprising a cord circuit at each central station and a trunk circuit between each central station in tandem, supervisory signal means in the cord circuits, relay means in the trunk circuits for discriminating between supervisory signals transmitted over the path on the basis of their duration, and means for controlling the cord circuit supervisory signals according to the discrimination.

8. In a manual straightforward telegraph system with full through supervision, the combination of a first central station, a second central station, a plurality of local stations associated with each central station, a continuous telegraph path connecting any local station associated with the first central station with any local station associated with the second central station through its associated central station, signal means in the path at each station, relay means in the path, responsive to control means at either local station for stopping the transmission of communication signals over the path without operating the signal means in the path.

9. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a plurality of local stations associated with each central station, at least one central station intermediate the first central station and the second central station, a telegraph path connecting any local station associated with the first central station with any local station associated with the second central station through the central stations in tandem, signal means in the path, means in the path responsive to control means at either local station for stopping the transmission of communication signals over the path from the other local station without operating the signal means in the path.

10. In a manual telegraph system, a first central station, a second central station, a plurality of local stations associated with each central station, a continuous telegraph path connecting any local station associated with said first with any local station associated with said second central station comprising a line circuit connecting each local station with its associated central station and a full duplex telegraph path connecting the central stations, signal means in the path at each station, relay means in the path at each central station responsive to control means at either local station for stopping the transmission of communication signals over the path without interfering with the full duplex operation of the path between central stations.

11. In a telegraph system, a first central station, a second central station, a plurality of local stations associated with each central station, at least one central station intermediate the first central station and the second central station, a telegraph path connecting any local station associated with the first central station with any local station associated with the second central station, through the central stations in tandem comprising a full duplex telegraph circuit connecting the central stations, relay means in the path at each central station responsive to control means at either local station for stopping the transmission of communication signals over the path from the other local station without interfering with the full duplex operation of the path between central stations.

12. In a telegraph system, the combination of a first central station, a second central station, a full duplex telegraph path connecting the stations, a cord circuit associated with said path comprising tip, ring and sleeve cord conductors at each station, said duplex path comprising a telegraph trunk circuit between said stations, means whereby supervisory signal means in the ring and sleeve circuits of the cord circuits are controlled by relays in the trunk circuit for discriminating between signals on the basis of their duration.

13. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a local station associated with each central station, at least one central station intermediate the first central station and the second central station, a telegraph path connecting the local station associated with the first central station with the local station associated with the second central station through the central stations in tandem, supervisory signal means in the first central station, and means in the path at each station to control the supervisory signal means in the first central station.

14. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a local station associated with each central station, a telegraph line circuit connecting each local station with its associated central station, a full duplex telegraph trunk circuit connecting the central stations, a cord circuit at each central station for interconnecting the local station associated with the first central station with the local station associated with the second central station through the trunk circuit, and signal means in the trunk circuit at the second central station operable solely on connection of a cord circuit to the trunk circuit at the first central station.

15. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a local station associated with each central station, one or more central stations intermediate the first central station and the second central station, a telegraph channel connecting the local station associated with the first central station with the local station associated with the second central station, comprising a telegraph line circuit connecting each local station to its associated central station, a telegraph cord circuit at each central station, and a telegraph trunk circuit connecting all the central stations in tandem, supervisory signal means in the cord circuit at the first central station, relay control means at each central station for operating the signal means in response to the connection of a cord circuit to the trunk circuit at each central station.

16. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a subscriber's station associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, at least one central station intermediate the first central station and the second central station, a telegraph path connecting the telegraph line circuit connected to the first central station with the telegraph line circuit connected to the second central station through the intermediate central stations in tandem, the path comprising a cord circuit at each central station and a telegraph trunk circuit between each central station and the next succeeding central station in tandem, recall signal means in the cord circuit at the first central station, and relay means in the path responsive to recall signal control means at each subscriber's station connected to the path to operate solely the recall signal means at the first central station.

17. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, at least one central station intermediate the first central station and the second central station, a full duplex telegraph path connecting the first central station and the second central station through the intermediate central stations in tandem, comprising a cord circuit at each central station and a trunk circuit between each central station and the next succeeding central station, recall signal means in the cord circuit at the second central station, and relay means in the path at each central station responsive to control means at the first central station to operate the recall signal means.

18. In a manual telegraph system, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, at least one central station intermediate the first central station and the second central station, a telegraph channel available for connecting any subscriber's station associated with the first central station with any subscriber's station associated with the second central station through the central stations in tandem, signal means connected with the path at each central station, and relay means in the path at each central station responsive to control means at the subscribers' stations to operate solely the signal means in the first central station.

19. In a manual straightforward telegraph

system with through supervision, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, telegraph line circuits connecting each subscriber's station with its associated central station, a full duplex telegraph path connecting any line circuit in the first central station with any line circuit in the second central station comprising a cord circuit at each central station and trunk circuit connecting the central stations, transmitting and receiving printers connected to the telegraph line circuits at subscribers' stations, and means connected to the line circuit at each subscriber's station for starting an unattended printer responsive to control means in the cord circuit at the first central station.

20. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, a full duplex telegraph path connecting any line circuit in the first central station with any line circuit in the second central station comprising a cord circuit at each central station and a trunk circuit connecting the central stations and ringing means connected to the line circuit at each subscriber's station responsive to control means in the cord circuit at the first central station.

21. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, a full duplex telegraph path connecting any line circuit in the first central station with any line circuit in the second central station comprising a cord circuit at each central station and a trunk circuit connecting the central stations, and disconnect signal means in the cord circuit at the first central station responsive to control means at each subscriber's station connected through said path.

22. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a plurality of subscribers' stations each comprising a teletypewriter, associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, at least one central station intermediate the first central station and the second central station, a full duplex telegraph path connecting any line circuit connected to the first central station with any line circuit connected to the second central station comprising a cord circuit at each central station and a trunk circuit connecting the central stations in tandem, and means connected to the line circuit at each subscriber's station connected through said path for starting an unattended teletypewriter responsive to control means in the cord circuit at the first central station.

23. In a manual straightforward telegraph system with through supervision, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, at least one central station intermediate the first central station and the second central station, a full duplex telegraph path connecting any line circuit connected to the first central station with any line circuit connected to the second central station comprising a cord circuit at each central station and a trunk circuit connecting the central stations in tandem, and ringing means connected to the line circuit at each subscriber's station connected through said path responsive to control means in the cord circuit at the first central station.

24. In a manual telegraph system, the combination of a first central station, a second central station, a plurality of subscribers' stations associated with each central station, a telegraph line circuit connecting each subscriber's station with its associated central station, at least one central station between the first central station and the second central station, a full duplex telegraph path connecting any line circuit connected to the first central station with any line circuit connected to the second central station comprising a cord circuit at each central station and a trunk circuit connecting the central stations in tandem, a disconnect signal means in the cord circuit at the first central station responsive to control means at each subscriber's station connected through said path.

25. In a manual straightforward telegraph system with through supervision, the combination of an originating central station, at least one intermediate central station, a completing central station, a plurality of subscribers' stations associated with the originating central station, a plurality of subscribers' stations associated with the completing central station, a telegraph line circuit connecting each subscriber's station with its associated central station, a telegraph channel connecting any telegraph line circuit connected to the first central station with any telegraph line circuit connected with the second central station comprising a cord circuit at the originating central station, a trunk circuit connecting each central station with the next succeeding central station in tandem and cord circuits identical each with the other at the intermediate and completing central stations.

26. In a manual straightforward telegraph system with through supervision, the combination of an originating central station, at least one intermediate central station, a completing central station, a plurality of subscribers' stations associated with the originating central station, a plurality of subscribers' stations associated with the completing central station, telegraph line circuits connecting each subscriber's station with its associated central station, a telegraph channel connecting any line circuit connected to the originating central station to any line circuit connected to the completing central station comprising cord circuits at each central station and telegraph trunk circuits identical each with the other connecting the central stations in tandem.

27. In a manual telegraph system, a first central station, a second central station, a two-channel telegraph path connecting the central stations comprising a cord circuit in the path at each central station, means including relays and signals in the cord circuit to receive message or supervisory signals incoming over one of said telegraph channels and at the same time to transmit message or supervisory signals outgoing over the other of said telegraph channels.

28. In a manual toll telegraph system, an originating central station, a cord circuit for use at the originating central station, relay, signal and

control means in the cord circuit to repeat subscribers' message signals in both directions, means to ring called and calling subscribers' stations, means to start unattended printers at the called and calling subscribers' stations, means to receive both calling and called subscribers' recall and disconnect signals, and means to transmit a recall signal to a remote central station.

29. In a manual toll telegraph system, an originating central station, a completing central station, at least one central station intermediate said central stations, a telegraph path connecting the central stations through the intermediate central stations, a cord circuit in the path at each intermediate station, signal means in the path at each intermediate central station, means including relays in the path at the intermediate central stations to repeat recall and disconnect signals from a local station connected to the completing end of the path to said originating central station and to repeat recall signals from the originating central station in the path to the completing central station.

30. In a manual toll telegraph system, a first central station, a second central station, at least one central station intermediate the first central station and the second central station, a local station associated with the first and a local station associated with the second central station, a telegraph path connecting the local stations through the central stations in tandem, supervisory and line signal means in the path at the central stations, a cord circuit in the path at each intermediate station, means including relays in the cord circuit for repeating communication and break signals between local stations, for repeating recall and disconnect signals from the local station associated with the second central station to the first central station and for repeating recall signals from the first central station to the second central station, relay means at the intermediate central station for maintaining the signal means thereat non-indicating during said repeating.

31. In a manual toll telegraph system, a first central station, a second central station, a local station associated with the first central station, a local station associated with the second central station, a telegraph path connecting the local stations through the central stations in tandem, a cord circuit together with supervisory signals and line signals all in the path at the second central station, means including relays in the cord circuit at the second central station for repeating communication signals and break signals from either local station to the other local station and means for repeating recall signals and disconnect signals from the local station associated with the second central station to the first central station and means for accomplishing all said repeating without operating the supervisory or line signals at the second central station.

32. In a manual toll telegraph system, an originating central station, a completing central station, at least one central station intermediate the originating and completing central stations, a telegraph trunk circuit connecting each central station with the next succeeding central station cooperating with a cord circuit at each central station to form a continuous full duplex telegraph path between stations, disconnect signal means including relays and signals at the intermediate and completing central station responsive solely to disconnect control means at the originating central station.

33. In a manual toll telegraph system, an originating central station, a completing central station, at least one central station intermediate said stations, a plurality of cord circuits at each station, a full duplex telegraph path connecting the stations comprising a trunk between each station and the next succeeding station and a cord circuit at each station, an originating and completing end on each trunk, multiple jacks connected to the trunk at each of said ends, protection means in each of said ends to guard against the connection of an interfering cord in a multiple jack while the path is being established and while the trunks are being released, automatic disconnect means in the cords at the intermediate and completing stations responsive to the removal of the cord from the trunk at the originating station to open the path through the cords and release the protection means at the completing end of the trunks to free said end for further use, timed-delay, relay control means at the intermediate and completing stations, operating disconnect signal means in the cords at said stations as a signal to remove the cords from the jacks, timed-delay, relay protection-release means in the originating ends of the trunks at the originating and intermediate offices, operating to release said ends immediately after the disconnect signals have registered in the cords connected to the completing ends of said trunks.

34. In a manual telegraph system, an outgoing trunk circuit operating in conjunction with a cord circuit, both of said circuits in the same switchboard, signal means in said trunk responsive to relay means also in said trunk, to indicate at said switchboard that said cord has been erroneously disconnected from said trunk.

35. In a manual teletypewriter system, an outgoing trunk circuit operating in conjunction with a cord circuit, both of said circuits in the same switchboard, relay means in said trunk, operating upon the erroneous disconnection of said cord from said trunk to maintain a connected incoming trunk in an operated condition, so that the connection may be reestablished by reinserting said cord in said outgoing trunk.

36. In a manual straightforward telegraph system, a first local telegraph station associated with a first central telegraph station, a second local telegraph station associated with a second central telegraph station, a central telegraph station intermediate the first central station and the second central station, a continuous telegraph path connecting said local stations through their associated central stations and the intermediate central station, a telegraph repeater in said path, a double-ended, three-conductor cord circuit, in the path at each central station, relay means in said cord circuits, in one of said conductors only, for transmitting and repeating all through communication and break signals between local stations, said means in said cords at said second and intermediate central stations transmitting and repeating answering, recall and disconnect signals from said second local station to said first central station.

37. A manual telegraph switching system, manual telegraph cord circuit, telegraph trunk circuit, incoming trunk line signal and telegraph repeater means therein for automatically signaling successive central stations connected to an originating central station in a tandem central station connection as said connection is being established.

38. A manual teletypewriter switching system,

manual telegraph cord circuit, telegraph trunk circuit, telegraph repeater, and incoming trunk line signal means therein for automatically signaling successive central stations connected to an originating station in a tandem central station connection as said connection is being established.

39. A manual telegraph switching system, manual telegraph cord circuit, telegraph trunk circuit, telegraph repeater and supervisory signal means therein for automatically transmitting reverting signals from successive central stations in a tandem connection to an originating central station to indicate successive steps as said connection is being established.

40. A manual straightforward teletypewriter switching system with manual telegraph cord circuit, telegraph trunk circuit, telegraph repeater, and supervisory signal means therein for automatically transmitting reverting signals from successive central stations in a tandem connection to an originating central station to indicate successive steps as said connection is being established.

41. A manual telegraph switching system, manual telegraph cord circuit, telegraph trunk circuit, telegraph repeater and incoming telegraph trunk line circuit signaling means therein for automatically signaling successive central stations connected to an originating central station in a tandem central station connection and telegraph repeater and supervisory signal means therein for automatically transmitting reverting signals from said successive central stations to said originating central station to indicate successive steps as said connection is being established.

42. A manual teletypewriter switching system, manual telegraph cord circuit, telegraph trunk circuit, telegraph repeater and incoming trunk line circuit signaling means therein for automatically signaling successive central stations connected to an originating central station in a tandem central station connection and telegraph repeater and supervisory signal means therein for automatically transmitting reverting signals from said successive central stations to said originating central station to indicate successive steps as said connection is being established.

43. A manual teletypewriter switching system, a plurality of manual teletypewriter switching offices therein and means including a telegraph repeater therein for automatic calling between switchboards.

44. A manual teletypewriter switching system, a plurality of manual teletypewriter switching offices therein and means including a telegraph repeater therein for automatic reverting signaling between switchboards.

45. A manual interoffice telegraph switching system, a multi-central office interconnection, comprising a telegraph repeater and a plurality of manual switching telegraph offices, between a calling and called subscriber in said system, means in said interconnection for supervising said calling subscriber's connection and means also in said interconnection for supervising said called subscriber's connection, both of said means located in a single switchboard.

46. A manual straightforward teletypewriter switching system, comprising means for establishing a telegraph channel interconnecting a calling and a called teletypewriter local station in a tandem connection through a plurality of teletypewriter manual central switching stations, a supervisory signal lamp in a manual cord circuit in said channel at the central station to which said calling station is connected and automatic means at the various stations through which said channel is extended for operating said lamp, in response to the extension of said channel, to indicate the progress of the channel as it is extended to the called subscriber.

47. A system in accordance with claim 46, including at least three manual central switching stations connected in tandem in the established channel.

48. A system in accordance with claim 46, including means for operating said lamp automatically in response to the completion of said channel by the answering of the called station.

49. A system in accordance with claim 46, including means for operating said lamp automatically in response to restoration of the termination of said channel at the called station to its normal condition when idle.

50. A system in accordance with claim 46, including means for flashing said lamp in response to the manipulation of the termination of said channel at the called subscriber's station.

51. A system in accordance with claim 46, including a manual cord circuit in said channel at each central station, a supervisory lamp in each of said cords and means in said system for preventing the operation of any of said lamps while said local stations are being interconnected other than said supervisory lamp in the cord at the central station to which the calling subscriber's station is connected.

52. A system in accordance with claim 46, including means whereby either local station which is receiving teletypewriter signals may "break" the transmission of said signals from the other local station and including means also for preventing the operation of said lamp in response to said break.

53. A system in accordance with claim 46, including at least three manual central stations in said channel, a manual cord circuit in said channel at each of said central stations, a supervisory lamp in each of said cords, means for transmitting a break signal in either direction between said local stations and means for preventing the operation of any lamp in any cord in response to the transmission of said break signal.

54. A system in accordance with claim 46, including a manual cord circuit in said channel at each of said central stations, a pair of supervisory lamps in each of said cords, means for flashing one of said lamps of said pair at the station to which said calling subscriber is connected in response to the manipulation of the termination of said channel at one of said local stations, and means for flashing the other lamp of said pair at the station to which said calling subscriber is connected in response to the manipulation of the termination of said channel at the other of said local stations.

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