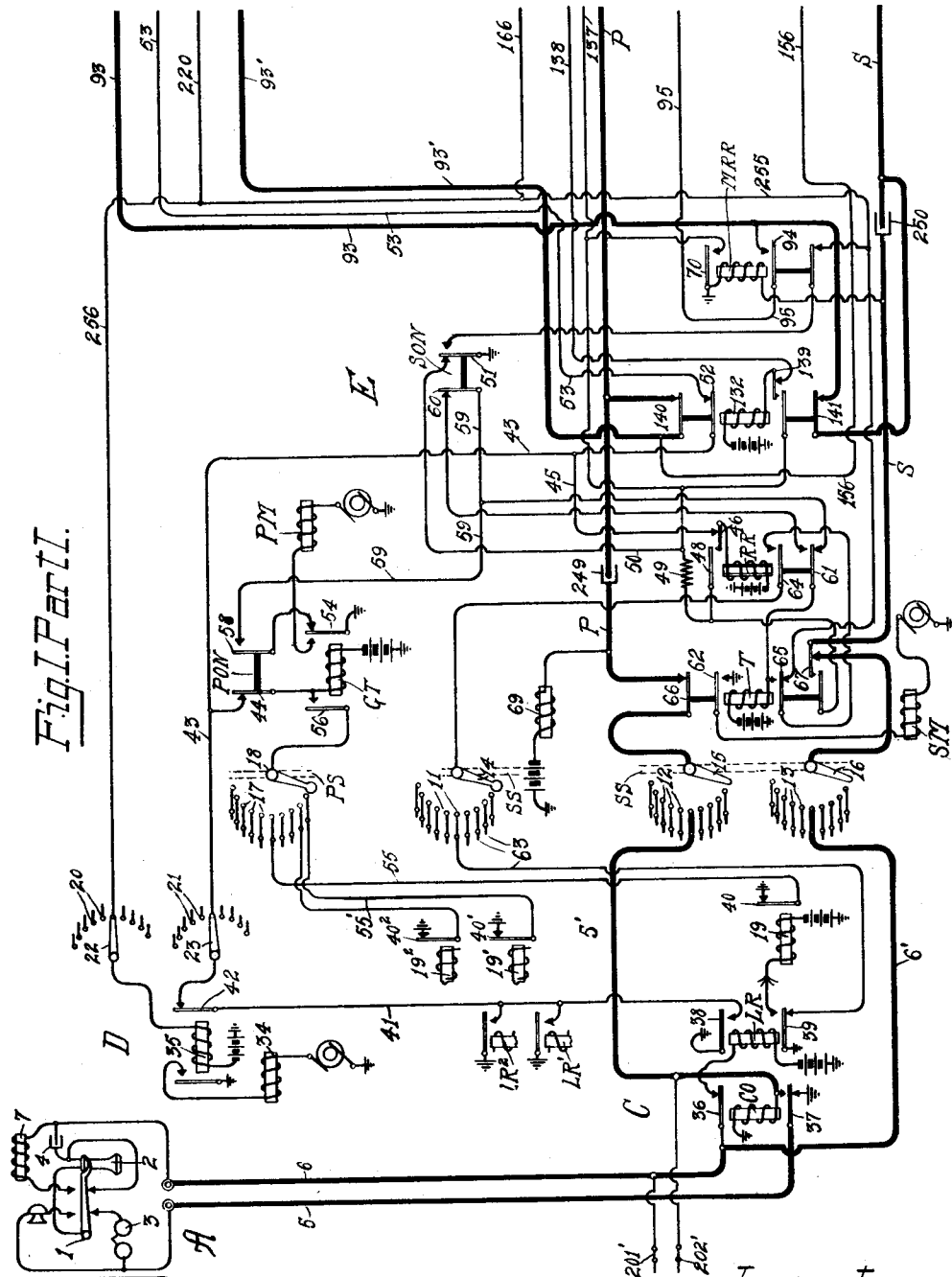


A. H. DYSON.
SEMI-AUTOMATIC TELEPHONE SYSTEM.
APPLICATION FILED FEB. 12, 1912.

1,126,963.

Patented Feb. 2, 1915.

6 SHEETS-SHEET 1.



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6 SHEETS—SHEET 2.

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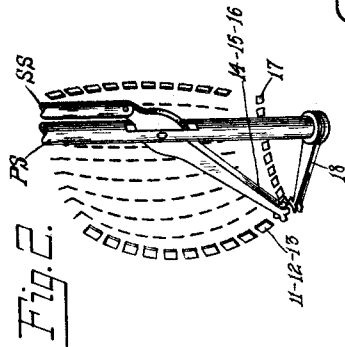
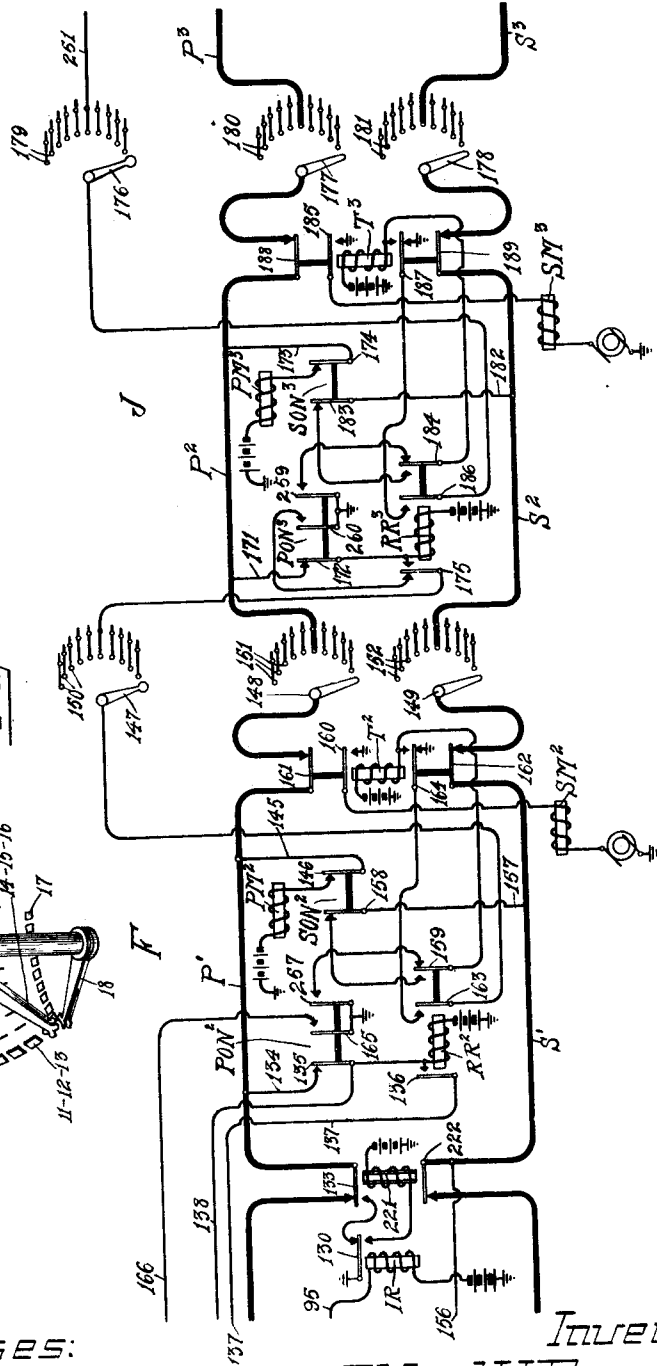


Fig. 2.

Fig. 1 Part 2.



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6 SHEETS—SHEET 3.

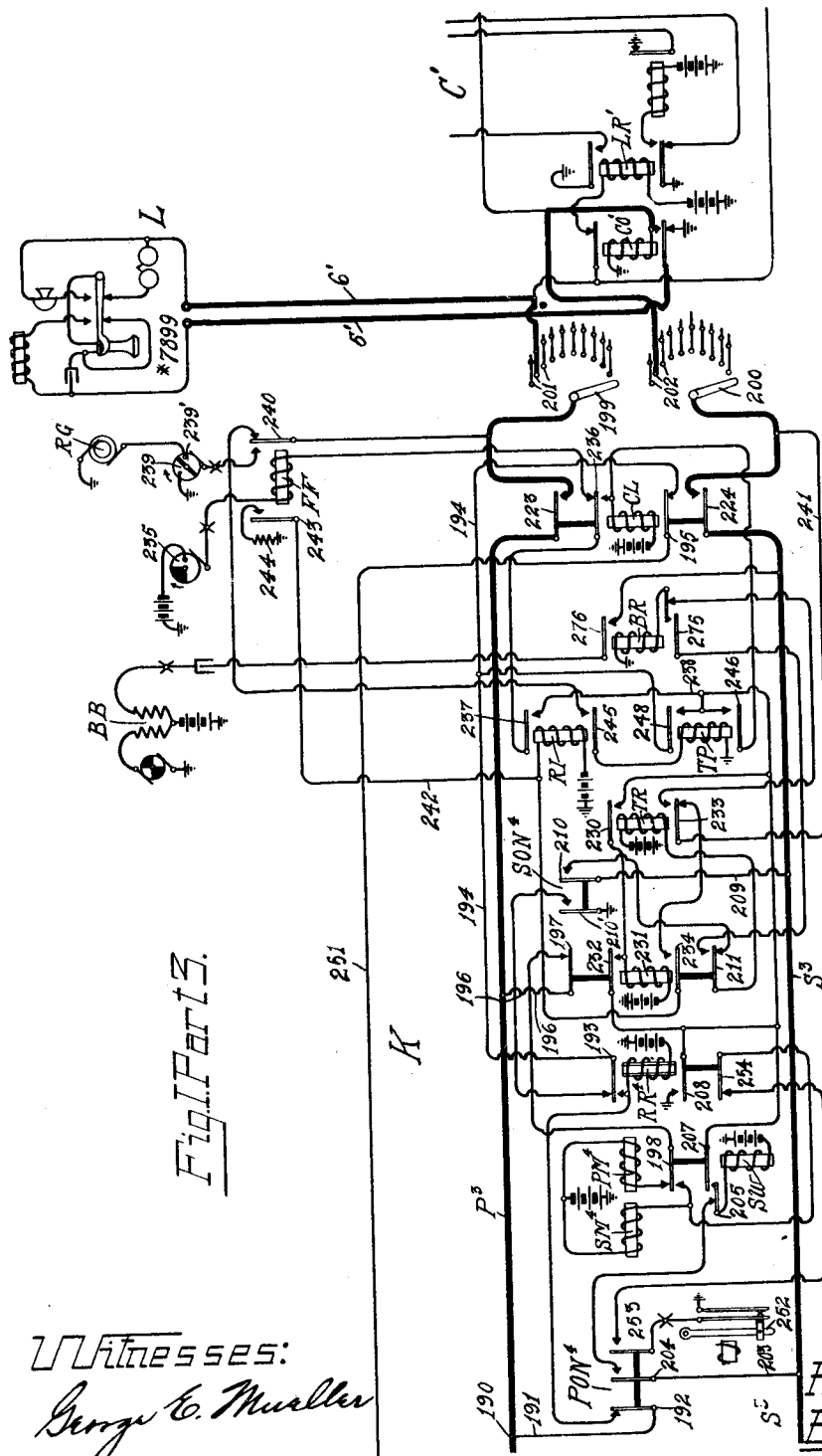


Fig. 1. Part 3.

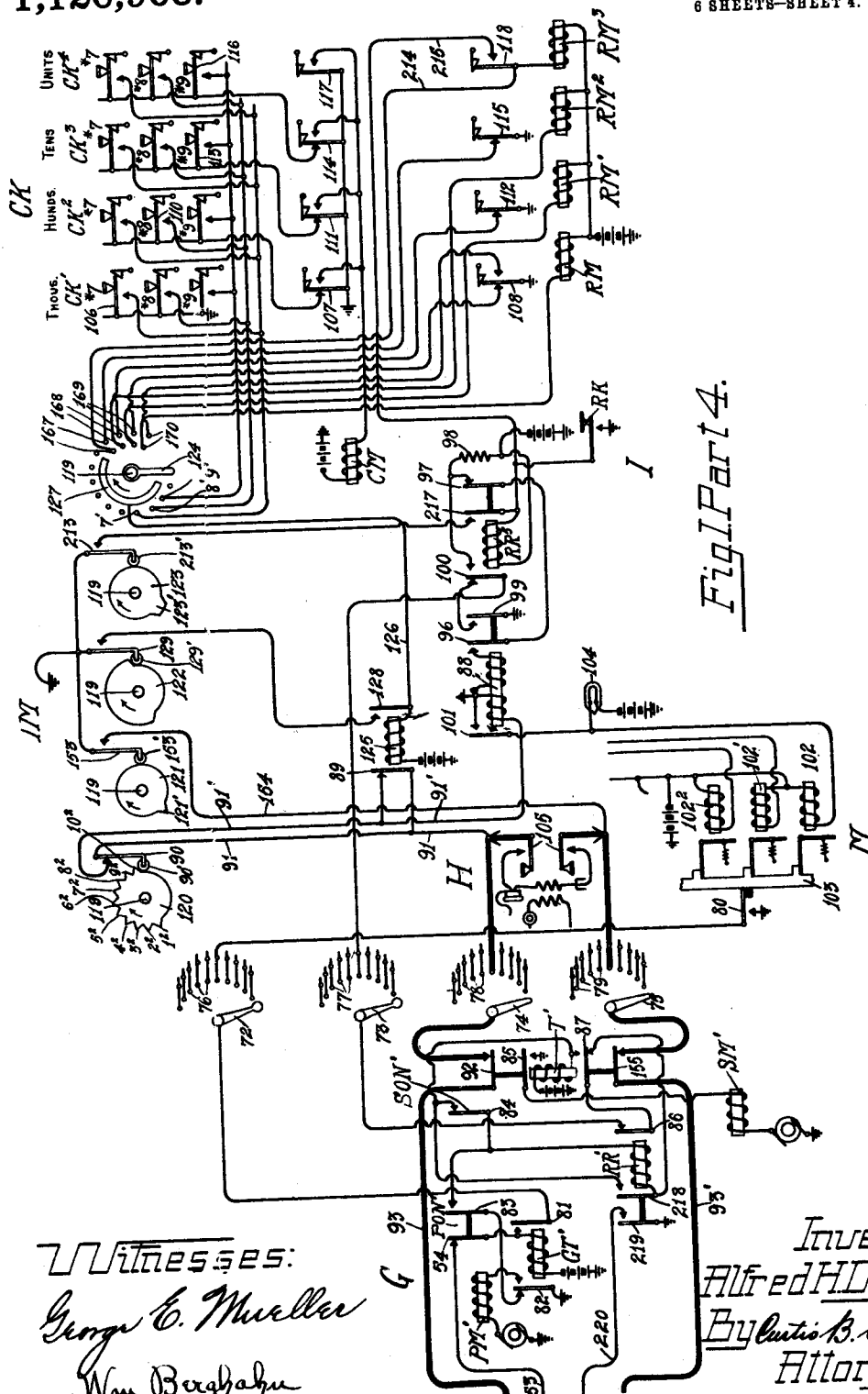
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6 SHEETS—SHEET 4.

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6 SHEETS—SHEET 5.

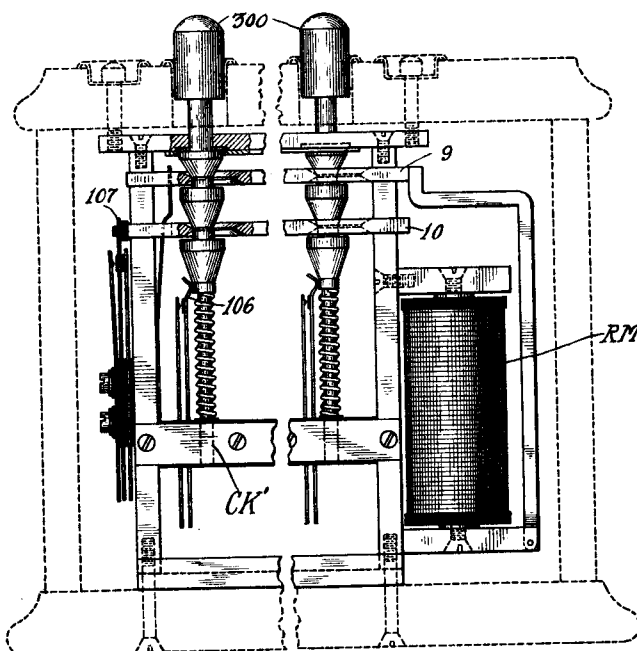


Fig. 3.

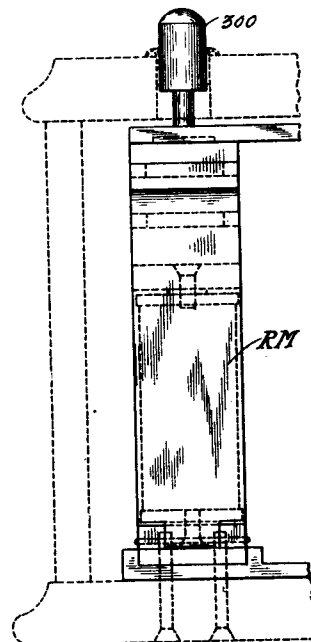


Fig. 4.

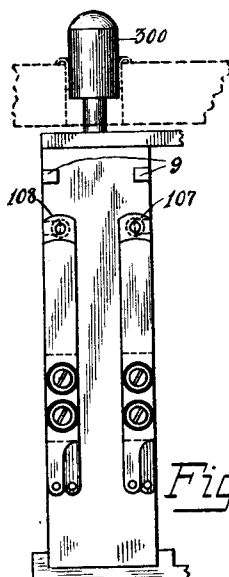


Fig. 5.

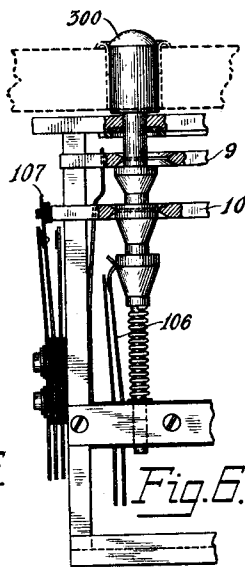


Fig. 6.

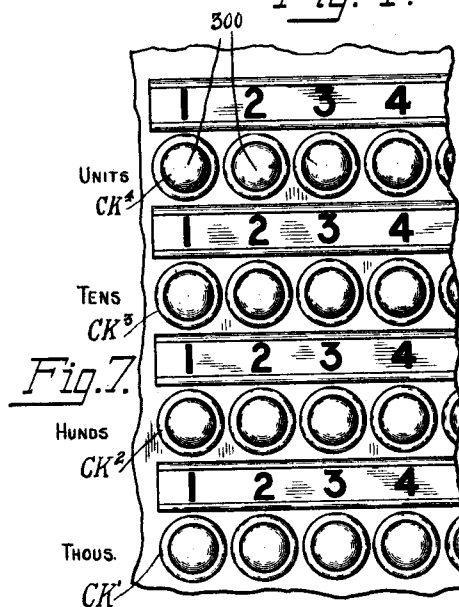


Fig. 7.

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UNITED STATES PATENT OFFICE.

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SEMI-AUTOMATIC TELEPHONE SYSTEM.

1,126,963.

Specification of Letters Patent.

Patented Feb. 2, 1915.

Application filed February 12, 1912. Serial No. 677,012.

To all whom it may concern:

Be it known that I, ALFRED H. DYSON, a citizen of the United States of America, residing in Chicago, county of Cook, and State of Illinois, have invented certain new and useful Improvements in Semi-Automatic Telephone Systems, of which the following is a specification.

My invention relates to telephone systems, and more particularly to the so-called semi-automatic systems in which automatic apparatus at the central office is used for connecting calling and called substations, but is controlled by an operator at a central office in establishing such connections, an object being to provide a system of the character described having improved circuit arrangements, the particular features thereof being more clearly brought out in the following specification and claims.

For a more complete understanding of my invention, reference is to be had to the accompanying drawings in which—

Figure 1 comprising parts 1, 2, 3 and 4, illustrates diagrammatically the arrangement of the circuits of my invention. Fig. 2 illustrates diagrammatically the contact bank of the preferred type of selectors and connectors used in connection with the circuits illustrated. Fig. 3 is a side elevation of an impulse transmitter control key. Fig. 4 is a right end elevation of a key and portion of the containing box of Fig. 3. Fig. 5 is a left end elevation of the key of Fig. 3. Fig. 6 shows a portion of the key of Fig. 3 with its plunger depressed. Fig. 7 shows an arrangement of a plurality of keys of Fig. 3, as used by the operator. Fig. 8 is a side elevation of the transmitting mechanism of the impulse sender. Fig. 9 is a plan view of the mechanism of Fig. 8. Fig. 10 is a sectional view along line 10—10 of Fig. 9 looking in the direction of the arrow indicated thereon. Fig. 11 illustrates a set of contact springs operated by the disks carried on the main shaft of the mechanism of Fig. 9. Fig. 12 illustrates the clutch disk of the mechanism of Fig. 8. Fig. 13 shows a portion of a holding plate for maintaining the mechanism of Fig. 8 at normal. Fig. 14 shows the four contact operating disks carried on the main shaft of the impulse transmitting mechanism.

Referring now in general to the circuits illustrated in Fig. 1, these may be more

readily followed out by placing parts 1, 2 and 3 alongside of each other with part 1 to the left of part 2, and part 3 to the right of part 2, while part 4 may be placed above part 2. In illustrating the circuit arrangement of my invention, I have shown the circuits necessary in establishing a single connection from a calling to a called substation. The arrangement illustrated includes a calling substation A connected by the line conductors 5, 6, to its line circuit C, which is located at the central office, a line selector E and first selector F which are connected as a pair, a second selector J, connector switch K, a line circuit C' and called substation L. For each paired line and first selectors E, F, an impulse sender selector switch G is provided, having access to a plurality of impulse senders I which may be divided in groups and distributed before different operators. An operator's telephone H is also provided for each operator, and is common to the group of impulse senders I controlled at the operator's position. Group control mechanism M is adapted to control the selection of an idle one of such groups of impulse devices I. The substation telephone lines are divided into groups, and there are a plurality of associated line and impulse device selectors E and G common to each such group of lines, and a master switch D is provided for each such group to control the starting of the selecting movement of an idle pair of such switches E and G upon initiation of a call from an associated line.

I have described in general the circuits and apparatus illustrated, and will now refer more particularly thereto. The system illustrated is adapted for use in serving 10,000 substation telephone lines 5—6 which are divided into groups of one hundred lines, each line terminating at the central office in a line circuit C. The substation telephones may be of any standard common battery design, and I have illustrated a well known substation telephone including a switch hook 1 and receiver 2 which normally maintains the lower switch hook contacts closed thereby connecting a call bell 3 and condenser 4 across the terminals of line conductors 5, 6. Upon removal of receiver 2, the lower switch hook contacts are adapted to be interrupted and the upper switch contacts closed, thereby connecting impe-

dance coil 7 and transmitter to the line terminals. Each line circuit C includes a line relay LR and a cut off relay CO. As previously stated, the lines and line circuits C are divided into groups of one hundred, and for each such group I provide preferably ten line selectors E having one hundred sets of bank contacts or line terminals 11, 12, 13, each line being multiply connected to its terminal sets 11, 12, 13 of the associated ten line selectors. These one hundred sets of contacts are further divided into ten sub groups or rows of ten contact sets each so that in the operation of switch E, its wipers 14, 15, 16 are first operated to select the row of contacts containing the terminal of the calling line, and are thereafter operated to select the desired terminals of the selected row. In order to control the selection of the group of terminals containing the terminals of the calling line, I provide a set of group terminals 17 and cooperating wiper 18, there being as many group contacts 17 as there are rows or sub groups of contacts 11, 12, 13 of which of course there are ten. Therefore, it will be seen that each group of one hundred lines is further divided into ten sub groups of ten lines each. For each sub group of ten lines a group relay 19 is provided, being common to its ten line circuits C and connected by conductor 55 to its group test contact 17.

For each group of one hundred lines a master switch D is provided, being adapted upon initiation of a call from any of its associated lines to start an idle line selector E and impulse sender selector G on a selecting operation. Master switch D is of a well known rotary switch construction, being adapted to move its wipers 22-23 forward only. As switch D is common to one hundred lines and ten line selectors E, there are ten sets of bank contacts 20, 21, provided therefor, the cooperating wipers 22, 23 being insulatingly mounted upon a shaft adapted to be advanced by a step by step movement effected by a well known ratchet and pawl arrangement controlled by the motor magnet 34, which is in turn controlled by a relay 35. As previously stated, switch D being common to one hundred lines, its switch starting conductor 41 is connected to the line relays LR, LR', LR'', etc., of its one hundred lines, so that any of the associated lines are adapted to effect a starting operation of a pair of selectors E-G by means of the common conductor 41.

Before proceeding further with the description of the circuits, it is believed that their operation will be more readily understood by referring to the type of selector and connector switch mechanism preferably used.

For use with the selector and connector

circuits of the system of Fig. 1 a switch such as is shown in an application of William Kaisling for automatic switch for telephone systems, Serial No. 600,664, filed January 3, 1911, may be used.

The switch referred to in the previous paragraph, in general comprises a bank of contacts made up of 100 sets of contacts with three contacts to each set, and divided into ten sub groups of ten contact sets each as illustrated in Fig. 2. A set of wipers are provided, to cooperate with the bank contacts, a primary magnet being adapted to primarily adjust the wipers to select a sub group of contacts, and a secondary magnet is provided to step the wipers in a secondary direction in a plane at right angles to the primary, to select a contact set of the selected sub group. The switch construction is such that the wipers are advanced against the tension of a pair of springs, one spring opposing each movement respectively. To release the wipers, that is, to restore them to normal, the secondary magnet is again actuated to step the wipers beyond the last contact of the sub group wherebv they are automatically restored to normal by the springs referred to, but over a different path than that taken by the wipers in the advance movement of the switch in selecting a contact. Thus, in the operation of the switch the contacting ends of the wipers travel in a primary direction to select a sub group of contacts, then in a secondary direction to select a contact in the group, and in the release of the wipers this secondary direction is continued until the contacting ends have passed beyond the last contact in the group, followed by the automatic release of the wipers, in which the contacting ends travel in a plane parallel to the primary movement but in an opposite direction until they reach a point directly above the starting point when they are moved downward through a plane parallel to the secondary movement, but in a direction opposite to the secondary movement, until they reach their normal starting point. It is to be understood that for a more complete understanding of this switch, reference is to be had to the above identified application.

Fig. 2 illustrates diagrammatically the contact bank and wiper arrangements of the switch construction referred to, but it is to be understood that the group wiper 18 and its associated group contacts 17 are used only on the selector switches E and G.

Referring again to line selector E, for adjusting the wipers 14, 15, 16 in a primary direction to select a sub group, a primary magnet PM is provided, being adapted to act upon ratchet mechanism and shaft PS, thereby carrying wipers 14, 15 and 16 step by step to any of the sub groups of contacts

11, 12, 13, its movement of course being controlled through the group contacts 17 and cooperating wiper 18 which is carried around by shaft PS. For controlling magnet PM a group test relay GT is provided, while a secondary magnet SM and associated test relay T is provided for controlling the secondary selecting movement of wipers 14, 15 and 16. Primary off normal contacts PON are adapted to be moved to their alternate position upon the first primary step of the wipers, while secondary off normal contacts SON are adapted to be moved to their alternate position upon the first secondary step of the wipers.

Release relay RR controls the restoration of switch E and is adapted to be energized upon closing of the starting circuit for switch E and subsequently deenergized to effect a release of switch E. Main release relay MRR, which is energized by current over the calling line upon connection therewith, is adapted to control the release of certain of the switches, and relay 132 is energized to cut off the talking conductors 93, 93' leading to the operator's outfit, responsive to the transmission of the first primary impulse. The first selector F includes a release relay RR² which is adapted to be energized responsive to the first impulse from the impulse sender I and remains energized until a release of the switch F is desired. Test relay T² has a function similar to relay T of line selector E. Impulse relay IR is adapted to be energized over a circuit including the impulse device I, and is operated responsive to primary impulses transmitted from said impulse sender I to repeat these impulses to operate the different switches in extending connection to a called line. Relay 221 is operated responsive to energization of relay IR and is so constructed that its armature will not vibrate responsive to impulses from relay IR of a predetermined rate, so that while relay IR is vibrating responsive to the operating impulses transmitted from sender I, alternate contact 133 of relay 221 remains closed. Such operation of relay 221 may be secured in any well known manner, but I preferably employ a relay having a copper sleeve about its core, thereby rendering its armature slow to retract upon the cessation of the circuit through its winding. Second selector J has magnets and relays with the functions corresponding to magnets and relays of first selector F and have corresponding reference characters but with a different suffix.

Connector switch K includes a mechanical structure such as previously described, except that only two wipers are used. The magnets and relays of switch K having functions similar to magnets and relays of switch J, have similar reference characters but with a different suffix. Release relay

RR⁴ of switch K is adapted to be energized responsive to the first primary impulse transmitted to switch K and is then locked up through a circuit controlled from the calling substation until a response is secured from the called substation whereby the control of relay RR⁴ is transferred to substation L. Switching relay SW is adapted to be energized responsive to the first secondary impulse transmitted to switch K, thereby disconnecting magnet PM⁴ from conductor P² and connecting in place thereof secondary magnet SM⁴. Test relay TR is adapted to be energized responsive to the last secondary impulse transmitted to switch K, to test the terminals of the called line whereby if idle ringing relay RI and interrupter relay FF are operated to connect ringing current from generator RG to the terminals of the called line, but if said line is busy, relays RI and FF are not operated but busy relay BR is energized, thereby connecting a characteristic busy back signal from machine BB in circuit, to transmit a busy signal to the calling substation. Tip relay TP is adapted to be energized upon response of a called subscriber whereby closing relay CL is also energized to close the circuit from the calling to the called substation. An interrupter 252 is provided preferably operated by a vibrating electromagnet, and is adapted to be connected to a secondary magnet SM⁴ upon deenergization of RR⁴ to effect the restoration of switch K.

Referring now to the interrupter wheels 235, 239 of part 3, these are mounted upon a shaft in the relative position shown, and are adapted to be rotated, from any source of power, in the direction of the arrow indicated in connection therewith. Interrupter wheel 235 is adapted to periodically close a circuit through interrupter relay FF and at the same time segment 239' is connecting ringing generator RG to alternate contact 240 of relay FF, and as rotation of said segment continues, it will be noted that segment 239' is moved off of its brush and grounded segment 239 is moved onto said brush previous to the interruption of the circuit through FF by the insulated portion of 235, so that after each ringing period ground from segment 239 is momentarily connected to the terminals of the called line to take care of any discharge, due to the ringing current having been applied, thereby stopping any tendency of tip relay TP to kick up its armature responsive to such discharge. Impulse sender selector G comprises switch construction similar to that of line selector E in that it has a group wiper 72 and three selecting wipers 73, 74, 75. The magnets and relays of switch G which have functions similar to magnets and relays of line selector E have similar reference characters, but with a suffix prime

added. Release relay RR' of selector G is not energized until the release of switch G, which is after the impulse sender I has operated to transmit the impulses.

As previously stated, the system is adapted for 10,000 lines and assuming a trunking capacity of ten per cent., which has been determined by practice to be sufficient although this may be changed to suit existing conditions, there would be one thousand line selectors E and therefore also 1000 connected impulse sender selectors G.

Impulse sender I.—Impulse sender I comprises the impulse mechanism IM and control keys CK, diagrammatically illustrated in part 4. Impulse mechanism IM comprises the plurality of plates 120, 121, 122, 123 mounted upon a single shaft 119, also carrying a wiper 124 adapted to be advanced into connection with the contacts shown associated therewith. Shaft 119 is normally inert, but to rotate said shaft I preferably provide a constantly rotating source of power which is adapted to be operatively connected with shaft 119 by the operation of clutch magnet CM. In the operation of impulse sender I, a plurality of primary impulses are first transmitted, which are caused by the operation of the teeth of plate 120, followed by a single secondary impulse effected by plate 121. The primary impulses referred to are preferably interruptions of a previously established circuit through conductors 91, 91', which it will be noted are closed at impulse contacts 90 and also at contacts 89 of shunt relay 125. Thus when shaft 119 is rotated and the teeth of plate 120 act upon impulse contact 90 to interrupt it, these interruptions do not interrupt the circuit through conductors 91, 91' until shunt contact 89 is opened.

In the present system, I have preferably arranged ten sub groups of ten contact sets each on the switches and therefore a maximum of ten primary impulses is sufficient to step the wipers of the switches to the farthest sub group, therefore ten impulse teeth 1² to 10² inclusive are provided on plate 120. Thus for each revolution of shaft 119 one series of impulses are transmitted, meaning primary and a secondary impulse, and impulse sender I is so arranged that as many revolutions of shaft 119 are made as there are digits in the called substation's number. That is if the called substation number is 99, two revolutions of shaft 119 are effected, and by the coöperation of shunt relay 125, nine effective interruptions of impulse contacts 90 result from each revolution of shaft 119, of course followed by a secondary impulse from contact 153' in each revolution. A signal relay 88 is also provided which is adapted to be energized upon connection made with its associated impulse sender I, thereby establishing an energizing circuit

for its associated signal lamp 104. A release relay RR² is also provided, being adapted to be energized after the impulses have been transmitted, to effect the restoration of selector switch G.

Referring now to control key CK, as the system is adapted for 10,000 lines, and which would be numbered from 1111 to 0000 inclusive which is a well known practice, although of course other designating characters may be used, four rows of control keys CK', CK², CK³, CK⁴, are provided, each row having ten plungers and associated contact springs 106 and a common set of springs 107, 108, although I have shown but three plungers in each row. The character of keys CK is clearly illustrated in Figs. 3 to 6, they being so arranged that when a plunger is depressed, it also actuates its common contacts 107, 108, all of the contacts being locked in such an operated position and held there until released by the energization of the associated release magnet RM.

Referring now to Figs. 3 to 6, which illustrate the preferred mechanical structure of control key CK, it comprises four keys similar to CK', although but a portion of a single key is illustrated, each such key CK' comprising ten plungers 200, each having a set of coöperating springs 106 which are adapted to be closed when the plunger is moved to its operated position as indicated in Fig. 6, where it is locked by means of the sliding plate 9. To actuate the common set of contacts 107, 108, a second sliding plate 10 is provided, being adapted to be moved to its alternate position and thereby operate said contact springs when a plunger is depressed as indicated in Fig. 6. The release magnet RM is adapted when energized to move the locking plate 9 toward the left and thereby release any of its associated actuated plungers, allowing their restoration and also the restoration of common contacts 107, 108. Fig. 7 illustrates an arrangement of the control key CK before an operator, the numerals indicating the digit value of the plunger in each of the rows.

Impulse mechanism IM is illustrated in Figs. 9 to 14 in which the parts already referred to Fig. 1, part 4, are indicated by like reference characters. In Fig. 1, part 4, I have illustrated a wiper 124 and its coöperating contacts, this being only diagrammatic, but in Figs. 8, 9 and 10 I have illustrated the preferred mechanical arrangement of this portion of the mechanism. Instead of the wiper 124 acting directly upon its associated contacts, I provide an arm having a roller at its end adapted to engage a pivoted member 303 which is associated with ten contact sets 127-1', 127-2', etc. The contacts 127 of these ten sets be-

ing connected in common and acting to connect any one of the contacts 1', 2', etc., to the conductor leading from contacts 127. In a like manner I provide the four sets of contacts 167, 168, 169, 170, each having such an associated member 303 which is likewise adapted to be actuated by the roller arm 124. These sets of contacts which are operated by arm 124 are mounted upon a drum 304 which is rigidly secured to bracket 305, thus preventing its rotation. To provide power for operating shaft 119 a constantly rotating shaft 306 is preferably provided and which may be operated by any desirable motor power, said shaft being suitably journaled, one portion thereof being shown in bearing 307 of plate 308. A clutch plate 309 is rigidly secured to shaft 306 while clutch mechanism 310 is loose upon said shaft 306, but normally held against rotation by means of a pin 311 carried by gear wheel 312 and engaging slot 308' of plate 308. For controlling the clutch mechanism, I preferably provide the clutch magnet CM having a pivoted armature 313 carrying a pair of rollers 314 upon its bifurcated end, said rollers riding in the central slotted portion of the hub of clutch member 310. A spring 315 tends to hold armature 313 and clutch member 310 in its normal or unoperated position. A pin 316 carried by member 310 is adapted to engage an opening 309' in constantly rotating clutch plate 309, when member 310 is actuated responsive to the energization of magnet CM. Pins 311—316 are so related to their cooperating members 308, 309 respectively that pin 311 disengages itself from plate 308 as pin 316 engages a hole 309' of plate 309. Gear 312 is in mesh with gear 317 which is rigidly secured to shaft 119, so that when clutch member 310 is moved into operative engagement with the constantly rotating shaft 306, due to the connection of gears 312, 317, power is transmitted to shaft 119 which is rotated in the direction of the arrow indicated in connection therewith. Upon de-energization of clutch magnet CM, and upon pin 311 reaching slot 308', clutch member 310 is restored to normal by the action of spring 315, whereby it is released from plate 309 and again held against rotation by the pin 311 engaging slot 308'.

On the basis previously referred to, that is an exchange of 10,000 lines and 1000 switches F and G, I preferably provide one hundred impulse senders I which are believed to be sufficient to establish any number of connections which may be desired at one time, although of course I contemplate using a number of senders I sufficient to take care of the calls, which may differ according to existing local conditions. These one hundred senders I are distributed among a plurality of operators, preferably

two senders to each operator. These one hundred senders I are multiply connected to the terminals 77, 78 and 79 of all of the selectors G, whereby all of the lines have access to all of the senders I. The senders I are further divided into ten sub groups of ten each, corresponding to the grouping of the contacts of switches G, so that in the operation of switch G it first selects the first sub group of contacts having an associated idle sender I and then selects the first idle sender I in the selected sub group. Each sub group of senders I and their terminals 77, 78 and 79 have a group contact 76 of switch G. When all of the senders I of a sub group are busy, the group contact 76 has a busy or grounded potential connected thereto to render the group unselectable, and for controlling this busy potential, group mechanism M is provided. Mechanism M comprises a plurality of magnets 102—102', 102², etc., there being as many such magnets 102 as there are senders I in the sub group, which we have assumed is ten. A common bar 103 cooperates with the armature of the ten magnets 102 in such a manner that when all of the magnets are energized, contact 80 is closed, thereby connecting ground or busy potential to the associated group contact 76. These magnets 102 are controlled from relay 88 which is energized as soon as its sender I is seized by a selector G, and maintained energized until the impulses have been transmitted or operator's releases key RK depressed.

In general the operation of sender I is as follows: Assuming the operator desires to call line No. 7899, she proceeds to depress the plungers of the control key CK corresponding to the digits of the number of the wanted line, first depressing the plunger in the thousands row followed by the plungers corresponding to the digit in the hundreds, tens and units rows. This operation closes springs 106, 110, 113 and 116 and also their common contact springs illustrated directly below, whereby a circuit for the clutch magnet CM is closed starting a rotation of shaft 119, and although the interruption of impulse contacts 90 is effected responsive to the 10², 9², 8², shunt relay 125 not having been energized, the circuit through 91, 91' is not interrupted until relay 125 is energized, which occurs upon wiper 124 connecting with contact 7', and at this time roller 90' is resting upon tooth 7² interrupting contacts 90. Relay 125 then locks itself through the contact 129, whereby the following teeth on impulse wheel 120 effect six more interruptions of conductors 91, 91', thus transmitting a total of 7 impulses. After the primary impulses have been transmitted a secondary impulse is transmitted from secondary contact 153 through the action of tooth 121'. Thereafter the closing

of contacts 170 by wiper 124, establishes an energizing circuit for the release magnet RM, whereby the contacts actuated by the plunger of the thousands key CK' are restored. Thus it will be seen that shaft 119 by its first revolution has transmitted the first series of impulses corresponding to the thousands digit of the called number, and clutch magnet CM being maintained energized through contacts 111, 114 and 117, shaft 119 makes three more revolutions operating the impulse springs each revolution and releasing upon each revolution the keys CK², CK³ and CK⁴ respectively, through cooperation of wiper 124 and contacts 169, 168, 167, respectively. Upon restoration of the contact 117 of key CK⁴ which is responsive to the last revolution of wiper 124, magnet CM deenergizes and upon shaft 119 reaching its normal position, the clutch mechanism disconnects shaft 119 from the constantly rotating shaft, thereby rendering impulse mechanism IM inert. Also upon the last revolution of shaft 119, release relay RR⁵ is energized by the branch circuit of the energizing circuit for RM⁵ whereby a release impulse is transmitted to switch G which is restored.

Having described in general the circuits and apparatus of my invention, its operation in establishing a connection from a calling to a called substation will now be described. Assuming that a subscriber at substation A desires connection with substation L, whose number we will assume is 7899, upon initiating a call by removing his receiver 2 from its switch hook, a circuit for line relay LR is established from battery, the winding of relay LR, normal contact 36, line conductor 6, substation A, returning over line conductor 5 to ground at normal contact 37, thereby energizing relay LR, and closing its alternate contacts 38 and 39. The closing of alternate contact 39 establishes an energizing circuit for group relay 19 which opens its normal contact 40, thus disconnecting ground from its group contact 17 rendering it selectable. The closing of alternate contact 38 is effective to establish a starting circuit for a line selector E and impulse-sender selector G. As the wipers of the master switch D are always stopped upon the terminals leading to an idle set of said selectors, it will be seen that upon the closing of said alternate contact 38, ground is connected to conductor 41, normal contact 42, wiper 23 and contact 21, conductor 43, normal contact 44, and the winding of the group test relay GT to battery, thereby effecting its energization, and causing the starting of switch E as will be described. The said ground connection to conductor 43 is also extended thereover to conductor 45, normal contact 46 and the winding of relay RR to battery effecting its energization, whereby it establishes a locking circuit for itself through its alternate contact 48, resistance 49, conductor 50 to ground at normal contact 51. Furthermore, the ground connection to conductor 43 extends through normal contact 52, conductor 53, normal contact 54 through the winding of group test relay GT' to battery, effecting its energization and causing the starting of switch G as will be described. Thus it will be apparent that upon the initial energization of the line relay LR, a starting circuit is closed for a line selector E and a paired impulse-sender selector G. Returning now to line selector E, it will be remembered that relays GT and RR are energized. The energization of GT closes alternate contact 54, thereby establishing a circuit for alternating current from generator through primary magnet PM. The first current impulse through magnet PM effects a primary step of group test wiper 18 into connection with the first group contact 17, also stepping wipers 14, 15 and 16 to the first sub-group or row of contacts 11, 12 and 13. The calling line is connected to terminals 11, 12, 13 of the fifth sub-group, therefore its group test conductor 55 is connected to the fifth group contact 17. Now, assuming that there is no other line in the hundred group which includes the line of substation A making a call, said first encountered group contact 17 is connected to ground through its conductor 55' and grounded contact 40'. Thus a maintaining circuit for relay GT is established from said grounded contact 17 through wiper 18, alternate contact 56 and the winding of GT, to battery, maintaining alternate contact 54 closed and causing magnet PM to advance wiper 18 and wipers 14, 15, 16 another step, and continuing to do so until the contact 17 leading to the group relay 19 of the calling line is reached, which being ungrounded at normal contact 40, relay GT loses its maintaining circuit, and is therefore deenergized, interrupting the circuit for magnet PM and rendering it inert. It will be noted that on the first primary step of the wipers normal contact 44 of switch PON is interrupted, thus interrupting the initial circuit for GT, but it will be remembered that a maintaining circuit from contacts 17 is substituted therefor.

Wipers 14, 15, 16 having been advanced five steps, thus placing them opposite the fifth sub-group or row of contacts 11, 12, 13, which is the subgroup including the terminals of the calling line, the next step is to effect a secondary operation of switch E to cause wipers 14, 15, 16 to select the terminals of the calling line, this being brought about as follows: Upon deenergization of magnet GT, as just stated, a circuit for test relay T is established, being traced from ground at normal contact 54 of GT, alternate contact 54

58, conductor 59, normal contact 60, alternate contact 61 (relay RR being energized as previously described), and the winding of relay T to battery causing its energization, whereby its alternate contact 62 is closed, establishing a circuit for secondary magnet SM from its connected alternating current generator. Responsive to the first impulse of current through magnet SM, it steps wipers 14, 15, 16 into engagement with the first set of contacts 11, 12, 13, and as we have assumed there is no other line calling, the test contact 11 connected to, is grounded through its associated conductor 63 and connected normal contact 39. This connection establishes a locking circuit for test relay T, being traced from said grounded contact 11, wiper 14, alternate contact 64, alternate contact 65, and the winding of relay T to battery, whereby the energizing circuit for SM is maintained, causing it to advance wipers 14, 15, 16, as long as wiper 14 is passing over grounded contacts 11. It will be noted that during the secondary movement of wipers 14, 15, 16, that the line wipers 15, 16 are disconnected at normal contacts 66, 67 of relay T so that they will not interfere with any existing connections. When the circuit for relay T is interrupted causing its deenergization and the interruption of the circuit for magnet SM, wipers 14, 15, 16 remain in connection with the terminals of the calling line. Upon the said initial energization of relay T, due to the closing of its alternate contact 67, and upon the opening of normal contact 51 of switch SON, a circuit for main release relay MRR is established, being traced from ground through the winding of said relay, secondary conductor S, alternate contact 67, alternate contact 48, and the winding of relay RR to battery, whereby said two relays are connected in series, thus maintaining relay RR energized (as its initial circuit was interrupted at normal contact 51), and causing the energization of relay MRR.

Line selector E having connected with terminals of the calling line, and its relay T having deenergized as described, a circuit for cut off relay CO is established by a circuit traced from ground through the winding of said relay CO, conductor 5', contact 12, wiper 15, normal contact 66, and the winding of impedance coil 69 to battery, causing the energization of cut off relay CO, whereby the initial energizing circuit for line relay LR is interrupted by the opening of normal contact 36, causing its deenergization followed by the restoration of group relay 19, whereby ground is restored to contact 17, unless some other line in the subgroup including line circuit C is making a call. In such case, of course, relay 19 would remain energized until the other calling line were selected, and its energizing circuit in-

terrupted. Also upon restoration of relay T, due to the interruption of its alternate contact 67, the initial energizing circuit for relay MRR is interrupted, but on the closing of normal contact 67 and the energization of cut off relay CO, it will be apparent that a path for current from battery through impedance coil 69 and out over the calling line and back along conductors 6, 6' and S through the winding of MRR to ground is provided, thus maintaining relay MRR energized and controlled from substation A. Furthermore, it will be remembered that after the opening of normal contact 51 of SON, relays LR and MRR are energized in series but upon the interruption of alternate contact 67, this series circuit was interrupted and another energizing path for relay RR is provided from the grounded alternate contact 70 of relay MRR. The connection from substation A is now extended over the heavily marked conductors to the first selector F. Now as soon as the line of substation A is selected and relay T restores, master switch D advances its wipers to the first idle set of selectors E, F, G, this being brought about as follows: Upon closure of normal contact 65 of relay T, a circuit for master switch relay 35 is established from battery through the winding of said relay 35, wiper 22, contact 20, conductors 256, 255, normal contact 65, alternate contact 64, wiper 14, contacts 11, 39 to ground, energizing said relay 35 and closing a circuit for magnet 34 which operates to advance wipers 22, 23 as long as wiper 22 is engaging grounded or busy terminals 20. Upon reaching such an idle contact 20, relay 35 restores, interrupting the circuit for magnet 34 whereby the wipers remain in engagement with the idle set of contacts 20, 21. The next call from the associated group, of course starts the switches F, G, connected with said selected contacts 20, 21. It is therefore apparent that but a single line selector is operating to select at any one period although more than one line be calling.

The operation of impulse-sender selecting switch G will now be described. It will be remembered that the ground connection to conductor 43 extending from master switch D was extended to conductor 53 and group testing relay GT' of switch G, causing its energization. Therefore a circuit for primary magnet PM' is established, whereby an impulse on the connected alternating current generator effects an operation of magnet PM' and a primary step of wiper 72. Switch G being of the construction previously described and referred to, its wipers 73, 74 and 75 are also advanced a single step bringing them opposite the first row or subgroup of contacts 77, 78 and 79. Assuming that the ten senders I connected to the first sub-group or row of contacts 77, 130

78 and 79 are busy, their associated group control mechanism M has its contact 80 closed, grounding and making busy the first test contact 76, whereby a maintaining circuit for relay GT' is established from the said grounded contact 76, through wiper 72, alternate contact 81, and relay GT' to battery. Therefore another primary step of switch G is effected, and assuming the test contact 76 of the second group and also of the third and fourth groups are busy, due to the associated devices I being in use, relay GT' remains energized until wiper 72 reaches the contact 76 of the fifth group as illustrated, which we will assume is ungrounded, and has idle devices I in its associated group. Therefore the relay GT' de-energizes, interrupting its alternate contact 82, whereby the circuit for magnet PM' is interrupted, rendering it inert and preventing any further primary movement of switch G. Thus it will be seen that the wipers of switch G received a primary operation and selected a sub-group of contacts having one or more idle devices I connected therewith. Therefore upon deenergization of relay GT', a secondary operation of switch G is effected, being brought about as follows: A circuit for test relay T' is established from ground at normal contact 82, alternate contact 83, which is now closed, normal contact 84 and the winding of relay T' to battery, causing its energization whereby its alternate contact 85 is closed and a circuit for secondary magnet SM' is established. The first impulse of alternating current from generator through magnet SM' to grounded contact 85 causes the magnet SM' to effect a secondary operation of wipers 73, 74, 75, into engagement with the first set of contacts 77, 78 and 79 of the selected group, which we will assume lead to a busy device I. Therefore, its contact 77 is grounded or in a busy condition, as will be pointed out later on, and therefore a maintaining circuit for test relay T' is established from the said grounded contact 77, wiper 73, normal contact 86, alternate contact 87, and the winding of T' to battery. The circuit for magnet SM' being maintained it continues to advance wipers 73, 74, 75 as long as test wiper 73 is wiping over busy or grounded contacts 77, and assuming that the fifth set of contacts are the first set in the group, which lead to an idle device I, the test contact 77 is in a condition as illustrated, that is, without any busy potential, and therefore relay T' losing its maintaining circuit deenergizes and interrupts the circuit for magnet SM' rendering it inert and allowing wipers 73, 74 and 75 to remain in engagement with the contacts 77, 78 and 79 leading to the impulse device I illustrated. Although the initial energizing circuit for T' is inter-

rupted upon the first secondary step of the wipers, due to the opening of contacts SON', it will be noted that a substitute circuit for relay T' is established from a grounded test contact 77, previous to the opening of the secondary off normal switch contact 84. A circuit has now been extended from calling substation A over the heavily marked conductors to the operator's telephone set H and impulse device I. Upon the said deenergization of test relay T' of switch G, following the selection of an idle sender I, a circuit for relay 88 is established from ground through left hand winding of 88, the parallel paths, through normal contacts 89 and 90 and conductors 91, 91', contact 78, wiper 74, normal contact 92, conductor 93, alternate contact 94 of relay MRR, conductor 95, and the winding of impulse relay IR, to battery, energizing said relays 88 and IR in series. The energization of IR effects the closure of its alternate contact 130 to establish an operating circuit for slow relay 223. Upon energization of 88 a locking circuit for itself is established through its right end winding, alternate contact 96, normal contact 97, protective resistance 98 to battery. The closing of alternate contact 99 of relay 88 connects ground through normal contact 100 to test contacts 77, thereby placing a busy potential upon said contacts and preventing any other switch G from selecting device I. The closing of alternate contact 101 of 88 establishes an energizing circuit for magnet 102 of mechanism M which attracts its armature, thereby relieving its pressure upon the common bar 103, while an energizing circuit for signal lamp 104 is also established through alternate contact 101, thereby indicating to the operator that device I has been selected by a calling line. The operator in response to the signal received actuates listening key 105 to connect her telephone set to the heavily marked conductors leading to the calling substation and finds that the calling subscriber desires to communicate with substation No. 7899, thereafter again restoring listening key 105. The operator now actuates the buttons corresponding to the digits of the called substation's number, which means that button #7 in the thousands row is first depressed, followed by the depression of buttons #8, #9, and #0, in the hundreds, tens and units rows, respectively. The operation of button #7 effects the closing of its contact 106, as well as the movement of contact springs 107, 108 to their alternate positions. While the operation of said buttons #8, #9, #0, in a like manner effects an operation of their associated springs 110 to 118, inclusive, as will be apparent from the previous description. The closing of alternate contacts 107, 111, 114 and 117 establishes an energizing circuit

for clutch magnet CM, thereby allowing the constantly rotating mechanism to act upon the shaft 119, rotating members 120 to 124 inclusive in a clockwise direction. Upon wiper 124 making connection with contact 7', which is the contact that controls the transmission of seven primary impulses, a circuit for shunt relay 125 is established from battery through said relay 125, conductor 126, common plate 127, contact 7' to ground at alternate contact 106, energizing said relay 125, which establishes a locking circuit for itself through alternate contact 128 to the grounded alternate contact 129 which has been closed by the cam plate 122.

The energization of relay 125 occurs while roller 90' is engaging impulse tooth 7² holding its contact 90 open, thus interrupting the circuit extending through conductors 91, 91', which is the first impulse or current interruption of the series of seven impulses which are transmitted responsive to the actuation of key #7 in the thousands row. The continued rotation of shaft 119 causes the next six impulse teeth of disk 120 to effect six more interruptions of contacts 90, thus making seven interruptions of the circuit extending through conductors 91, 91'. Although the left winding of relay 88 had its circuit interrupted seven times, it will be remembered that said relay 88 is maintained energized through its alternate contact 96. It will also be remembered that impulse relay IR of first selector F was included in circuit extending over conductors 91, 91' and the left winding of relay 88, therefore said relay IR has its circuit interrupted seven times responsive to the said seven interruptions or impulses, each interruption causing it to retract its armature to interrupt alternate contact 130 and close normal contact 130, these operations of IR being rapid enough to prevent deenergization of the slow relay 221, which slow relay maintains its armature attracted during the transmission of the impulses. The first closure of normal contact 130 establishes an energizing circuit for relay RR² of switch F, operator's circuit disconnect relay 132 of switch E and primary magnet PM², of switch F, being traced over the following paths. The circuit for release relay RR² is traced from ground at normal contact 130, alternate contact 133, conductor 134, normal contact 135, the winding of RR² to battery, causing its energization, whereby it establishes a locking circuit for itself through its alternate contact 136, conductor 137, to ground at alternate contact 70. The circuit for relay 132 is established from ground at said normal contact 130, alternate contact 133, normal contact 135, conductor 138, normal contact 139, and the winding of said disconnect relay 132 to battery, whereby it is energized disconnecting the talking conduc-

tors 93 and 93' from conductors P, S, at its normal contacts 140, 141. Relay 132 also establishes a locking circuit for itself through its alternate contact 139, to ground, at alternate contact 70. Thus it will be seen that upon the first impulse transmitted, relay 132 is energized to disconnect the operator's talking strands from the talking conductors of the connection which is being established, and also energizes relay RR². This first impulse also, of course, operates primary magnet PM² of selector F, being traced from said normal contact 130, alternate contact 133, conductor 145, normal contact 146, and the winding of magnet PM² to battery, causing its energization and the advancement by a single primary step of wipers 147, 148 and 149. This first impulse just described is, of course, followed by six more impulses, due to the following six energizations or operations of impulse relay IR, but as primary off normal contact 135 was interrupted upon the first primary step of switch F, said six impulses follow the previously described path through primary magnet PM² effecting six more operations thereof, and consequently six more primary steps of wipers 147, 148, 149, thus bringing them to the seventh sub-group or row of contacts 150, 151 and 152.

Referring again to impulse device I, as the last tooth I² of disk 120 leaves roller 90', tooth 121' of disk 121 engages the roller of 153' of contact 153, thereby closing alternate contact 153 and transmitting a so-called secondary impulse to first selector switch F to start its secondary movement, this secondary impulse being traced from grounded contact 153, conductor 154, contact 79, wiper 75, conductor 93', conductors 156, S', 157, normal contact 158, alternate contact 159, and the winding of test relay T² to battery, causing its energization whereby its alternate contact 160 is closed establishing an operating circuit for secondary magnet SM². The interruption of contacts 161, 162 of relay T², disconnects the talking conductors from the line wipers 148, 149 so that in wiping over the multiple contacts of any existing connections they will not interfere therewith. Responsive to the first impulse of current from alternating current generator through magnet SM², wipers 147, 148 and 149 receive a single secondary step advancing them into engagement with the first set of contacts 150, 151, 152, of the selected sub-group, and assuming that these contacts lead to a busy second selector J, test contact 150 has a ground or busy potential connected thereto, whereby a maintaining circuit for relay T² is established from said grounded contact 150 through wiper 147, alternate contact 163, alternate contact 164, and relay T², to battery, whereby the operating circuit for SM² being maintained it continues to

advance wipers 147, 148, 149 as long as wiper 147 is passing over busy contacts 150. Assuming the fifth set is the first idle one, its test contact 150 is without a ground connection, and therefore relay T² has its maintaining circuit interrupted, deenergizing and interrupting the circuit through magnet SM², whereby the wipers remain in engagement with the selected set of contacts.

Upon the first primary step of switch F, its primary off normal contact 165 is closed, thereby connecting ground to conductor 166 which extends back to the contact 20 of master switch D, maintaining a busy potential upon said contact 20 until first selector F is subsequently restored. Simultaneously with the cessation of the last primary impulse, contact 129 is interrupted restoring relay 125, and also wiper 124 engages the first set of release contacts 167 but without establishing any circuit there-through at this time. The continued rotation of shaft 119 brings wiper 124 into engagement with contacts 170, which are the release circuit contacts of magnet RM, whereby a circuit is established for said release magnet RM traced from battery through the winding thereof, contacts 170 which were crossed by wiper 124, to grounded alternate contact 108, energizing said magnet RM, whereby the contacts actuated in key CK' are restored, the restoration to normal of contact 108 causing the interruption of the said circuit through magnet RM allowing it to deenergize. Thus it will be seen that the first series of impulses, seven in number, having been transmitted, and the contacts actuated by the #7 plunger of key CK' have been restored, clutch magnet CM being maintained energized, as contacts 111, 114, 117 are still closed, the continued advancement of shaft 119 brings wiper 124 into engagement with contact 8' whereby a circuit for a shunt relay 125 is established to remove the shunt from impulse contacts 90. This circuit for relay 125 is established from battery through the winding of said relay 125, conductor 126, plate 127, contact 8', alternate contact 110, at key #8 in the hundreds row, to ground at normal contact 107. At the time relay 125 is energized as just stated, roller 90' is resting upon tooth 8² interrupting contact 90, and the continued rotation of shaft 119, again closes contact 90, followed by seven interruptions thereof, due to the passing of the next seven impulse teeth of plate 120, making eight interruptions of the circuit through conductors 91, 91'. This series of eight interruptions of the circuit through conductors 91, 91' cause eight operations of impulse relay IR of first selector F as before, the said eight operations or deenergizations of relay IR being effective to transmit eight impulses through normal contact 130 thereof to the second selector J. The first closure of normal contact 130 establishes a circuit through primary magnet PM³ and release relay RR³ of switch J, being traced from ground at said normal contact 130, alternate contact 133, conductor P', normal contact 161, wiper 148, contact 151, conductor 171, normal contact 172, the winding of relay RR³, to battery, the said impulse also flowing over conductor P², conductor 173, normal contact 174, the winding of primary magnet PM³ to battery. The resulting energization of RR³ causes it to establish a locking circuit through its alternate contact 175, contact 150, wiper 147, alternate contact 163, and normal contact 164 to ground. The first impulse transmitted to primary magnet PM³ and the following seven impulses, causes said magnet PM³ to step wipers 176, 177 and 178, to the eighth row or sub-group of contacts 179, 180 and 181, respectively.

Following the last primary impulse, shunt relay 125 has its circuit interrupted due to the opening of contact 129 whereby it is restored, and at the same time a secondary impulse is closed through contact 153, this impulse being effective to start a secondary selecting operation of switch J and flowing over a path traced from said grounded contact 153, conductor 154, contact 79, wiper 75, conductor 93', conductor 156, secondary conductor S', wiper 149, contact 152, secondary conductor S², conductor 182, normal contact 183, alternate contact 184, the winding of test relay T³ to battery, causing its energization and establishing an operating circuit for secondary magnet SM³ through alternate contact 185. The first impulse flowing from the alternating current generator through SM³ causes it to step the wipers of switch J into engagement with the first set of bank contacts, which, assuming they are busy, have their test contact 179 grounded, whereby a maintaining circuit for test relay T³ is provided, being traced through wiper 176, alternate contact 186, alternate contact 187, and the winding of T³ to battery. The operation of switch J is similar to the operation of switch F as described, that is, T³ is maintained energized and the wipers of switch J advanced until an idle set of contacts is reached, whereby T³ deenergizes interrupting the circuit of magnet SM³ and preventing any further advance of the wipers, which we will assume have stopped upon the fifth set of contacts leading to switch K illustrated. It will be noted that during the secondary travel of the wipers of switch J, line wipers 177, 178 have their circuit interrupted at normal contacts 188, 189, and upon deenergization of relay T³, a busy potential is placed upon test contacts 179 selected, being traced from

normal contact 187 of T², alternate contact 186, to wiper 176 and contact 179.

Returning now to impulse device I, following the last secondary impulse as described, the continued rotation of shaft 119 brings wiper 124 into engagement with contacts 169 to effect the release of the actuated contacts in the hundreds key CK², this being brought about by a circuit through release magnet RM', traced from battery through said magnet RM', contacts 169, which are now crossed by wiper 124 to ground at normal contact 108, resulting in the energization of RM', whereby the contacts 110, 111, 112, are restored. The continued rotation of shaft 119, clutch magnet CM still being energized, starts the third revolution of shaft 119 and the mechanism carried thereby, to send the third series of impulses corresponding to the digit 9 in the tens unit, and upon wiper 124 making contact with contact 9', which is the contact for controlling the transmission of nine impulses, roller 90' at this time resting upon contact 9², a circuit for shunt relay 125 is established, whereby it is energized and locked up through its alternate contact 128. The said energizing circuit for relay 125 is traced from battery through the winding of said relay, conductor 126, plate 127, wiper 124, contact 9', to closed contact 113 of plunger #9 in the tens key CK³ to ground at normal contact 111. The impulse contacts 90 being open at the time shunt relay 125 energizes, the circuit through conductors 91 and 91' is interrupted and again closed as the roller rides off tooth 9² followed by eight more interruptions due to the actuation of the following eight teeth of plate 120. These nine interruptions cause nine operations of impulse relay IR, in the manner as previously described, thereby transmitting nine impulses from grounded impulse contact 130, over the primary conductor P', P², normal contact 188 of switch J, wiper 177, contact 180, conductor P³, the first one of the nine impulses dividing at point 190, part of the current flowing through conductor 191, normal contact 192, and the winding of release relay RR⁴ to battery energizing said relay whereby it establishes a locking circuit for itself through its alternate contact 193, conductor 194, normal contact 195 to the grounded test contact 179. As just stated, the first impulse dividing at contact 190 also follows a path along conductor P³, conductor 196, normal contacts 197, 198, and the winding of primary magnet PM⁴, to battery causing its operation, whereby the wipers 199, 200, receive a single primary operation, thus moving primary off normal switch PON⁴ to its alternate position and due to the opening of its contact 192 interrupting the initial circuit through release

relay RR⁴. Therefore, the following eight impulses traverse a path along the primary conductor P³ and through magnet PM⁴ causing eight more operations thereof, whereby the wipers are advanced eight more steps bringing them to the ninth sub-group of contacts 201, 202, which is the sub group including the terminals of the called line. A secondary impulse from secondary contact 153 of the impulse device I follows the transmission of the primary impulses as before, this secondary impulse flowing over the previously described path to the secondary conductor S', S² of switches F and J, then through normal contact 189, wiper 178, contact 181, conductor S³, conductor 203, alternate contact 204, normal contact 205, and winding of switching relay SW to battery, causing its energization whereby it is locked up through its alternate contact 207, the grounded alternate contact 208 of relay RR⁴. The energization of said switching relay SW disconnects the primary magnet PM⁴ from the primary conductor and connects the secondary magnet SM⁴ thereto.

Up to the present three series of impulses have been transmitted, whereby the sub-group of contacts, of connector switch K, including the terminals of the called line have been selected so that the final series of impulses, which are nine in number corresponding to the last digit of the number of the called line, are transmitted to cause the selection of the desired terminals. Returning now to impulse device I, following the transmission of the last secondary impulse, a continued rotation of shaft 119 brings wiper 124 in connection with terminals 168, whereby an energizing circuit for release magnet RM² is established to effect the restoration of the operated contact springs 113, 114, 115 in the tens key CK³. The said circuit for RM² is traced from battery through the winding thereof, contacts 168 to ground at normal contact 112, whereby said magnet is energized restoring its associated actuated contact springs, and upon wiper 124 leaving said contacts 168, the circuit for RM² is interrupted, whereby it is restored. Shaft 119 now continues on its fourth revolution, magnet CM still being energized through alternate contact 117, and upon wiper 124 reaching contact 9', relay 125 is energized, and the transmission of nine primary impulses followed by a single secondary impulse, as last described is effected. The final nine primary impulses traverse a path over the primary conductor P', P² and P³, to conductor 196 of switch K as previously described, normal contact 197, and alternate contact 198, through the winding of secondary magnet SM⁴ to battery, causing nine operations thereof, and advancing wipers 199, 200 to the ninth set of terminals, which are the terminals of the

called line. The final secondary impulse just referred to traverses the previously described path to secondary conductor S', S², S³, conductor 209, alternate contact 210, normal contact 211 and the winding of line test relay TR to battery causing its energization. Up to this period in the operation of the system in establishing a connection, the operation is the same whether the wipers 199, 200 have connected to terminals of an idle or a busy line, but the operation of connector K after this period differs depending upon whether the called line is idle or busy, and if idle ringing current is connected to the terminals thereof, while if busy, a characteristic busy signal is transmitted to the calling substation.

Release of sender I and selector G.—Following the transmission of the final set of impulses, impulse sender I and impulse sender selector G are restored to normal, thus making sender I available for selection by another calling line for use in establishing other connections. Now as to the method of restoring impulse sender I to normal, as shaft 119 continues its rotation following the last secondary impulse, periphery 123' of cam 123 engages roller 213' closing contacts 213 and at the same time wiper 124 is connecting contacts 167. The closing of contacts 167 establishes a circuit for release magnet RM² traced from battery through the winding of said magnet, conductor 214, contacts 167, to grounded normal contact 115, energizing magnet RM² and causing the restoration of its associated contact springs 116, 117, 118, but previously to the opening of contacts 118, the ground connection which caused the energization of RM² also causes a flow of current through said contacts 118, conductor 215, and the winding of release relay RR² to battery, causing its energization, whereby it establishes a locking circuit for itself through its alternate contact 217 to ground at said alternate contact 213, this locking circuit being the preferred method employed to energize relay RR² for a sufficient length of time to transmit a release impulse to switch G. Due to the opening of contact 117 of the units key CK¹, the circuit for clutch magnet CM is interrupted, whereby the rotation of shaft 119 is continued until it reaches the normal stopping point, where it remains due to the action of clutch mechanism disconnecting shaft 119 from the driving shaft as previously described. It will be noted that as wiper 124 leaves contacts 167, the circuit for release magnet RM² is interrupted, allowing it to restore.

Returning now to release relay RR² which relay transmits a release impulse to switch G, it having energized as described, interrupts the locking circuit for relay 88 due to the opening of contact 97, whereby said

relay 88 restores and interrupts the circuit through signal lamp 104 and magnet 102. Also due to the closing of alternate contact 100 of relay RR², a circuit for release relay RR' is established, being traced from battery through protective resistance 98, alternate contact 100, contact 77, wiper 73, normal contacts 86, 87, the winding of RR', alternate contact 83 of PON to ground at normal contact 82, causing the energization of RR' whereby its alternate contact 218 is closed connecting the winding of test relay T' in series with the winding of RR', thereby energizing T', RR' and T' now being energized over the said series circuit. The initial energizing circuit for RR' being through its normal contacts 86, said contacts 86 are adjusted so they do not break until after locking contact 218 is closed. Although alternate contact 219 is closed while relay RR' is energized, this has no effect upon the circuits at this time. As it will be noted, the conductor 220 leading therefrom is already connected directly to ground through conductor 166 and contact 165 of switch F. This ground from 219 is to maintain a ground or busy potential at contact 20 of master switch D during release of switch G, should a calling subscriber hang up before a connection to the called line is completed.

The restoration of switch G is effected responsive to the energization of RR' and T' by an operating circuit established for magnet SM', through alternate contact 85 of relay T'. It will be remembered that to restore switch G its wipers are advanced in a secondary direction until they have passed beyond the last contact in the group, this operation being effected by magnet SM' due to the closing of its circuit, as just described. As wipers 73, 74, 75, pass beyond the last contact of the bank, a release pawl is automatically withdrawn allowing them and wiper 72 to restore, this restoring movement also causing restoration of the primary and secondary off-normal switches. Upon the opening of contact 83 of PON the series circuit including the windings of RR' and T' is interrupted allowing them to restore, the restoration of T' interrupting the circuit through magnet SM'. Switch G and impulse sender I having been restored, sender I is available for use in establishing other connections and may be selected by other selector switches G.

Referring now to the first selector F, its impulse relay IR having had its circuit interrupted by the restoration of switch G, said relay IR deenergizes, thereby interrupting the circuit for relay 221, which also deenergizes closing its normal contacts 133, 222 and restoring the continuity of the primary and secondary talking conductors. A connection now extends from the calling

- substation A to called substation L, being traced over the heavily marked primary and secondary conductors and interrupted only at contacts 223, 224, of connector K. The talking conductors 93, 93', leading back from switch G are disconnected from the primary and secondary conductors P and S, respectively, at contacts 141 and 140 of relay 132.
- 10 *Called line idle.*—Returning now to connector switch K, it will be remembered that its relays SW, RR', are energized followed by the energization of line test relay TR responsive to the last secondary impulse.
- 15 Assuming now that the line of substation L is idle, its terminals 201, 202 are at normal as indicated in Fig. 1, Part 3. Relay TR upon its said energization closes its contact 230 thereby connecting the winding of disconnect relay 231 to the grounded contact 208 of release relay RR', causing the energization of said relay 231 which establishes a locking circuit for itself through its alternate contact 232 to ground at said contact 208. Relay 231 also by the interruption of its normal contact 197 disconnects the conductor leading to the operating magnets SM', PM', from the primary conductor P³.
- 20 Returning now to relay TR, it will be noted that although upon closure of its alternate contact 233 the winding of busy relay BR is connected to the secondary conductor S³ and therefore through to the cut-off relay CO', both of the relays BR and CO' being connected to the same terminal of battery are not energized and further it will be noted that upon energization of relay 231, due to the interruption of its normal contact 211, the secondary impulse through relay TR is interrupted, causing the restoration thereof whereby its normal contact 233 closes. Therefore ringing relay RI is connected in series with relay CO', the circuit thereof being traced from battery through said relay RI, alternate contact 234, normal contact 233, conductor S³, wiper 200, contact 202, and the winding of CO' to ground, energizing both said relays. The energization of CO' disconnects line relay LR', thereby removing the called substation control thereof.
- 25 Responsive to energization of ringing relay RI, the interrupter relay FF is energized by a circuit traced from battery through the live segment of interrupter wheel 235, the winding of FF, normal contact 236, alternate contact 237, conductor 238, to ground at alternate contact 208. Interrupter relay FF is therefore energized and at this time the generator segment 239' is connected to alternate contact 240 of relay FF and therefore ringing current is applied to the terminals of the called line, the circuit thereof being traced from ringing generator RG, interrupter wheel 239', alternate contact 240, conductor P³, wiper 199, contact 201, conductor 6', the call bell and condenser of substation L, conductor 5', contact 202, wiper 200, conductors S³, 241, normal contact 233, alternate contact 234, conductor 242, alternate contact 243 and non inductive winding 244 to ground. During the revolution of the two interrupter wheels 235-239, it will be noted that due to their relative position upon their shaft, generator current from RG is disconnected by segment 239' previous to the interruption of the circuit through FF by live segment 235, so that ground from segment 239 is momentarily connected to alternate contact 240 and therefore to the terminal of the called line, taking care of any discharge of ringing current from said line which otherwise would have a tendency to kick up relay TP. Due to the continued rotation of the interrupter wheels 235-239, ringing current is connected to the terminals of the called line upon each energization of FF, while upon each deenergization of FF the tip relay TP is connected to a terminal of the called line so that upon response of the called subscriber and the following deenergization of relay FF a circuit for said relay TP is established from ground through its winding, alternate contact 245, normal contact 240, wiper 199, contact 201, conductor 6', the upper switchhook contacts of substation L whose receiver has been removed, conductor 5', contact 202, wiper 200, conductor 241, normal contact 233, alternate contact 234 and the winding of RI to battery, causing the energization of tip relay TP which is now connected in series with relay RI. Responsive to the closing of alternate contact 246 of TP, the circuit closing relay CL is energized by a circuit traced from battery through the winding of said relay CL, alternate contact 246, conductor 238 to ground at alternate contact 208, causing the energization of CL whereby its normal contact 236 is interrupted, disconnecting relay FF and rendering it inert.
- 30 Due to the opening of normal contact 195 of CL, the control of release relay RR' is removed from the calling subscriber, but as tip relay TP energized before CL did, and due to the closing of alternate contact 248 of said tip relay TP, ground from alternate contact 208 through said contact 248, conductor 194 and locking contact 193 of RR' transfers the control of RR' to the called substation. The closing of alternate contacts 223 and 224 of CL established the continuity of the talking circuit between the substations A and L which is traced over the heavily marked conductors connecting the two substations and which have condensers 249, 250 interposed at line selector E. Talking battery for the called substation is supplied

through the windings of relays RI and TP, while the talking battery for the calling substation is supplied through windings of impedance coil 69 and relay MRR at line selector E. Thus the two substations are connected for conversation, the relays RI and TP at connector K being connected in bridge of the called line while impedance coil 69 and relay MRR are connected in bridge of the calling line. Of course the two cut-off relays CO and CO' are maintained energized over the paths previously described.

Release.—The subscribers having finished their conversation may now effect the restoration of the apparatus used in establishing the connection, the release of connector K and line circuit C' being preferably controlled from the called substation L, while the release of line circuit C, line selector E, first selector F and second selector J is preferably controlled from the calling substation A. Assuming that the subscriber at L replaces his receiver first, the circuit for tip relay TP is interrupted due to the opening of the upper switchhook contacts, (RI remaining energized by the circuit through CO') causing the restoration of said relay TP and by the opening of its alternate contact 248 interrupting the locking circuit for relay RR⁴. Said relay RR⁴ therefore deenergizes interrupting its alternate contact 208, the ground from which it will be remembered maintains relays SW, 231 and CL energized, these relays now also restoring. The restoration of CL disconnects wipers 199 and 200 from the talking strands to prevent interference with any existing conversations during release, while due to the closing of its normal contact 195, ground is connected to test conductor 251 from alternate contact 210' of switch SON⁴ thereby maintaining the multiplied test contacts 179 busy during the release of switch K. Responsive to deenergization of relay 231 of switch K, its alternate contact 234 interrupts the series circuit through relays RI and CO' whereby they are deenergized, thus all the relays of switch K are at normal. Returning now to release relay RR⁴ upon its said deenergization, a release circuit for the secondary magnet SM⁴ is established traced from ground through common interrupter 252, alternate contact 253, normal contact 254 and the winding of SM⁴ to battery, whereby said magnet is operated responsive to the interruptions of its circuit by interrupter 252, advancing wipers 199—200 in a secondary direction beyond the last contact in the sub-group, causing the automatic restoration of the wipers, as previously described.

Upon restoration of PON⁴, its contact 253 is interrupted, interrupting the circuit through magnet SM⁴ rendering it inert,

and upon restoration of switch SON⁴, its alternate contact 210' is interrupted, thereby disconnecting ground from test conductor 251 and switch K being at normal is now available for selection for use in establishing other connections. The calling subscriber now replacing receiver 2 upon its switchhook, the circuit for main release relay MRR of line selector E is interrupted, causing its restoration, whereby its alternate contact 70 is interrupted, thereby interrupting the circuit for relays 132 and RR of line selector E, and release relay RR² of first selector F, causing their restoration. Responsive to the restoration of relay RR a circuit for test relay T is established traced from battery through the winding of said relay T, normal contact 61, conductor 59, alternate contact 58 and normal contact 54 to ground. Relay T therefore energizes, closing its alternate contact 62 establishing a release circuit for secondary magnet SM which is therefore operated to advance wipers 14, 15, 16 beyond the last contact of the sub-group, whereby they and wiper 18 are automatically restored as previously described. It will be noted that during the restoring movement of wipers 14, 15, 16 over contacts 11, 12, 13, that wiper 14 has its circuit interrupted at alternate contact 64 of release relay RR, while wipers 15, 16 are disconnected at normal contacts 66, 67 of relay T. Furthermore, it will be noted that during the restoring movement of switch E and until its switch SON is restored, that ground from alternate contact 51 thereof is connected to test contact 20 of the master switch, being traced through normal contact 254, conductors 255, 256 to terminal 20, thereby rendering switch E unselectable during its release movement. Upon restoration of switch PON, its alternate contact 58 is interrupted, thereby interrupting the circuit for relay T which is restored, opening the operating circuit for magnet SM. It will be remembered that cut-off relay CO was energized over the primary conductor and through impedance coil 69 to battery, therefore, when contact 66 of relay T was interrupted, said relay CO was restored. Relay CO being restored the line of substation A is available for use in the establishment of other connections.

The restoration of switch E having been described, reference will now be made to the restoration of switch F. It will be remembered that release relay RR² deenergized and its circuit was interrupted by the restoration of relay MRR of switch E, therefore upon the closing of its normal contact 159 a circuit for relay T² is established from ground through alternate contact 257 of PON², normal contact 159 and the winding of T² to battery, whereby T² is energized and due to the closing of its alternate

contact 160 an operating circuit for magnet SM² is established, thereby advancing wipers 147, 148 and 149 and causing the release of switch F in a manner as previously described. Upon restoration of switch PON², its contact 257 is interrupted, causing the restoration of relay T², which interrupts the circuit for magnet SM². Switches E and F having been restored and conductor 10 256 leading to master switch D having been disconnected from ground at switch SON and PON², the said pair of switches are now adapted to be selected by master switch D and used for establishing other connections.

Referring now to second selector J, it will be remembered that its release relay RR² was energized and locked up through its alternate contact 175 and then over the 20 test conductor and contacts 163, 164 to ground, so that upon deenergization of RR² of switch F as just described, the circuit for relay RR² is interrupted at contact 163 of RR², causing the restoration of RR². A 25 circuit for relay T² is therefore established, being traced from battery through the winding of said relay, normal contact 184 and alternate contact 259 to ground, causing the energization of T², whereby its alternate 30 contact 185 is closed and an operating circuit for magnet SM² is established, causing said magnet SM² to advance wipers 176, 177 and 178 in a manner as previously described, causing the restoration of switch 35 J. Upon restoration of PON², its contact 259 is interrupted thereby causing restoration of T² which opens the circuit for SM². It will be noted that during the restoring movement of switch J contact 260 of PON² 40 is closed connecting ground to test contact 150 and rendering switch J unselectable until PON² is restored.

Called line busy.—In the description just given of the operation of the system, it was 45 assumed that the called line was idle, we will now assume that it is busy upon connection made therewith. As previously stated, the operation of the apparatus up to the transmission of the last secondary impulse is the same whether connection is 50 made to an idle or busy line, and it will be remembered that up to this period, that is up to the period including the transmission of the last impulse, at switch K, relays 55 SW, RR⁴ and test relay TR were energized. The energization of TR which was responsive to the last secondary impulse, by the closing of its alternate contact 233 connects busy relay BR to the wiper 200. The line 60 of substation L being busy, its cut-off relay CO' has been energized, and if the line be busy as a called line, this energization is effected by a flow of battery from the connected switch K, or if busy as a calling 65 line, CO' is energized by battery from

a connected line selector E. Therefore, in either case, there is a connection from battery to terminals 202 of the called line so that upon relay BR being connected therewith, said relay is en- 70 ergized and establishes a locking circuit for itself through its alternate contact 275, alternate contact 211 and the winding of TR, this circuit then maintaining both of said relays energized. In this instance, due 75 to the failure of relay TR to deenergize upon cessation of the last secondary impulse, neither ringing relay RI or interrupter relay FF are cut in circuit, thus excluding ringing current from the terminals of the 80 called line. But busy relay BR having been energized as stated, a characteristic busy signal is transmitted to the calling substation, preferably a signal transmitted by the well known form of busy back apparatus 85 BB, which is connected through alternate contact 276 of relay BR to the secondary conductor S², this signal then traversing the path back over the said heavily marked secondary conductor out over line conductor 90 6 and substation A, returning over line conductor 5 and cut-off relay CO to ground. The calling subscriber receiving the signal knows that the called line is busy and therefore by replacing receiver 2 upon its switch- 95 hook, effects the release of the mechanism used in establishing the connection.

In the previous description, it will be remembered that the release of connector K was controlled from the called substation 100 while the release of the other switches was controlled from the calling substation, but in this instance the release of all the switches is effected by the restoration of the calling substation receiver. In the connection now being described, the release of 105 line circuit C, line selector E, first selector F and second selector J, is effected responsive to the restoration of relay MRR of line selector E, as previously described, 110 followed by the release of connector K as will now be described. In the present connection it will be remembered that closing relay CL of switch K was not energized and therefore release relay RR⁴ of switch K is 115 locked up through its alternate contact 193, conductor 194, normal contact 195 and conductor 251 which was grounded through wiper 176 of the connected second selector J as previously described. Now upon de- 120 energization of RR³ of switch J in the release thereof as before described, the circuit for RR⁴ of switch K is interrupted at contact 186 of said relay RR³, whereby said relay RR⁴ of switch K deenergizes opening its 125 alternate contact 208, whereby relays SW and 231 (which were locked up through said contact 203) are restored, and alternate contact 211 of relay 231 being thereby interrupted, the series energizing circuit for 130

relays 213, BR, is interrupted, causing their deenergization. Upon restoration of release relay RR⁴ and due to the closing of its normal contact 254, a release circuit for magnet SM⁴ is established as previously described whereby the wipers and off normal contacts of switch K are restored. All of the apparatus used in establishing the connection to the terminals of the busy called-for line having been restored, it is available for use in establishing other connections.

Called subscriber not responding.—Assuming now that a connection has been extended to the terminals of the called line which is idle, and ringing current is being applied thereto in a manner as previously described, and that no response is secured from the called substation L. It will be remembered that upon switch K connecting to an idle line that relays SW, RR⁴, 231, RI and CO' are energized, and that relay FF is alternately connecting the ringing generator RG and tip relay TP in bridge of the terminals of the called line, and furthermore relay CL not having been energized as yet, as the called subscriber has not responded, release relay RR⁴ is still maintained energized through its alternate contact 193 and normal contact 195 to the grounded conductor 251 leading to test contacts 179. Therefore the subscriber at the calling substation, failing to get a response from the called substation, replaces his receiver upon its switchhook whereby main release relay MRR is restored, effecting the restoration of line circuit C, line selector E, first selector F and second selector J as before. In the present instance switch K is also restored, this being effected due to the interruption of the energizing circuit for RR⁴ at second selector J. Relay RR⁴ therefore restores, interrupting the circuit for relays SW and 231 followed by the restoration of relays RI and CO', the restoration of RI interrupting the circuit for relay FF which is rendered inert. Also upon deenergization of RR⁴ a circuit for magnet SM⁴ is established causing the release of switch K in a manner as previously described. Should a connection be extended through to an operator, and the operator for some reason desires to release the connected selector G, means are provided in the form of a manually operated key RK, which upon being depressed, energizes relay RR⁵ thereby effecting a release of the connected switch G in a manner as previously described.

Although I have chosen to illustrate my invention as a 10,000 line system, it is apparent that it is by no means limited to such an exchange, as second selector J may be left out in smaller sized exchanges, or in larger sized exchanges other selectors such as third selectors similar to switch J may

be used, between the second selector J and connector K. The operator's impulse transmitter I is also capable of use in connection with different sized exchanges, for instance, where only first selectors and connectors are used, the keys CK², CK³ and CK⁴ only are used, or if a larger exchange is contemplated, and more selectors are used as previously stated, then more keys such as CK¹ may be added, and of course, an additional set of release contacts such as 167, 168, 169 and 170, for each such additional key which may be added.

It will be apparent to those skilled in the art that many changes and modifications of my invention may be readily made, and I do not desire to be limited to the exact structure as illustrated, but aim to cover all such modifications as come within the spirit and scope of the appended claims.

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

1. A telephone system comprising telephone lines, a line selector for connection thereto, a first selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, and means actuated upon initiation of a call over one of said lines to simultaneously start said line and sender selectors to select the calling line and an idle impulse sender respectively.

2. A telephone system comprising a line selector, telephone lines terminating thereat, a first selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, means actuated upon initiation of a call over one of said lines to simultaneously start said line and sender selectors to select the calling line and an idle one of said senders respectively, said sender being then adapted to cause operation of said first selector to extend the circuit of the calling line.

3. A telephone system comprising a line selector, telephone lines terminating thereat, a first selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, means actuated upon initiation of a call over one of said lines to simultaneously start said line sender selectors to select the calling line and an idle one of said senders respectively, second selectors and connectors, said sender being adapted to cause the operation of said first and second selectors and connectors to extend the circuit of the calling line to a called line.

4. A telephone system comprising a line selector, telephone lines terminating thereat, a first selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, means actuated upon initiation of a call over

one of said lines to simultaneously start said line and sender selectors to select the calling line and an idle one of said senders respectively, second selectors and connectors, means for actuating said first and second selectors and connectors responsive to the operation of said impulse sender, to extend the circuit of the calling line, and means for automatically restoring said sender selector after said sender is operated.

5. A telephone system comprising telephone lines, line selectors, impulse sender selectors and first selectors permanently associated in threes, impulse senders terminating at said sender selectors, and a master switch common to said lines and selectors.

6. A telephone system comprising telephone lines, line selectors for connection thereto, a first selector and impulse sender selector individual to each line selector, impulse senders terminating at said sender selector, a master switch common to said lines and selectors, said master switch being adapted upon initiation of a call over one of said lines to start an idle pair of said line and sender selectors to select said line and an idle one of said senders respectively.

7. A telephone system comprising telephone lines, line selectors for connection thereto, a first selector and impulse sender selector individual to each line selector, impulse senders terminating at said sender selector, a master switch common to said lines and selectors, said master switch being adapted upon initiation of a call over one of said lines to start an idle pair of said line and sender selectors to select said line and an idle one of said senders respectively, second selectors and connectors, means for actuating said first and second selectors and connectors responsive to the operation of said impulse sender, to extend the circuit of the calling line, and means for automatically restoring said sender selector after said sender is operated.

8. A telephone system comprising telephone lines, line selectors for connection thereto, a first selector and impulse sender selector individual to each line selector, impulse senders terminating at said sender selector, a master switch common to said lines and selectors and having starting contacts one for each pair of said line and sender selectors, and a starting circuit common to said lines adapted upon initiation of a call over one of said lines to close a starting circuit over one of said contacts to cause the associated line and sender selectors to select said line and an idle one of said senders respectively.

9. A telephone system comprising a pair of line and impulse sender selectors, telephone lines divided into groups and terminating at said line selector, groups of impulse senders terminating at said sender

selector, means actuated upon initiation of a call over one of said lines to cause said line selector to select the calling line group and the calling line in the group, means simultaneously actuated upon initiation of said call to start the corresponding sender selector to select the first idle group and the first idle sender in said group, and a first selector switch individual to said line and sender selectors responsive to said impulse sender.

10. A telephone system comprising telephone lines, line selectors for said lines, a first selector and impulse sender selector individual to each line selector, a plurality of impulse senders common to said lines, and means responsive to a call over one of said lines to simultaneously start an idle paired line and sender selector to select the calling line and the first idle sender respectively.

11. A telephone system comprising line selectors, first selectors and impulse sender selectors associated in threes, and means for simultaneously starting a line and sender selector to perform their selecting operations.

12. A telephone system comprising a line selector, telephone lines terminating thereat, a directive selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, means actuated upon initiation of a call over one of said lines to simultaneously start said line and sender selectors to select the calling line and an idle one of said senders respectively, other directly controlled switches, means for actuating said directly controlled selectors and switches responsive to the operation of said impulse sender to extend the circuit of the calling line.

13. A telephone system comprising a line selector, telephone lines terminating thereat, a directive selector and impulse sender selector individual to said line selector, impulse senders terminating at said sender selector, means actuated upon initiation of a call over one of said lines to simultaneously start said line and sender selectors to select the calling line and an idle one of said senders respectively, other directly controlled switches, means for actuating said directly controlled selectors and switches responsive to the operation of said impulse sender to extend the circuit of the calling line, and means for automatically restoring said sender selector after said sender is operated.

14. A telephone system comprising telephone lines, line selectors for connection thereto, a directive switch and impulse sender selector individual to each line selector, impulse senders terminating at said sender selector, a master switch common to said lines and selectors, said master switch being adapted upon initiation of a call over

one of said lines to start an idle pair of said line and sender selectors to select said line and an idle one of said selectors respectively, other directly controlled switches, means 20 for actuating said directly controlled switches responsive to the operation of said impulse sender to extend the circuit of the calling line. 25

15 15. A telephone system comprising telephone lines, line selectors for connection thereto, a directive switch and impulse sender selector individual to each line selector, impulse senders terminating at said sender selector, a master switch common to said lines and selectors, said master switch being adapted upon initiation of a call over one of said lines to start an idle pair of said

line and sender selectors to select said line and an idle one of said selectors respectively, other directly controlled switches, means 20 for actuating said directly controlled switches responsive to the operation of said impulse sender to extend the circuit of the calling line, and means for automatically restoring said sender selector after said 25 sender is operated.

Signed by me at Chicago, county of Cook, and State of Illinois, in the presence of two witnesses.

ALFRED H. DYSON.

Witnesses:

GEORGE E. MUELLER,
CARRIE F. ANDERSON.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."