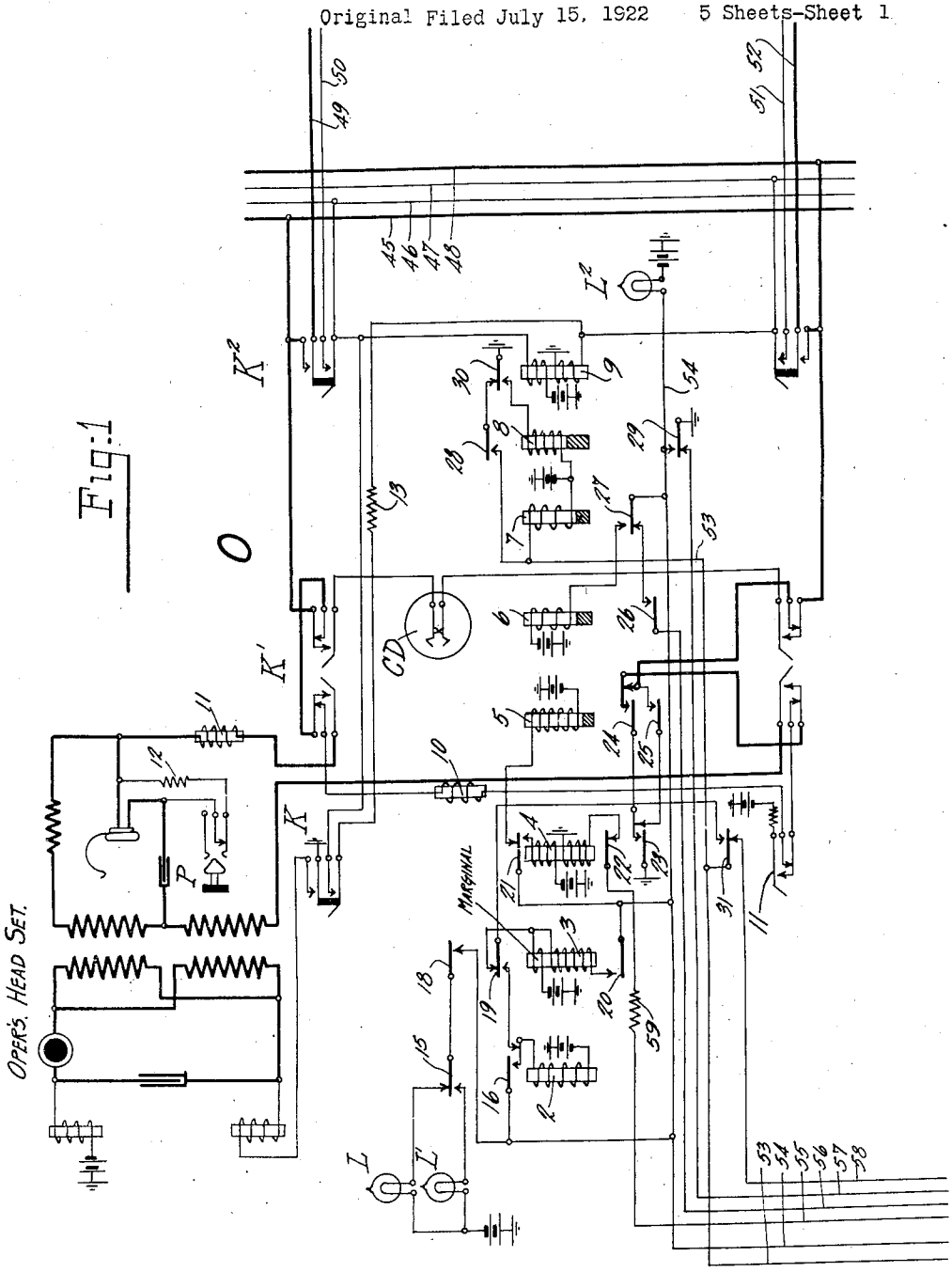
Aug. 23, 1927. 1,640,085

F. T. MADSEN

SERVICE OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS

Original Filed July 15, 1922 5 Sheets-Sheet 1

Fig. 1



Inventor
Fred T. Madsen
Chas. Tu. Cauby Atty.

Aug. 23, 1927. 1,640,085

F. T. MADSEN

SERVICE OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS

Original Filed July 15, 1922 5 Sheets-Sheet 2

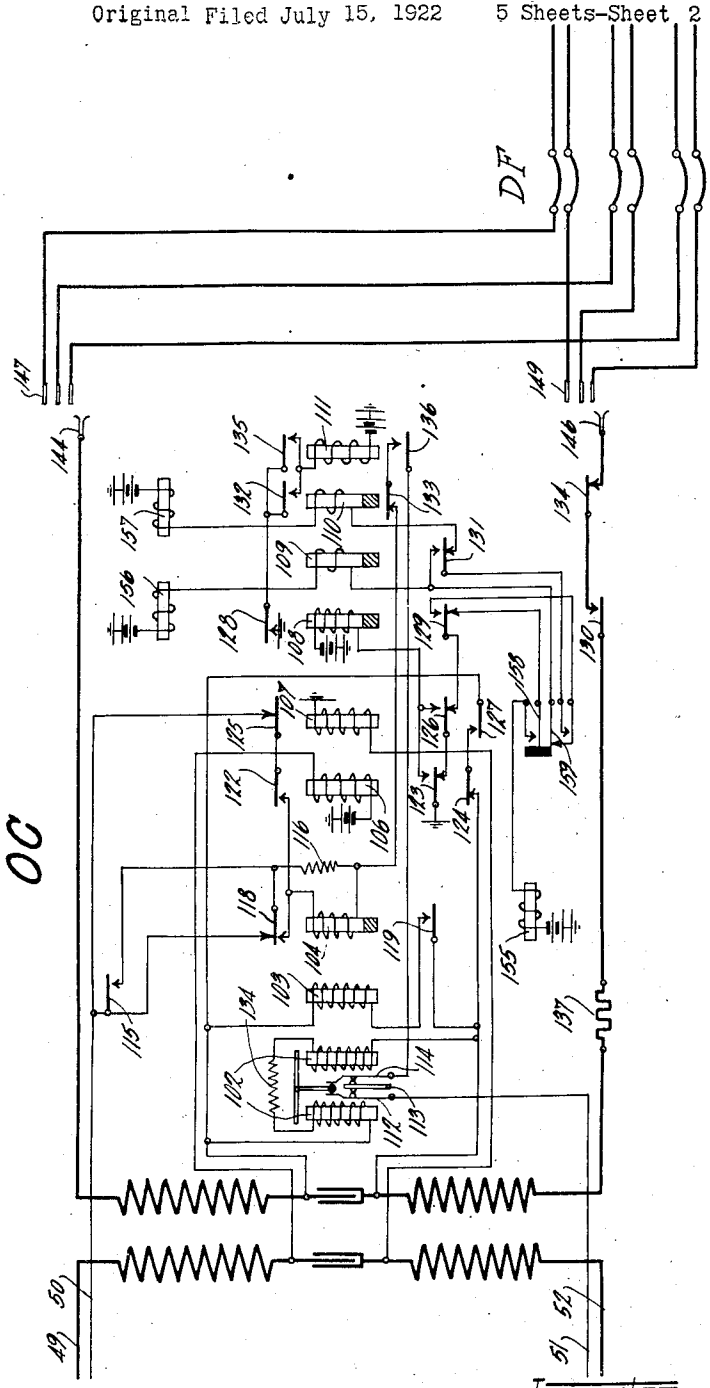


Fig: 2

—Inventor—
Fred T. Madsen
Chas. Tu. Cauby Atty

Aug. 23, 1927. 1,640,085

F. T. MADSEN

SERVICE OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS

Original Filed July 15, 1922 5 Sheets-Sheet 3

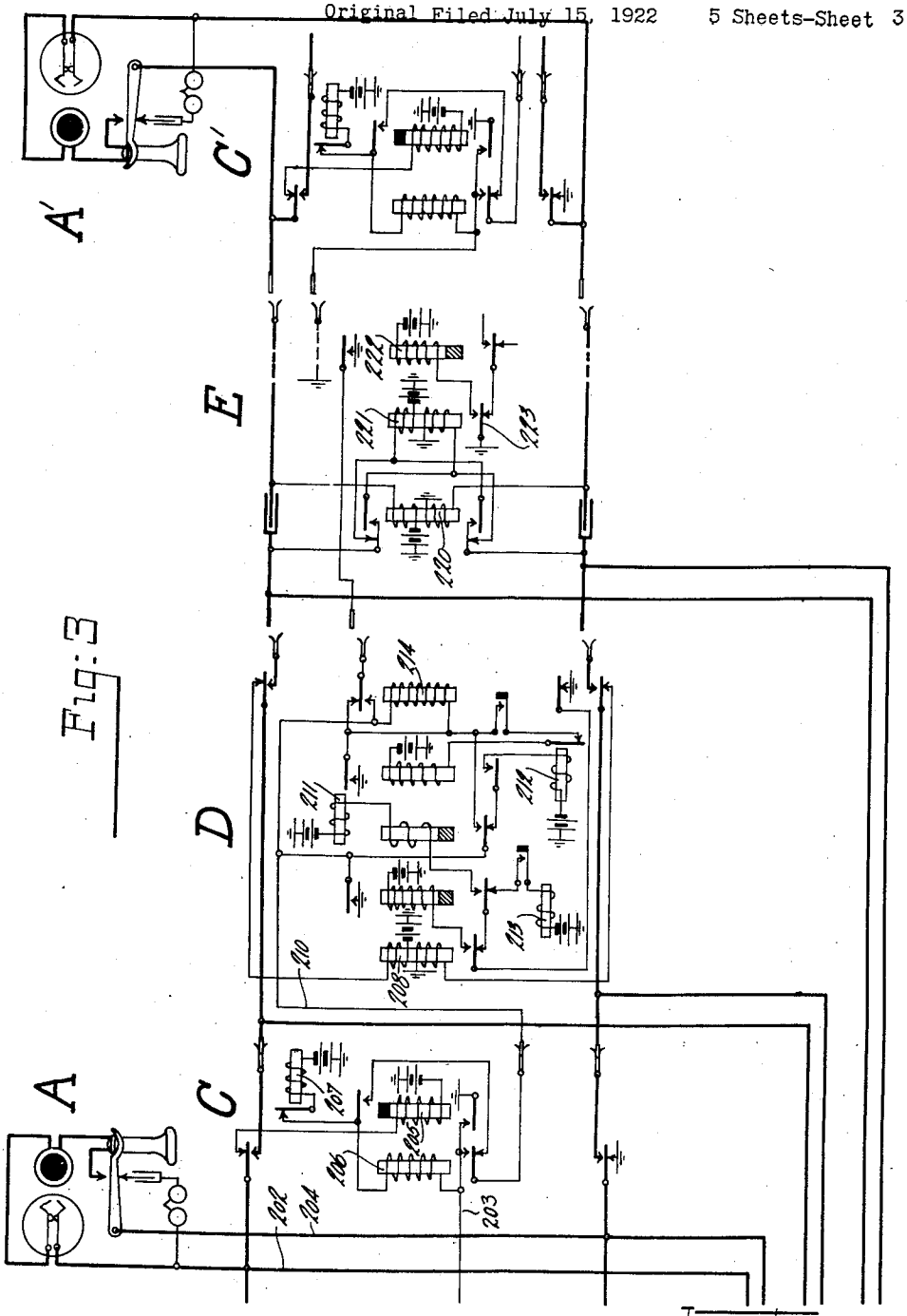


Fig: 3

Inventor
Fred T. Madsen
Chas. Tu. Candy Atty.

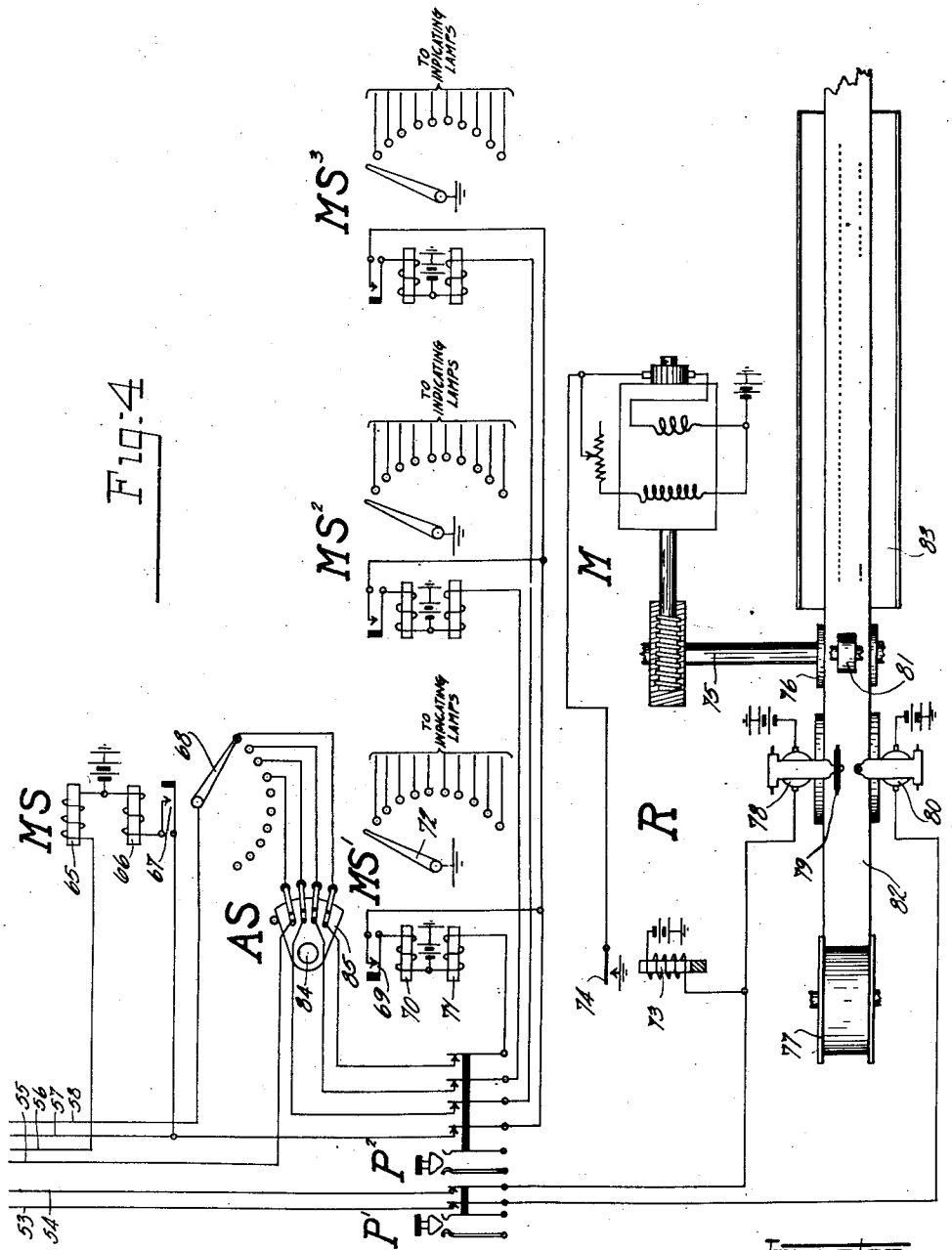
Aug. 23, 1927. 1,640,085

F. T. MADSEN

SERVICE OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS

Original Filed July 15, 1922 5 Sheets-Sheet 4

Fig. 4



Inventor
Fred T. Madsen
Chas. Tu. Candy Atty.

Aug. 23, 1927. 1,640,085

F. T. MADSEN

SERVICE OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS

Original Filed July 15, 1922 5 Sheets-Sheet 5

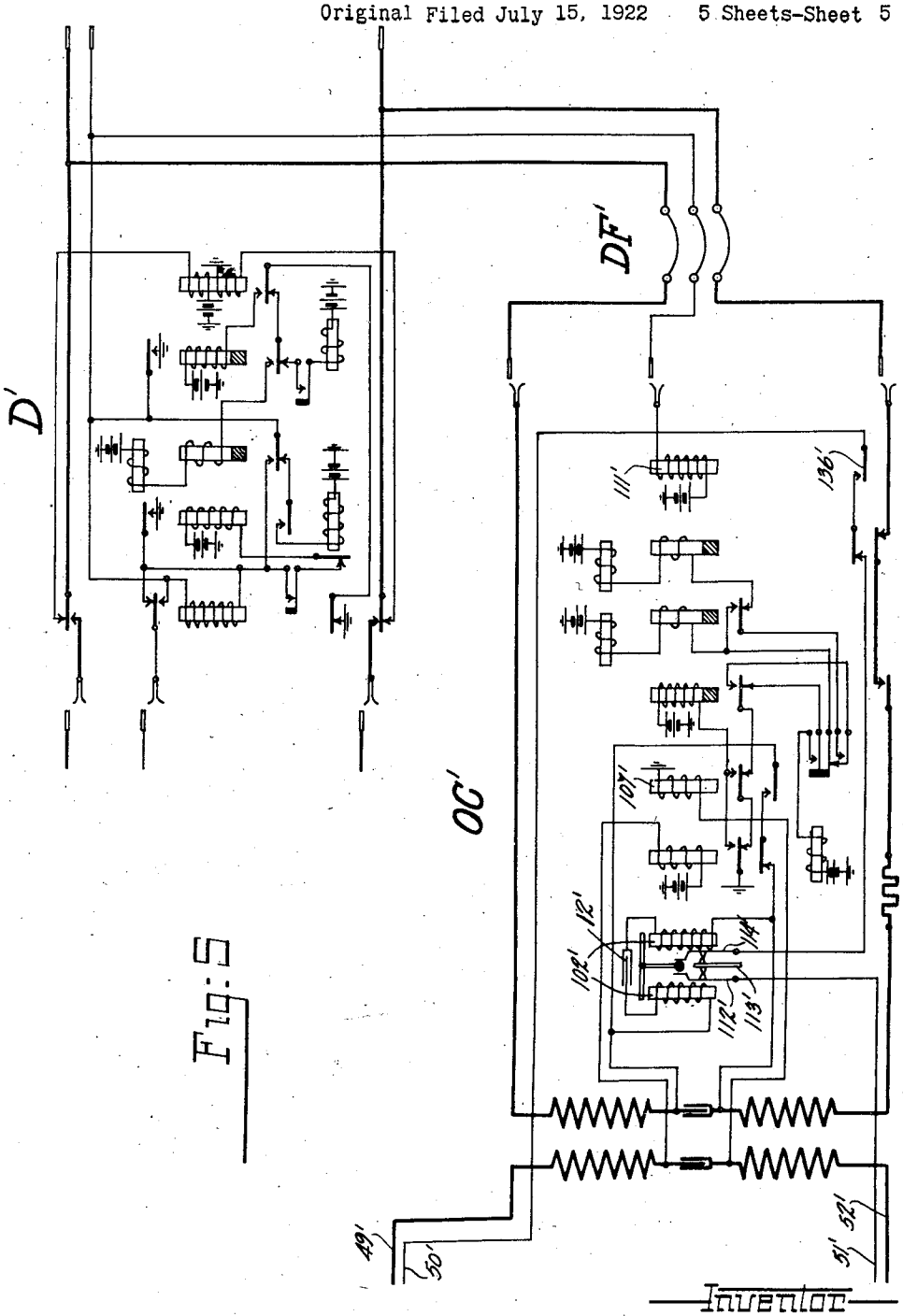


Fig. 5

Inventor
Fred T. Madsen
Chas. In. Canby Atty.

Patented Aug. 23, 1927. 1,640,085

UNITED STATES PATENT OFFICE.

FRED T. MADSEN, OF FOREST PARK, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE.

SERVICE-OBSERVING APPARATUS FOR AUTOMATIC TELEPHONE SYSTEMS.

Application filed July 15, 1922, Serial No. 575,333. Renewed June 26, 1926.

The present invention relates to service observing apparatus for automatic telephone systems, and has for its object the provision of new and improved circuit arrangements whereby an operator may connect with any one of several lines or trunks and observe the traffic on that line or trunk.

Another object is the provision of a new and improved impulse repeater which, when bridged across a calling line or trunk, repeats the interruptions produced by the calling subscriber's calling device and does not appreciably interfere with the successful operation of the automatic switches controlled by the calling subscriber.

The above pointed out objects, together with such others as are not specifically mentioned at this time, will be explained fully hereinafter, reference being had to the accompanying drawings, comprising Figs. 1–5, inclusive. In order to enable Figs. 1–4, inclusive, to be understood best, Figs. 1, 2, and 3 should be placed in order with the corresponding lines at the ends thereof in alignment, and Fig. 4 should be placed under Fig. 1, with the corresponding inter-connecting lines in alignment. When laid out thus, Figs. 1 and 4 represent certain equipment associated with the observation operator's position; Fig. 2 shows an observation connector on the distant end of the trunk terminating at the observation operator's position; and Fig. 3 represents a sufficient amount of automatic equipment to enable a complete connection to be established between a calling and a called automatic line. Fig. 5 shows a desirable modification and may be substituted for Figs. 2 and 3.

Referring now particularly to Fig. 1, the trunk which extends to the observation connector OC, Fig. 2, terminates in the contacts of the trunk key K^2, by means of which it may be connected with the operator's circuit O. Conductors 45–48, inclusive, of the operator's circuit O may be multiplied to as many of these trunk keys as desired, and consequently, there may be several trunks terminating in the operator's position, such as the trunk comprising conductors 49–52, inclusive. In practice, in a large multi-office system, the operator is provided with one trunk to each office in the system.

Referring now to Fig. 4, the so called minor switch MS associated with the operator's circuit O, Fig. 1, is of simple and well known construction and has an operating magnet 65 which operates the wiper 68 in a step by step manner so as to bring it into engagement with the desired one of the associated contacts. The release magnet 66 is provided for the purpose of restoring the wiper 68 to normal, and the off normal contacts 67 are used to open the circuit of release magnet 66 when the wiper 68 reaches normal position. The minor switches MS^1, MS^2, and MS^3 are mechanically identical with the minor switch MS with the exception that the wipers of the former are normally off the associated banks, as shown, while the wiper of the latter is normally on the first contact as shown. The adapting switch AS comprises a knob 84, which is secured to the rotatable non-conducting member 85, and the associated wipers and contacts as shown. This switch may be rotated in a clockwise direction until the first wiper stands on the last bank contact, and back again to the starting point.

The observation connector OC, Fig. 2, is mechanically of the usual vertical and rotary type and accordingly its bank contacts are arranged in horizontal rows or levels. The observation connector OC′, the selector D′, Fig. 5, the selector D, and the connector E, Fig. 3, are mechanically identical with the observation connector OC.

The line switches C and C′, Fig. 3, are of the well known rotary type in which the wipers have no normal position and move in a forward direction only.

The automatic substations A and A′ are of the usual type, having talking, signalling, and switch controlling instrumentalities. The line of substation A, the line conductors of the selector D, and the line conductors of the connector E are cabled over to the distributing frame DF, Fig. 2. The bank contacts of the connector OC also are cabled to the distributing frame DF, and the three sets of bank contacts shown are jumpered to the three pairs of line conductors shown on the other side of the frame. Preferably, only such trunks and lines as are thought to be likely to require observation

are cabled to the distributing frame, and only those that are to be observed from time to time need be jumpered to the bank contacts of the connector OC. Similarly the contacts in the bank of the observation connector OC', Fig. 5, are cabled to the distributing frame DF' and certain trunks such as the trunk leading to the selector D' are cabled to the other side of the frame. It will be noted that the release trunk conductor also of the selector D' is carried over to the distributing frame DF', and that the connector OC' has a third wiper adapted to cooperate with contacts that are cabled to the other side of the frame DF'. The reason for carrying the release trunk conductor over in this case, is twofold and will be explained subsequently.

Before the operation of the traffic observation equipment is explained, the operation of the automatic switches in establishing a connection will be considered briefly. For this purpose, it will be assumed that the subscriber at substation A desires to converse with the subscriber at substation A'. When the receiver is removed at substation A, a circuit is closed over line conductors 202 and 204 for line relay 205 of the line switch C. Upon the energization of line relay 205, the line switch C operates in the usual manner to select an idle trunk, which trunk it will be assumed is the one extending to the selector D. It will be understood, of course, that the trunk selecting operation of the line switch C is necessary only in case the wipers of the switch are standing on a busy trunk when the call is initiated, and that the mechanical movement of the wipers is effected by the buzzer like action of stepping magnet 207 which magnet operates from ground on the test contacts of busy trunks. In any event, switching relay 206 energizes at the end of the trunk selecting movement, or immediately upon the energization of line relay 205 in case the line switch is standing on an idle trunk, and extends the calling line through to the selector D. The line and release relays of the selector D now energize in the usual manner and the latter, upon energizing, places ground upon the release trunk conductor 210 so as to establish the usual holding circuit for the line switch C.

The calling subscriber now operates his calling device in accordance with the first digit in the desired number, thereby producing a corresponding number of interruptions in the circuit of line relay 208 of the selector D. In response to each of the resulting deenergizations of line relay 208, an impulse of current is delivered to vertical magnet 211 and as a result the wipers of the selector D are stepped up opposite the desired level of bank contacts. Upon the termination of the vertical movement of the selector D, the trunk selecting movement is initiated in the usual manner, whereupon an idle trunk is selected, which trunk it will be assumed is the one extending to the connector E. That being the case, switching relay 214 of the selector D, upon energizing in the usual manner at the end of the trunk selecting operation, extends the connection to the connector E, whereupon line and release relays 221 and 222 of the connector E energize. Upon energizing, release relay 222 places ground upon the release trunk conductor of the connector E, thereby establishing the usual holding circuit for the line switch C and the selector D.

Most of the circuits of the connector E have been omitted for the sake of simplicity, only the line, release, and back bridge relays being shown. This is considered to be permissible for the reason that the operation of connectors is well known to those skilled in the art.

Upon the calling of the second digit in the desired number, the connector E raises its wipers opposite the desired level of bank contacts, and upon the calling of the third and last digit in the desired number rotates them into engagement with the bank contacts in which the desired line terminates. The called line is now cleared of its attachments and the called subscriber's bell is now rung in the usual manner and, upon the response of the called subscriber the source of ringing current is removed and the called line is connected through to the windings of back bridge relay 220 as shown by the dotted conductors. Back bridge relay 220, upon energizing, reverses the incoming trunk conductors as regard their connection with the line relay 221. This is a standard operation and is used in certain cases to give supervision to toll operators and for operating meters and the like.

When the receiver is replaced at the called substation, back bridge relay 220 deenergizes and reverses the trunk conductors back to normal, and when the receiver is replaced at the calling substation the circuit of line relay 221 is opened. Upon deenergizing, line relay 221 opens the circuit of release relay 222, which relay deenergizes also, whereupon ground is removed from the release trunk conductor of the connector E and the switch is restored to normal in the usual manner. When ground is removed from the release trunk conductor of the connector E, switching relay 206 of the line switch C and switching relay 214 of the selector D deenergize. Upon the deenergization of switching relay 214, the usual circuit is closed for release magnet 213 of the selector D, whereupon the switch wipers are restored to normal position in the usual manner.

It will be assumed now that the operator desires to observe the traffic on the line of substation A. That being the case, she oper-

ates her key K^2, thereby placing a bridge across trunk conductors 49 and 52, of the observation connector OC. This bridge includes the upper and lower contacts of the key K^2, contacts of the key K', normally closed contacts controlled by spring 24 of relay 5, other contacts of the key K', contacts of the key K, and the impedance 10. In the observation connector OC, relays 106 and 107 energize in series with each other over trunk conductors 49 and 52. Line relay 106, upon energizing, closes a circuit for release relay 108 at armature 123. Release relay 108, upon energizing, connects up wiper 146 at armature 130, and at armature 129 opens a point in the circuit of release magnet 155 and prepares a circuit for vertical magnet 156.

The operator now throws the key K' in such a direction as to operate the right hand springs thereof, thereby substituting the calling device CD for the bridge including the impedance 10. The operator now manipulates the calling device CD in accordance with the bank level in which the line of substation A terminates in observation connector OC, thereby producing a corresponding number of interruptions in the circuit of line relays 106 and 107 of the observation connector OC. Line relays 106 and 107 are deenergized a corresponding number of times and, upon each deenergization, an impulse of current is sent to vertical magnet 156, the first impulse of current being transmitted by way of the following path: from ground by way of armature 123 and its resting contact, armature 126 and its resting contact, armature 129 and its working contact, resting contact of off normal spring 159 and said spring, relay 109, and vertical magnet 156 to battery. By the operation of vertical magnet 156, the wipers 144 and 146, are raised step by step until they stand opposite the desired level of contacts, which is the level in which contacts 147 and 149 are located. Relay 109 is energized in series with vertical magnet 156 and, being slow acting, retains its armature attracted throughout the vertical movement, thereby maintaining its own circuit and that of vertical magnet 156 intact after the off normal springs shift as they do upon the first vertical step. At the end of the vertical movement, relay 109 deenergizes and transfers the operating circuit from the vertical to the rotary magnet.

The operator now manipulates the calling device CD in accordance with the digit necessary to step the wipers of the observation connector OC into engagement with the bank contacts in which the line of substation A terminates. Each time line relays 106 and 107 deenergize in response to one of the second series of interruptions produced in their circuit, they send an impulse of current to rotary magnet 157 over the following circuit: from ground by way of armature 123 and its resting contact, armature 126 and its resting contact, armature 129 and its working contact, normally open contacts controlled by off normal spring 159, armature 131 and its resting contact, relay 110, and rotary magnet 157 to battery. By the operation of rotary magnet 157, the wipers 144 and 146 are rotated step by step into engagement with the desired set of bank contacts, which, in this case, are the contacts 147 and 149. Relay 110 is energized in series with rotary magnet 157 and, being slow acting, retains its armature attracted throughout the rotary movement, thereby maintaining wiper 146 disconnected. As a further result of the energization of relay 110, it closes a circuit for relay 111 at armature 132. Relay 111, upon energizing, closes a locking circuit for itself at armature 135, and at armature 136 prepares a circuit for the line relay of the operator's circuit O. At the end of the rotary movement, relay 110 deenergizes; connects up wiper 146 at armature 134; and at armature 133 closes a bridge across conductors 50 and 51 as follows: from conductor 51 by way of spring 112, post 113, spring 114, armature 136 and its working contact, armature 133 and its resting contact, resistance 116, and the resting of armature 118 and said armature, to conductor 50. Line relay 9 of the operator's circuit O now starts to energize. Also, assuming the line of substation A to be idle, polarized relay 102 energizes in series with line relay 205 of line switch C and opens the circuit of line relay 9 of the operator's circuit O at spring 112 or spring 114, depending upon the directions in which it is polarized. This occurs soon enough to prevent line relay 9 from operating release relay 8. Line relay 205 of the line switch C does not energize at this time on account of the high resistance of relay 102 of the observation connector OC.

The operator now throws her key K' to the opposite or listening position, whereupon the calling device CD is disconnected from in bridge of the conductors 49 and 52, and the operator's head set is bridged across said conductors 49 and 52. It will be noted that the impedance 11 is in series with one of the operator's listening taps and that the operator's receiver is shunted by the resistance 12. The impedance 11 is provided for the purpose of preventing a heavy flow of voice currents so as not to materially affect transmission on the line or trunk under observation. The resistance 12 is shunted around the operator's receiver so as to enable her to listen to the dialling without hearing unbearably loud clicks.

Assuming now that some one calls the line of substation A, switching relay 205 of the

line switch C is pulled up part way in the usual manner, upon ground being placed upon private normal conductor 203 by the connector which seizes the line of substation A by way of the normal conductors extending to the left of the line switch C. The connector now applies ringing current to the line of substation A in the usual manner.

The operator now hears the ringing current being applied to the called line. This ringing current, however, is not loud enough to cause the operator any discomfort owing to the resistance 12 being shunted around her receiver. The bridge, across the conductors of the called line, including relay 102 is high enough to prevent the ring-cut-off relay of the calling connector from operating. Relay 102, however, may operate in synchronism with the ringing current, but line relay 9 of the operator's circuit O does not respond owing to the fact that, since its circuit is closed only when springs 112 and 114 are both in contact with post 113, its circuit is closed only a very short time during each swing of the armature of relay 102, which closure occurs at a time when the armature of relay 102 is moving rapidly. During each silent period, relay 102, of course, is energized in series with the ring-cut-off relay of the connector.

When the subscriber at substation A responds by removing his receiver, the ring-cut-off relay of the calling connector energizes in the usual manner and completes the talking circuit, whereupon the calling and called subscribers may converse. As a further result of the removal of the receiver at the calling substation, relay 102, being short circuited, deenergizes and closes a circuit for line relay 9 of the operator's circuit O. Line relay 9, upon energizing, closes a circuit for release relay 8. Release relay 8, upon energizing, closes a circuit for the line lamp L^2 at armature 29, whereupon the said line lamp L^2 becomes lighted, giving the operator answering supervision. In case she desires to listen in, the operator operates her push button P, thereby removing the resistance 12 from in shunt of her receiver. The operator does this so that she may ascertain whether or not the subscribers experience any difficulty in conversing with each other and if so she makes a note of the difficulty.

When the conversation is finished, the two subscribers hang up their receivers. Relay 102 in the connector OC energizes and opens the circuit of line relay 9, whereupon line and release relays 9 and 8 deenergize and line lamp L^2 becomes extinguished.

Assuming now that subscriber at substation A calls a subscriber, the subscriber at substation A′ for example, relay 102 of the observation connector OC deenergizes owing to being shunted, when the receiver is removed at the calling substation. Upon deenergizing, relay 102, closes a circuit for line relay 9 of the operator's circuit O. Line relay 9, upon energizing, closes a circuit for release relay 8 at armature 30. Release relay 8, upon energizing, prepares a circuit for relay 7 at armature 28 and at armature 29 places ground upon conductor 54, thereby closing a circuit for the line lamp L^2, which lamp becomes lighted. As a further result of the ground potential being placed upon conductor 54, a circuit is closed for magnet 78 of the tape recording device R by way of contacts on the push button P′. Magnet 78, upon energizing, presses the sharp toothed wheel 79 into engagement with the tape 82. Relay 73 energizes in multiple with magnet 78 and closes a circuit for the compound wound motor M at armature 74. The motor M now rotates in such a direction as to drive the tape 82 toward the right, through the medium of the shaft 75 and the friction driving pulley 76. The idler pulley 81 is used to press the tape down on the driving pulley 76. Accordingly, the tape starts to move to the right and the saw toothed wheel 79 revolves as the tape passes under it and punches a dotted line in the tape, such as the one shown in the drawing. As a still further result of ground being placed on conductor 54, relay 5 energizes in series with armature 21 and its resting contact and at armatures 24 and 25 shifts the two conductors controlled thereby over to the normally closed contacts controlled by armature 23.

In the meantime, the subscriber's individual line switch C selects an idle first selector the selector D for example.

The calling subscriber now operates his calling device in accordance with the first digit in the desired number, thereby opening the circuit of the line relay of the selector D a corresponding number of times. In response to the deenergizations of the line relay of the selector D, the wipers of the selector are raised opposite the desired level of bank contacts after which an idle trunk, the trunk extending to the connector E for example, is selected in the usual manner. Each time the springs of the calling device at the calling substation separate, a momentary high potential exists across the conductors of the calling line due to the self induction of line relay 208. This high potential causes the polarized relay 102 in the connector OC to respond promptly. Each time the springs of the calling device at the calling substation close, relay 102 of the connector OC is shunted and the armature is quickly restored to normal, the high potential produced at the break of the calling device springs having subsided. This operation is repeated each time an interruption is produced in the calling line. It may be stated that, while polarized relay 102 is energized in series

with line relay 208 each time the calling device at substation A interrupts the circuit of the latter, the impedance of the bridge including the relay 102 is so high that the operation of line relay 208 is not noticeably affected.

Each time line relay 9 in the operator's circuit O deenergizes in response to the opening of its circuit by polarized relay 102 of the observation connector OC, it closes a circuit for slow acting relay 7. Relay 7 attracts its armature and, being slow acting, retains it attracted throughout the series of deenergizations of line relay 9. Upon energizing, relay 7 closes a circuit for relay 6 at armature 27. Relay 6, upon energizing, prepares a circuit for stepping magnet 65 of the minor switch MS, Fig. 4, at armature 26. As a further result of each deenergization of line relay 9, a circuit is closed for punch magnet 80 of the register R in multiple with relay 7, by way of conductor 53 and contacts of the push button P′. Punch magnet 80 is accordingly energized upon each deenergization of line relay 9 and punches a corresponding number of holes in the moving tape 82. Each time the circuit of relay 7 and punch magnet 80 is closed, a branch thereof extends by way of armature 31 of relay 4 and its resting contact, conductor 58, wiper 68, the first associated bank contact, lower contact and wiper of the adapting switch AS, right hand contacts of the push button P^2, and operating magnet 71 of the minor switch MS to battery. Accordingly the operating magnet 71 of the minor switch MS′ is energized upon each deenergization line relay 9 over the above circuit. By the operation of magnet 71, wiper 72 is advanced step by step until it comes into engagement with the bank contact corresponding to the number of deenergizations of the line relay 9, which number in turn corresponds to the first digit dialled by the calling subscriber. At the end of the series of deenergizations of line relay 9, the said line relay comes to rest in an energized condition, leaving the circuit of slow acting relay 7 open. Relay 7, upon deenergizing, opens the circuit of relay 6 at armature 27. Relay 6, however, being slow acting, retains its armature attracted for an interval. As a further result of the deenergization of relay 7, it closes at armature 27 and its resting contact the following circuit for stepping magnet 65 of the minor switch MS: from ground by way of armature 29 and its working contact, armature 27 and its resting contact, working contact of armature 26 and said armature, conductor 56, and stepping magnet 65 to battery. Stepping magnet 65, upon energizing, advances wiper 68 into engagement with the second associated bank contact. A moment later relay 6 deenergizes and opens the circuit of stepping magnet 65.

In response to the calling of the second digit in the desired number, the wipers of the connector E Fig. 3, are raised opposite the desired line in the usual manner. In the operator's circuit O, line relay 9 is deenergized a number of times corresponding to the digit called and at the first deenergization relays 7 and 6 energize one after the other as above described. At this time, magnet 80 of the register R punches a second series of holes in the tape 83, the number of which corresponds to the digit dialed. Also, upon each deenergization of line relay 9, the stepping magnet of the minor switch MS^2 is energized over a circuit which extends as previously traced to wiper 68, and thence by way of the second associated bank contact, contact and wiper of the adapting switch AS, second pair of contacts, from the right, of the push button P^2, and the stepping magnet of the switch MS^2, to battery. By the operation of the stepping magnet of the switch MS^2, the associated wiper is advanced into engagement with the contact corresponding to the second digit dialed. At the end of the series of deenergizations of relay 9, relays 7 and 6 fall back one after the other in the order named and send an impulse of current to stepping magnet 65 of the minor switch MS, whereupon the associated wiper 68 is advanced into engagement with the third associated bank contact.

When the calling device at the calling substation is turned for the third digit in the desired number, the wipers of the connector E are rotated into engagement with the set of bank contacts in which the desired line terminates. In the operator's circuit O, line relay 9 is deenergized a number of times corresponding to digit dialed and, upon each deenergization, sends an impulse of current to the punch magnet 80 of the register R. Accordingly, a third series of holes is punched in the tape 82. Since wiper 68 is in engagement with its third associated bank contact, the stepping magnet of the minor switch MS^3 is energized upon each deenergization of line relay 9 over a circuit with extends as traced to wiper 68 and thence by way of an easily seen path to stepping magnet of the minor switch MS^3. As a result, the wiper of the minor switch MS^3 is advanced into engagement with the bank contact corresponding to the third digit dialed.

The conductors extending from the bank contacts of the minor switches MS′–MS^3, inclusive, are assumed to extend to a bank of lamps located so as to be seen by the operator. These lamps are placed in vertical rows and each is numbered. This enables the operator to observe the digit called as soon as the corresponding minor switch is operated and, when the last digit is called, she can see the complete number at a glance.

Also she can see the number dialed by counting the number of holes in each series of holes punched in the tape 83.

At the end of the calling of the third and last digit in the number, relays 7 and 6 fall back one after the other in the order named, as hereinbefore described, and send an impulse of current to stepping magnet 65 of the minor switch MS. Upon energizing in response to this impulse of current, stepping magnet 65 advances the wiper 68 into engagement with the fourth associated bank contact. When this occurs, relay 4 energizes in series with relay 7 over the following circuit: from ground by way of the lower winding of relay 4, resting contact of armature 22 and said armature, resistance 59, conductor 55, upper wiper and associated contact of the adapting switch AS, fourth bank contact of the minor switch MS, wiper 68, conductor 58, resting contact of armature 31 and said armature, and relay 7 to battery. However, neither relay 7 nor magnet 80, which is in multiple with relay 7, is energized over this circuit on account of the high resistance 59. Upon energizing, relay 4 opens the circuit of slow acting relay 5 at armature 21. Relay 5, however, being slow acting, retains its armature attracted for an interval. As a further result of the energization of relay 4, it closes a locking circuit for itself at armature 21 and, upon energizing a little further, opens its initial circuit at armature 22. As a further result of the energization of relay 4, it disconnects the operating conductor 53 from conductor 58 and connects it to the upper winding of relay 3 at armature 31, and at armature 23, places ground on conductor 49 by way of armature 24 and its working contact, springs of the key K′, the operator's head set, other springs on the key K′, and springs of the key K^2, at the same time disconnecting conductor 52. This holds line relay 106 of the connector OC energized and permits line relay 107 to deenergize. Upon deenergizing, line relay 107 closes a circuit for relay 104 in multiple with resistance 116 at armature 125. Relay 104, upon energizing, opens a point in the bridge across conductors 50 and 51, and prepares a locking circuit for itself in multiple with resistance 116 at armature 118. This does not open the bridge across conductors 50 and 51 on account of the multiple path through armatures 122 and 125. As a further result of the energization of relay 104, it places relay 103 in bridge of polarized relay 102 at armature 119. Relay 103 is adjusted with very weak spring tension and, consequently, is able to energize in multiple with the calling subscriber's loop. Upon energizing, relay 103 again completes the bridge across conductors 50 and 51 over a path which is exclusive of armatures 122 and 125. Relay 103, it may be stated, is of a resistance high enough to allow any line relay, such as line relay 220 of the connector E, to deenergize quickly in series with it.

Returning now to operator's circuit O, slow acting relay 5, upon deenergizing, unites the two sections of the interrupted bridge at the normally closed contacts controlled by armature 24, and at armature 25 disconnects the other of the normally closed contacts controlled by armature 23. When this occurs, line relay 107 in the connector OC energizes again and opens the initial circuit of relay 104. Relay 104, however, remains locked up through armature 118.

When the subscriber at substation A′ responds to the ringing of his bell by removing his receiver, the line wipers of the connector E are disconnected from the source of ringing current and are connected to the windings of back bridge relay 220, as shown by the dotted conductors. Back bridge relay 220, upon energizing over the calling subscriber's loop, reverses the incoming line conductors as regards their connection with windings of line relay 221. In the observation connector OC, relay 103 deenergizes when the current falls to zero in the first direction and energizes again when the current builds up to maximum in the reverse direction. This is accomplished very quickly and results in a momentary opening of the circuit of line relay 9 in the operator's circuit O. Line relay 9, upon deenergizing, operates magnet 80 of the register R over conductor 53 in the usual manner. As a further result of the deenergization of line relay 9, a circuit is closed for the upper winding of relay 3 by way of conductor 53, armature 31 and its working contact, armature 19 and its resting contact, and upper winding of relay 3 to battery. Relay 3 energizes over this circuit far enough to operate the lightly adjusted armature 20 but not far enough to operate the more stiffly adjusted armatures 18 and 19. This adjustment is made easy due to the fact that the upper winding of relay 3 comprises a small number of turns of wire having a relatively high resistance. Armature 20, upon coming into engagement with its working contact, connects the lower winding of relay 3 to the grounded conductor 54. No current flows through the lower winding of relay 3 at this time, however, owing to the fact that the said winding is grounded at both terminals. Line relay 9, upon energizing after its momentary deenergization, removes ground from conductor 53, whereupon magnet 80 of the register E deenergizes and relay 3 pulls all the way up owing to the fact that current now flows through its upper and lower windings in series. Upon energizing fully, relay 3 disconnects the operating circuit from its own upper winding and extends it to relay 2 at armature 19, and at

armature 18 closes a circuit for the lamp L. Lamp L, upon becoming lighted, signifies to the operator that the called man has answered.

By the above mentioned momentary energization of magnet 80 of the register R, a hole is punched in the tape thereby recording the fact that the called subscriber has answered.

It will be noted that relay 104 in the observation connector OC is slow acting. This prevents the said relay 104 from deenergizing upon the momentary deenergization of relay 103 as explained above.

Upon the termination of the conversation, the two subscribers replace their receivers. Assuming that the subscriber at substation A′ replaces his receiver first, back bridge relay 220, upon deenergizing, reverses the line conductors of the connector E back to normal. When this occurs, relay 103 is again deenergized momentarily in the previously described manner and momentarily interrupts the circuit of line relay 9 of the operator's circuit O. When this occurs an impulse of current is delivered to magnet 80 of the register R whereupon another hole is punched in the tape 82. Also, an impulse of current is sent to relay 2 by way of the previously traced circuit to armature 19 of relay 3 and thence by way of the working contact of armature 19 and the normally closed contacts controlled by armature 16. Relay 2, upon energizing, closes a locking circuit for itself and opens its initial circuit at armature 16, and at armature 15 opens the circuit of the lamp L and closes the circuit of the lamp L′. The lamp L becomes extinguished and the lamp L′ becomes lighted to inform the operator that one of the subscribers has replaced his receiver.

When the receiver is replaced at the calling substation, the line relay 221 of the connector E deenergizes and polarized relay 102 in the connector OC energizes, in series with the line relay of the connector E and in multiple with relay 103, and opens the circuit of line relay 9 of the operator's circuit O. Line relay 9, upon deenergizing, opens the circuit of release relay 8 and closes the usual circuit for magnet 80 of the register R. Magnet 80, upon energizing, pierces the tape 82 again.

When the release of the connection occurs, due to the deenergization of release relay 222 of the connector E, which deenergization occurs before the deenergization of release relay 8 in the operator's circuit O, which relay has an exceptionally slow adjustment, switching relays 206 and 214 of the line switch C and the selector D, respectively, deenergize. When the upper and lower armatures of relay 206 break away from their working contacts, the circuit of relay 102 in the observation connector OC is opened, whereupon the said relay 102 deenergizes. Almost immediately the upper and lower armatures of switching relay 206 of the line switch C come into engagement with their resting contacts, thereby closing a circuit for relay 102 of the observation connector OC in series with line relay 205. When this occurs, relay 102 energizes, comparatively slowly at this time, however, on account of its high impedance. The momentary deenergization of relay 102 at this time causes a momentary energization of line relay 9 in the operator's circuit O. This energization is of sufficient duration to permit magnet 80 of the register R to retract its armature sufficiently long to skip a slight space on the tape 82 after which it is attracted again. The momentary energization of relay 9, however, is not of sufficient duration to completely saturate release relay 8 and, consequently, the said release relay 8, which was almost at the point of letting go when line relay 9 energized, retracts its armature almost immediately after the deenergization of relay 9. Upon deenergizing, release relay 8 opens the circuit of the magnet 80 of the register R and the circuit of relay 7 at armature 28, and at armature 29 opens the circuit of the line lamp L^2 and the locking circuit of relays 2, 3, and 4, whereupon the line lamp L^2 becomes extinguished. As a further result of the removal of the ground potential from conductor 54, the circuit of relay 73 and magnet 78 of the register R is opened. Consequently, magnets 78 and 80 deenergize simultaneously, thus terminating the two records being made on the tape 82. Relay 73, being slow acting, retains its armature attracted for a slight interval, thereby allowing time for tape 82 to be pulled out far enough to permit the complete record of the call to be exposed to the operator's view. When relay 73 deenergizes, the circuit of the motor M is opened, whereupon the tape 82 stops moving. As a further result of the deenergization of release relay 8 of the operator's circuit O, a circuit is closed for release magnet 66 of the minor switch MS, release magnet 70 of the minor switch MS′, and the release magnets of the minor switches MS^2 and MS^3 in multiple. The circuit of the release magnet of the minor switch MS is as follows: from ground by way of armature 29 of release relay 8 and its resting contact, conductor 57, off normal contacts 67, and release magnet 66 to battery. A branch of this circuit extends by way of a pair of contacts controlled by the push button P^2, to off normal contacts 69, and release magnet 70 of the minor switch MS′ to battery. This circuit extends also to the release magnets of the minor switches MS^2 and MS^3 by way of their respective associated off normal contacts. Upon the

energization of the release magnets of the minor switches MS–MS³, inclusive, the wipers of the said minor switches are restored to normal position, the circuit of the release magnets being opened by the off normal contacts when the associated wipers reach normal position. The operator's equipment is now completely restored to normal.

Assuming now that the subscriber at substation A is making a call and that he obtains the wrong number, the operator, who operates her push button P to remove the resistance 12 from in shunt of her receiver after all the digits of the number have been dialed, learns from the conversation that something is wrong.

In order to converse with the calling subscriber and in order to be able to hold up the connection subsequently until the difficulty is located, the operator operates her talking key K. The upper pair of contacts of the key K supply talking current to the operator's head set. The next pair of contacts below, upon being closed, close a local circuit for line relay 9 through resistance 13 so as to prevent a false operation as will be explained subsequently. Spring 11, upon being operated, prepares the circuit for placing battery on conductor 52 and disconnecting conductor 49 when the key K′ is restored subsequently. When the key K′ is restored, line relay 106 of the observation connector OC deenergizes and places a shunt around the condenser which is between the right hand windings of the repeating coil at armature 124 in series with armature 127, thereby holding the connection independent of the calling subscriber. The non-inductive resistance 137 is high enough to prevent the calling subscriber's transmitter from being robbed of too much talking battery so that the subscriber can converse with the test man when he comes in on the connection at the switch room as he does in the usual manner while searching for the defective switch. When this shunt is closed, relay 103 deenergizes and opens the bridge across conductors 50 and 51 at armature 115. Line relay 9 in the operator's circuit O does not deenergize, however, being held up over the local circuit including resistance 13. Relay 104 deenergizes in response to the deenergization of relay 103; disconnects relay 103 at armature 119; and at armature 118 opens its locking circuit and again closes the bridge across conductors 49 and 50.

Before having restored the key K′, the operator observes, either on the tape 82 or on the bank of lamps controlled by the minor switches MS′–MS³, inclusive, the number called by the calling subscriber, and then asks him what number he desires. This is done so as to enable a check to be made to ascertain the cause of wrong numbers. In case the subscriber replies that he is dialling a number other than that indicated to the operator, the inference is that he has not properly dialled the desired number, in which case the operator requests him to replace his receiver and call the number again. However, if he says that he is calling the number set up by the operator's indicating devices, the inference is that some one of the automatic switches through which the connection is extended has not operated properly. In this case, the operator requests the subscriber to wait a moment. She then restores the key K′ as above pointed out and gets in touch with an attendant at the automatic exchange in any desired manner and tells him of the difficulty. The attendant immediately proceeds to trace the connection through and find out which switch has failed to respond properly. He can easily do this because he has the called number given to him by the operator. As soon as the attendant has located the switch that is causing the trouble, he releases the connection by removing ground from the release trunk conductor of the switch giving the trouble and then makes that switch busy and informs the operator that he has finished. The attendant, of course, may make such repairs and adjustments on the switch giving the trouble as may be necessary. When the connection is released by the attendant the line switch C immediately picks out an idle first selector in the usual manner.

The operator, upon being informed by the attendant that he is through, again throws her key K′ into listening position and requests the calling subscriber to replace his receiver and dial the number over again. The operator then restores her key K to normal and releases the locking push button P so as to replace the shunt around her receiver. When the key K is restored to normal, line relay 9 is again placed under control of the observation connector OC and relay 107 in the observation connector OC energizes owing to the circuit change produced by the lower contacts of the key K.

When the receiver is replaced at the calling substation, polarized relay 102 energizes in series with the line relay of the first selector which has been selected by the line switch C and opens the circuit of line relay 9 of the operator's circuit O. Line relay 9, upon deenergizing restores conditions in the operator's circuit to normal in the usual manner. Upon the deenergization of the line relay of the first selector to which the connection has been extended by the line switch C responsive to the release of the original connection by the attendant, the switch shaft steps up one step and is released again upon deenergization of the associated release relay.

When the receiver is removed at the calling substation the line switch C operates in the usual manner to select an idle first selector and polarized relay 102 in the observation connector OC deenergizes and closes the circuit of line relay 9 in the operator's circuit O. Line and release relays 9 and 8 now energize with the hereinbefore described results and the line lamp L^2 becomes lighted. The calling subscriber now proceeds to call the desired number in the usual manner, which number is set up in front of the operator as hereinbefore described.

The preferable arrangements for jumpering lines or trunks to the banks of the observation connector OC is to connect only subscriber's line or only first selector trunks, etc., in one level of bank contacts. When this is done, the operator may dial the observation connector OC up opposite the desired level and then in on the first set of bank contacts in that level; observe the traffic on the first trunk or line; and then operate her calling device for the digit one and step the switch wipers over to the second set of bank contacts and so on to the tenth, observing the connected trunks or lines one by one as she sees fit.

It will be understood that the operator can dial the observation connector OC up to the proper level and observe the traffic on any one of several first selector trunks depending upon which ones are jumpered over to the banks of the observation connector. The observing of traffic on a first selector trunk is very much similar to observing traffic on a subscriber's line as hereinbefore described. The principal difference is that a trunk handles outgoing calls only and that a trunk is used much more frequently than a subscriber's line.

In case the operator desires to observe the traffic on a certain connector trunk, for example the traffic on the connector E she dials the connector OC up and around into engagement with the proper set of bank contacts. It is readily apparent that only two digits are called after the connector E is reached. In order to cause the last two digits called to be registered upon the minor switches MS^2 and MS^3, which they are when a line or a first selector trunk is under observation, and in order for relay 3 in the operator's circuit O to be operated at the end of the last digit called, the operator turns the adjusting switch AS in a clock-wise direction by means of the knob 84. This shifts the wipers of the switch forward until each one stands on the contact next in order. This allows the first digit received, or the one which operates the connector E vertically, to be received by the minor switch MS^2 and the second digit received, or the one which operates the connector E to bring the wipers thereof into engagement with the desired line, to operate the last minor switch MS^3. Then, at the end of the last digit, the wiper 68 comes into engagement with the third associated bank contact and closes a circuit for the lower winding of relay 4 including the upper wiper of the adjusting switch AS. Otherwise the operations accompanying the observation of traffic on a connector trunk are similar to the operations accompanying the observation of traffic on a first selector trunk.

It is to be understood that in case the observation equipment is used in connection with a larger or smaller automatic system, suitable changes may be made in the number or recording minor switches such as the minor switch MS′ etc., and also that the adjusting switch AS may be suitably changed to meet the requirements.

The push buttons P′ and P^2 are provided for the purpose of enabling the operator to disconnect either the register R or the recording switches, or both, depending upon what may be desired in any particular instance or on any particular occasion.

When the operator desires to release the observation connector OC, either because she wants to reoperate the said connector OC to get on another trunk or because she wants to connect her set with a trunk leading to another office, she restores the connecting key K^2 to normal, whereupon line relays 106 and 107 deenergize and open the circuit of release relay 108, at the same time closing the usual circuit for stepping magnet 157. Incidentally stepping magnet 157 advances the wipers 144 and 146 into engagement with the next set of bank contacts. Release relay 108, upon deenergizing, opens the circuit of relay 111 at armature 128, and at armature 129 opens the circuit of rotary magnet 157 and closes a circuit for release magnet 155 by way of off normal spring 158 and its contact. Release magnet 155 now energizes, whereupon the shaft and wipers are restored to normal position in the usual manner, the circuit of release magnet 155 being opened at off normal spring 158 by the switch shaft when the latter reaches normal position.

Referring now particularly to Fig. 5, which drawing is best understood when placed to the right of Fig. 1 in place of Figs. 2 and 3, the operation of the observation connector OC′ will now be explained. The circuits of the connector OC′ are very similar to the circuits of the connector OC, the principal difference being that the resistance 134 associated with relay 102 of the connector OC is replaced by the condenser 12′ in the connector OC′. This so changes the operation of the relay 102′ that relays 103 and 104 of the connector OC may be omitted. Another difference between the two circuits is that a third wiper is added and is connected as shown. This wiper connects re-

lay 111′ to the release trunk conductor of the trunk under observation.

It will be assumed now that the operator has stepped the observation connector OC′ onto the trunk leading to the selector D′. This is done, it will be understood, in the same manner as the connector OC is stepped onto a desired set of contacts. It will be assumed now that the selector D′ is seized. This is accomplished by the seizing switch, which switch is similar to the line switch C, by placing a bridge across the line conductors of the selector D′ and simultaneously placing ground on the release trunk conductor. When this occurs relay 111′ energizes due to ground being placed on the release trunk conductor of the selector D′ and closes a bridge across conductors 50′ and 51′ at armature 136′, whereupon line and release relays 9 and 8 in the operator's circuit O energize in the usual manner and perform the usual functions.

Each time the bridge across the line conductors of the selector D′ is opened by the calling subscriber's calling device, the line relay of the selector D′ deenergizes in the usual manner and polarized relay 102′ is energized quickly on account of the high potential discharge from the windings of the line relay of the selector D′, and at either spring 112′ or 114′, depending upon which way the relay is polarized, opens the circuit of line relay 9 of the operator's circuit O. The high potential which operates relay 102′, and consequently the charge on the condenser 12′, begins to subside almost immediately and entirely disappears before the springs of the calling device close again. The capacity of the condenser 12′ is of such a value that relay 102′ is not operated again by the minute discharge of the condenser 12′ when the calling device springs again close. This allows only one opening in the circuit of line relay 9 for each opening in the bridge across the line conductors of the selector D′ and, as a result, line relay 9 responds to each opening of the bridge across the busy conductors of the selector D and produces the hereinbefore described results. This operation is repeated for each of the following two digits.

At the end of the third digit, relays 4 and 5 in the operator's circuit O operate in the hereinbefore described manner. However, the momentary deenergization of line relay 107′ of the connector OC′, resulting from this operation is merely incidental and does not have any particular function.

When the reversal in the current flow occurs, upon the answering of the called subscriber, the condenser in series with the right hand windings of the repeating coil associated with the connector OC′ as well as the condenser 12′ in series with relay 102′, is discharged when the springs of the back bridge relay of the connector, such as back bridge relay 220 of the connector E, Fig. 3, close together, and are charged in the opposite direction when those springs operate fully, resulting in the momentary energization of relay 102′. This deenergizes line relay 9 momentarily and gives a corresponding registration on the tape 82. This operation is repeated in case the called subscriber replaces his receiver ahead of the calling subscriber.

When the receiver is replaced at the calling substation, relay 102′ energizes momentarily, just as though the bridge across the line conductors were opened by the calling device, and consequently causes a registration on the recording tape at the operator's position. When ground is removed from release trunk conductor by the connector to which the connection has been extended, the switching relay of the selector D′ and relay 111′ of the observation connector OC′ deenergize. Relay 111′ upon deenergizing, opens the circuit of line relay 9 at armature 136′ whereupon the operator's equipment is restored to normal in the usual manner.

There is one record made on the recording tape at the operator's position when the observation connector OC′ is used, that is not made when the observation connector OC is used as will now be explained. Assuming now that the selector D′ is seized by a line switch such as the line switch C, and that the calling subscriber operates his calling device for the first digit in the usual manner, and that the selector D′, upon finding an idle trunk, switches through on a trunk that does not have the three conductors continuous. In this case, ground is not placed upon the release trunk conductor by the switch ahead before the release relay of the selector D′ deenergizes and removes ground from the release trunk conductor at that point. Consequently, the switching relay of the selector D′, the switching relay of the line switch which seized the selector D′, and relay 111′ of the observation connector OC′ deenergize simultaneously. Relay 111′, upon deenergizing, opens the circuit of line relay 9 of the operator's circuit O, whereupon punch magnet 80 energizes. The switching relay of the selector D′ upon deenergizing, closes the usual release magnet circuit, whereupon the said selector D′ is restored to normal position in the usual manner. Almost immediately the relays of the line switch operate again and seize the selector D′ again, whereupon relay 111′ energizes and again closes the circuit of line relay 9 of the operator's circuit O, whereupon line relay 9 energizes and punch magnet 80 deenergizes.

The record made by magnet 80 at this time, informs the observing operator or anyone who later inspects the tape of the fact

that a trunk leading to a connector of a certain group is open. It can be readily seen that an open trunk causes the record to be made because punch magnet 80 is held energized longer than usual at this time, and it can be ascertained which group of connectors contains the one having the open trunk by observing the digit dialled immediately before the open trunk was reached.

The operation accompanying the recording of the finding of an open trunk is substantially the same in case a subscriber's line is under observation. In that case, of course, a private normal conductor, such as conductor 203 of the line switch C, is cabled back to the distributing frame DF' and the ground thereon operates relay 111' in the same manner as the ground on release trunk conductor of the selector D'. The operations accompanying the use of the connector OC', other than the exceptions noted, are identical with the operations when the observation connector OC is used.

What is claimed is:

1. The combination, with an automatic switch operated by interruptions in a closed control circuit, of an impulse repeating relay bridged across said control circuit and inoperative as long as the circuit is closed, and a second circuit, said repeating relay being adapted to energize to control said second circuit each time said control circuit is interrupted to operate said switch.

2. The combination, with an automatic switch operated by interruptions in a closed control circuit, of an impulse repeating relay bridged across said control circuit, said relay being shunted as long as the circuit is closed, a second circuit controlled by the energization of said relay each time said control circuit is interrupted to operate said switch, and a second automatic switch controlled over said second circuit.

3. In combination, two relays connected in series with a battery, the first relay being of relatively high resistance and normally energized, the second relay being of relatively low resistance and normally deenergized, means for shunting the high resistance relay to reverse the condition of said relays, and means for producing a series of interruptions in the shunt, the first relay energizing each time the shunt is opened and the second relay energizing each time the shunt is closed.

4. In combination, two relays connected in series with a battery, the first relay being of relatively high resistance and normally energized, the second relay being of relatively low resistance and normally deenergized, means for shunting the high resistance relay to reverse the condition of said relays, means for producing a series of interruptions in the shunt, the first relay energizing each time the shunt is opened and the second relay energizing each time the shunt is closed, and two automatic progressively movable switches controlled by said relays, respectively.

5. In a telephone system, a line terminating in an automatic switch, a line relay and a battery connected in series across said line at said switch, a relatively high resistance relay temporarily connected in bridge of said line and normally energized, said line relay being normally deenergized, means for closing a low resistance bridge across said line when the same is taken for use to energize said line relay, the high resistance relay being shunted out and deenergized, and means for producing interruptions in said low resistance bridge to operate said switch, said high resistance relay being energized at each interruption.

6. In a telephone system, a line terminating in an automatic switch, a line relay and a battery connected in series across said line at said switch, a relatively high resistance relay temporarily connected in bridge of said line and normally energized, said line relay being normally deenergized, means for closing a low resistance bridge across said line when the same is taken for use to energize said line relay, the high resistance relay being shunted out and deenergized, means for producing interruptions in said low resistance bridge to operate said switch, said high resistance relay being energized at each interruption, a circuit closed by said high resistance relay when the same is deenergized, and an automatic switch controlled over said circuit in accordance with the subsequent energizations of said high resistance relay.

7. In a telephone system, means for connecting a calling and called line, means for reversing the direction of current flow in the calling line when the called party responds and when he hangs up, a nonpolar supervisory relay bridged across the calling line, said relay being responsive indifferently to current flow in either direction, and signalling means controlled by said relay when the same is momentarily deenergized by a current reversal through its winding.

8. In a telephone system, means for connecting a calling and called line, means for reversing the direction of current flow in the calling line when the called party responds and when he hangs up, a nonpolar supervisory relay bridged across the calling line, said relay being responsive indifferently to current flow in either direction, a signal operated by the momentary deenergization of said relay due to the current reversal through its winding when the called party answers, and a second signal operated by said relay in the same way when the called party hangs up.

9. In a telephone system, means including a series of automatic switches for connecting a calling and a called line, registering apparatus for recording the digits in the called number, a supervisory relay, and means controlled by said registering apparatus responsive to the last digit in the number for connecting said relay in bridge of the calling line.

10. The combination, with an automatic telephone system in which a connection between a calling and called line is established by means of a series of automatic switches, of graphic recording apparatus temporarily associated with the calling line, and intermediate controlling equipment for operating said apparatus to make records indicating the duration of the call, the number of the called party, the time of answering and release by the called party, and the time of release by the calling party.

11. The combination with an automatic telephone system in which a connection between a calling and called line is established by means of a series of automatic switches, of graphic recording apparatus temporarily associated with the calling line, and intermediate controlling equipment for operating said apparatus to record the operation of each switch and the answering and hanging up of the called party, all timed with respect to the beginning and the end of the call.

12. The combination, with a telephone system in which a connection between a calling and a called line is established by means of a series of automatic switches, of service observing equipment for recording the progress of the call, and means for automatically controlling said equipment to record the premature release of one of said switches.

13. The combination, with a telephone system in which a connection between a calling and a called line is established by means of a series of automatic switches of service observing equipment comprising means for recording the progress of the call, means for associating said equipment with any switch in the series in order to intercept the call at any desired point, and means for setting said equipment for a particular fractional portion of the call depending on the point at which the call is to be intercepted.

14. In a telephone system, a line terminating in an automatic switch, a closed control circuit for said switch including a line relay connected in series with a battery, means for producing a series of interruptions in said circuit to operate said line relay, an impulse repeating relay bridged across said line in series with a condenser, and an automatic switch controlled by said repeating relay.

15. In a telephone system, a main exchange and a plurality of branch exchanges, a plurality of different types of automatic switches in each branch exchange for completing connections between calling and called lines, an observation connector switch in each branch exchange having access to subscribers' lines and said plurality of different types of automatic switches associated therewith, service observation equipment at said main exchange, trunk lines extending from the main exchange to the observation connectors in the branch exchanges, and operator controlled means included in said main exchange for connecting said equipment to any trunk line and for operating the associated connector switch to connect with any subscriber's line or switch to which such connector has access.

16. In a telephone system, subscribers' lines terminating in automatic switches, trunk lines of different orders terminating in automatic switches of different orders, means whereby a calling subscriber operates his associated switch and an automatic switch of each order to complete a connection to a called line, service observing equipment, a connector switch having access to said subscribers' lines and said trunk lines, and means for operating said connector to connect said equipment with any trunk line in use so as to intercept the call at any desired point.

17. In a telephone system, a series of automatic switches for establishing a connection between a calling and a called line, service observation equipment, a connector switch associated with said equipment having access to said subscribers' lines and all of said switches, and means for operating said connector switch to connect said equipment with either of said lines or any of said switches.

18. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, a recording device associated with said equipment for making records indicating the duration of a call, the number of the called party, the time of answering of the called party, and the time of release by the called and calling parties, means for associating said equipment with a trunk line of said plurality, means for seizing said trunk line, means controlled over said seized trunk line for operating the associated automatic switch to extend a connection to a called line, and means operative responsive to the seizure of said trunk line for automatically starting said device.

19. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, a recording device associated with said equipment for making records indicating the duration of a call, the number of the called party, the time of answering of the

called party, and the time of release by the called and calling parties, means for associating said equipment with a trunk line of said plurality, means for seizing said trunk line, means controlled over said seized trunk line for operating the associated automatic switch to extend a connection to a called line, means operative responsive to the seizure of said trunk line for automatically starting said device, means responsive to the calling party hanging up his receiver for automatically stopping said device, and means for maintaining said device operated a short interval after the replacement of the calling subscriber's receiver in order to allow the recording device to move far enough to be easily read.

20. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, means for associating said operator's equipment with any one of said trunk lines, subscriber controlled means for seizing one of said trunk lines and for operating the associated automatic switch to extend a connection to a called line, means included in said equipment operated responsive to such seizure for notifying the operator that a call is in progress over the connected trunk line, and a registering device associated with said equipment operated in synchronism with said associated automatic switch.

21. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, means for associating said operator's equipment with any one of said trunk lines, subscriber controlled means for seizing one of said trunk lines and for operating the associated automatic switch to extend a connection to a called line, means included in said equipment operated responsive to such seizure for notifying the operator that a call is in progress over the connected trunk line, a registering device associated with said equipment operated in synchronism with said associated automatic switch, and operator controlled means for disconnecting said device from said equipment.

22. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, means for associating said operator's equipment with any one of said trunk lines, subscriber controlled means for seizing one of said trunk lines and for operating the associated automatic switch to extend a connection to a called line, means included in said equipment operated responsive to such seizure for notifying the operator that a call is in progress over the connected trunk line, a registering device associated with said equipment operated in synchronism with said associated automatic switch, first and second visual signals at said equipment, and means operated responsive to the called party answering for lighting said first signal and for operating said device, said last means operated again responsive to either party hanging up his receiver for lighting said second signal and for operating said device.

23. In a telephone system, a plurality of trunk lines, each of said plurality terminating in an automatic switch, operator's equipment, means for associating said operator's equipment with any one of said trunk lines, subscriber controlled means for seizing one of said trunk lines and for operating the associated automatic switch to extend a connection to a called line, means included in said equipment operated responsive to such seizure for notifying the operator that a call is in progress over the connected trunk line, a registering device associated with said equipment operated in synchronism with said associated automatic switch, subscriber controlled means for releasing said associated automatic switch, and operator controlled means for preventing said release.

24. In a telephone system, a plurality of subscribers' lines and trunk lines of different orders terminating in an intermediate distributing frame, an automatic switch, jumpers on said frame connecting said subscribers' lines and trunk lines with the banks of said switch, operator's equipment, means included in said operator's equipment for operating said switch to connect to any one of said subscribers' lines or any one of said trunk lines, and means associated with said operator's equipment for observing the progress of a call on said connected line and for making a permanent record of such call when the same is made.

25. In a telephone system, a plurality of subscribers' lines and trunk lines of different orders terminating in an intermediate distributing frame, an automatic switch, jumpers on said frame connecting said subscribers' lines and trunk lines with the banks of said switch, operator's equipment, means included in said operator's equipment for operating said switch to connect to any one of said subscribers' lines or any one of said trunk lines, means associated with said operator's equipment for observing the progress of a call on said connected line and for making a permanent record of such call when the same is made, and means for automatically notifying the operator when such a call is made.

26. In a telephone system, a plurality of subscribers' lines and trunk lines of different orders terminating in an intermediate distributing frame, an automatic switch, jumpers on said frame connecting said subscribers' lines and trunk lines with the banks of said switch, operator's equipment, means included in said operator's equipment for operating said switch to connect to any one of said

subscribers' lines or any one of said trunk lines, means associated with said operator's equipment for observing the progress of a call on said connected line and for making a permanent record of such call when the same is made, and said first means also adapted to operate said switch from said connected line to successive lines without releasing said switch in order to observe the calls on such successive lines.

27. In a telephone system, means including a series of automatic switches for connecting a calling and called line, registering apparatus for recording the digits in the called number, an observation connector, a supervisory relay and a pair of line relays in said connector, means for operating said line relays in accordance with one or more digits to operate said connector to connect said apparatus with a switch of said series, and means controlled by said registering apparatus responsive to the last digit in the number for operating the first of said line relays and not the second to cause said supervisory relay to be connected in bridge of the calling line.

28. In a telephone system, means including a series of automatic switches for connecting a calling and called line, registering apparatus for recording the digits in the called number, an observation connector, a supervisory relay and a pair of line relays in said connector, means for operating said line relays in accordance with one or more digits to operate said connector to connect said apparatus with a switch of said series, means controlled by said registering apparatus responsive to the last digit in the number for operating the first of said line relays and not the second to cause said supervisory relay to be connected in bridge of the calling line, and operator controlled means for operating the second of said line relays and not the first to prevent the calling subscriber from releasing the switch with which said apparatus is connected.

29. In a telephone system, a series of automatic switches for establishing a connection between a calling and a called line, service observation equipment, an observation connector associated with said equipment, means included in said equipment for operating said connector to connect said equipment with any switch in said series, said equipment comprising two indicating means to record the progress of a call, one indicating means being a series of switches to operate lamps to indicate the digits dialled in establishing a connection, the other indicating means being a register to record the digits dialled on a tape, and means in said equipment for disconnecting either one or both of said indicating means.

30. In a telephone system, a series of automatic switches for establishing a connection between a calling and a called line, trunk lines between each of said switches, service observation equipment for recording the progress of the call, and means for automatically controlling said equipment to make a record should any of the switches in said series encounter an open or faulty trunk line.

31. In a telephone system, a series of automatic switches for establishing a connection between a calling and a called line, said series comprising a non-numerical switch, a single digit numerical switch and a two digit numerical switch, service observation equipment comprising visual indicating means, there being one indicating means provided for each digit of the called number, means for associating said equipment with any one of said switches, and means for setting said equipment to use only a certain number of said indicating means dependent upon which switch said equipment is associated with.

32. The combination with a circuit having a source of current therein, of a second circuit, a relay having a winding in said second circuit, a condenser in said second circuit, means for altering the flow of current in said first circuit, the change of current in said first circuit inducing a current in said second circuit which charges the condenser and flows through said winding, said relay responding to said induced current, and means controlled by said relay.

33. The combination with a line circuit having a source of current therein, of a second circuit, a relay having a winding in said second circuit, a condenser in said second circuit arranged to be charged by the source of current in said line, means for changing the flow of current in said line, the change of current in the line circuit inducing a current in said second circuit which charges the condenser and flows through said winding, said relay responding to the induced current, and a variably operable switch actuated by said relay.

In witness whereof, I hereunto subscribe my name this 7th day of July, A. D., 1922.

FRED T. MADSEN.