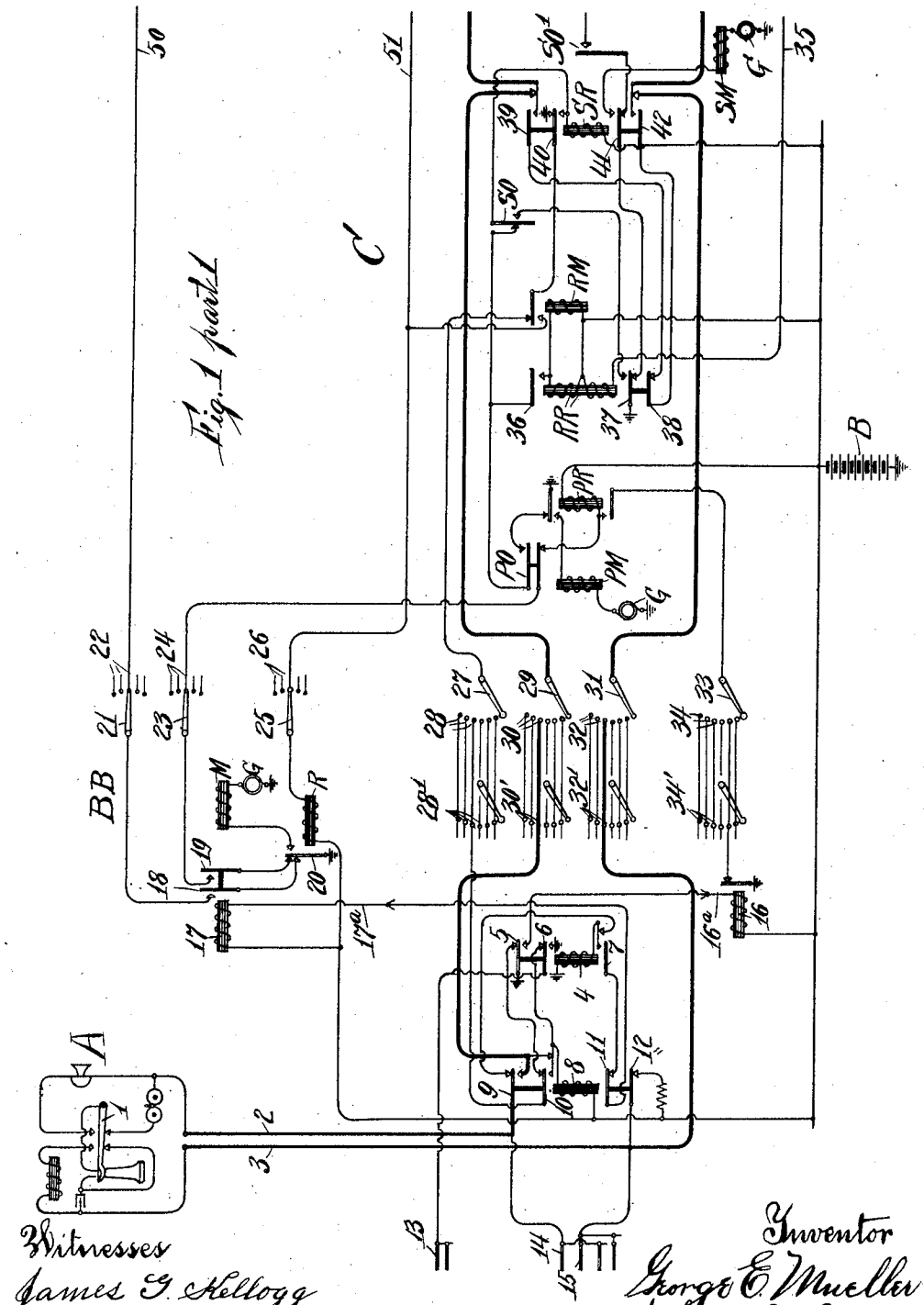
G. E. MUELLER.

SEMI-AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED NOV. 16, 1907.

1,391,135. Patented Sept. 20, 1921.

6 SHEETS—SHEET 1.



Witnesses

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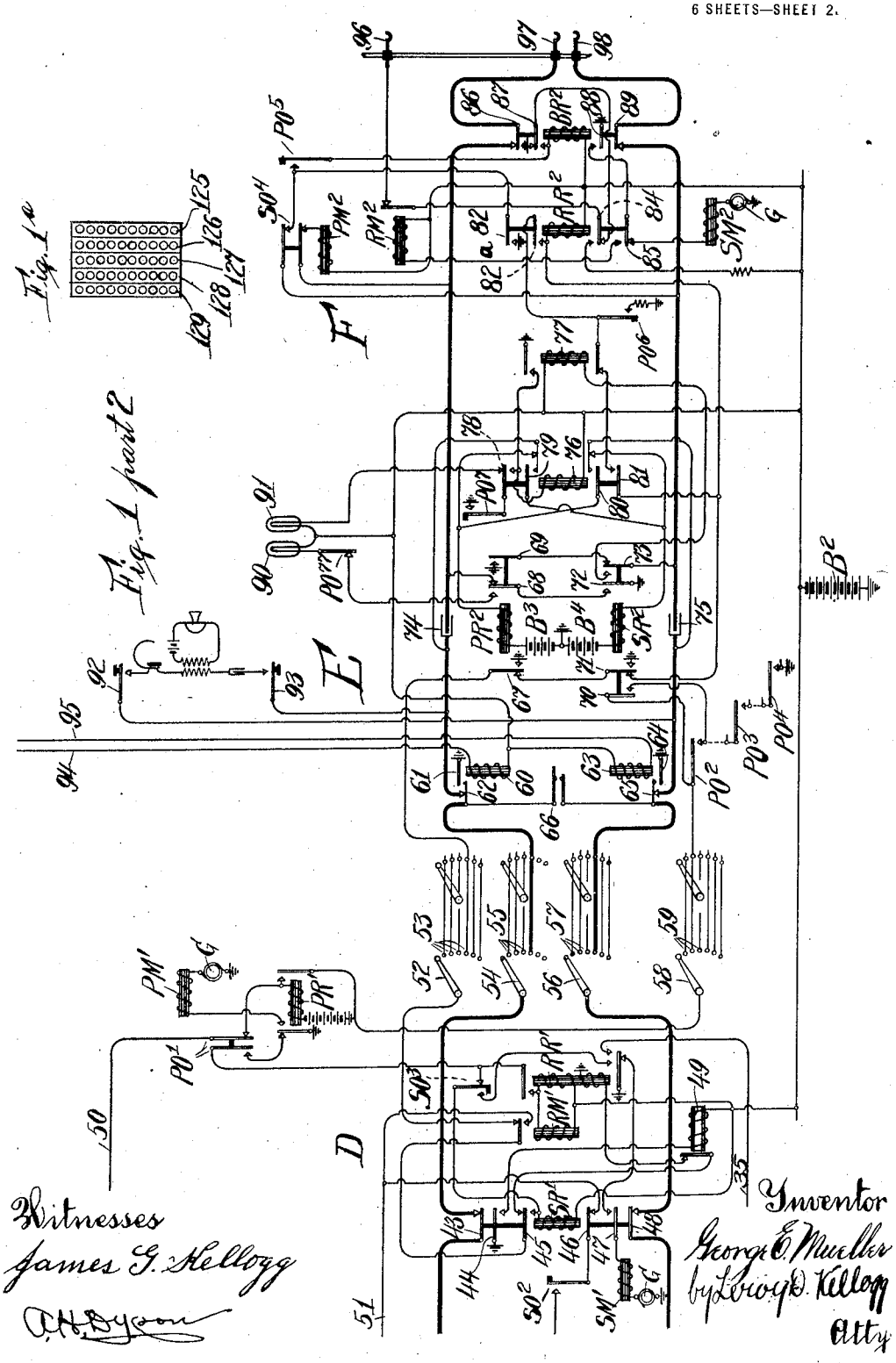

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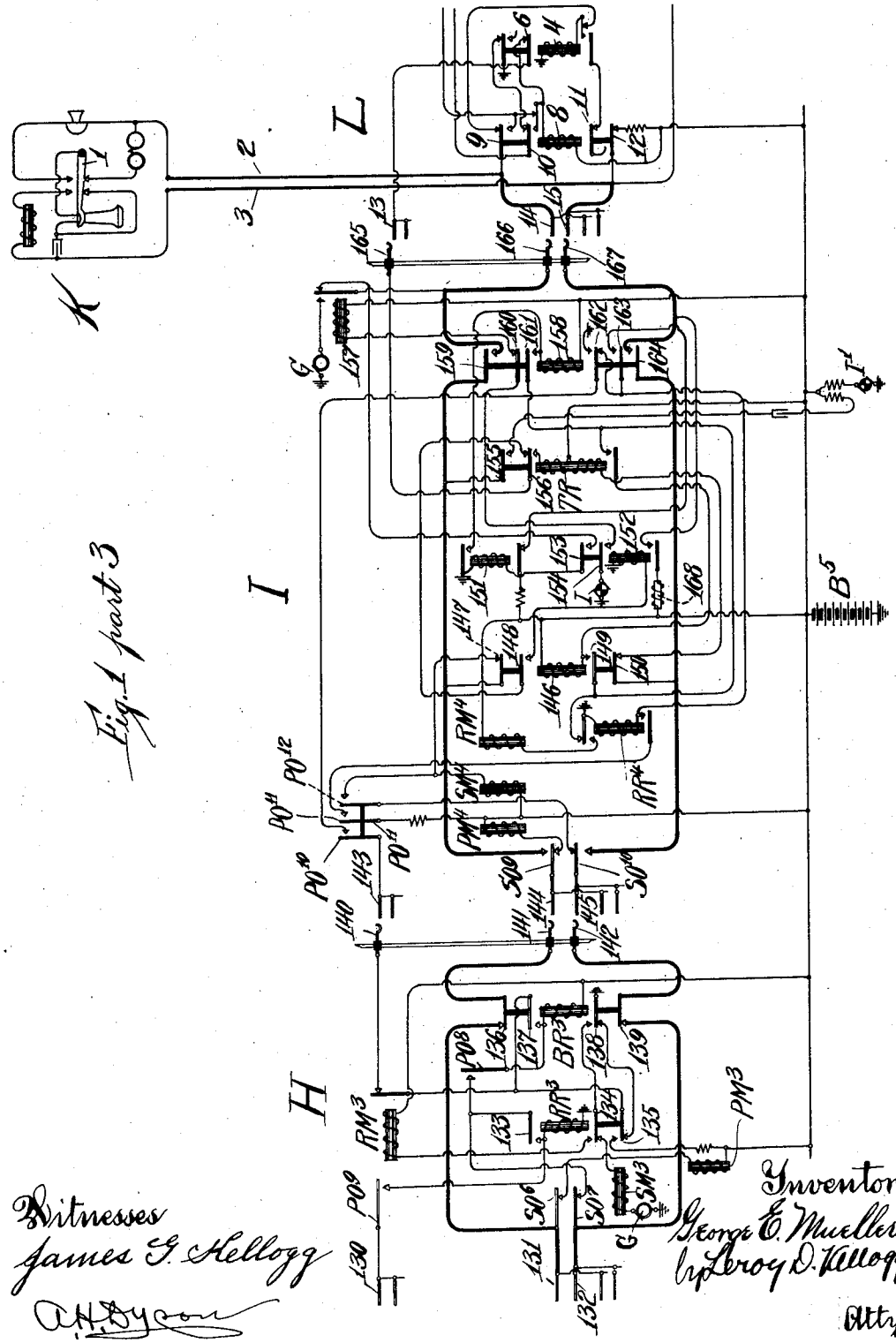
6 SHEETS—SHEET 3.



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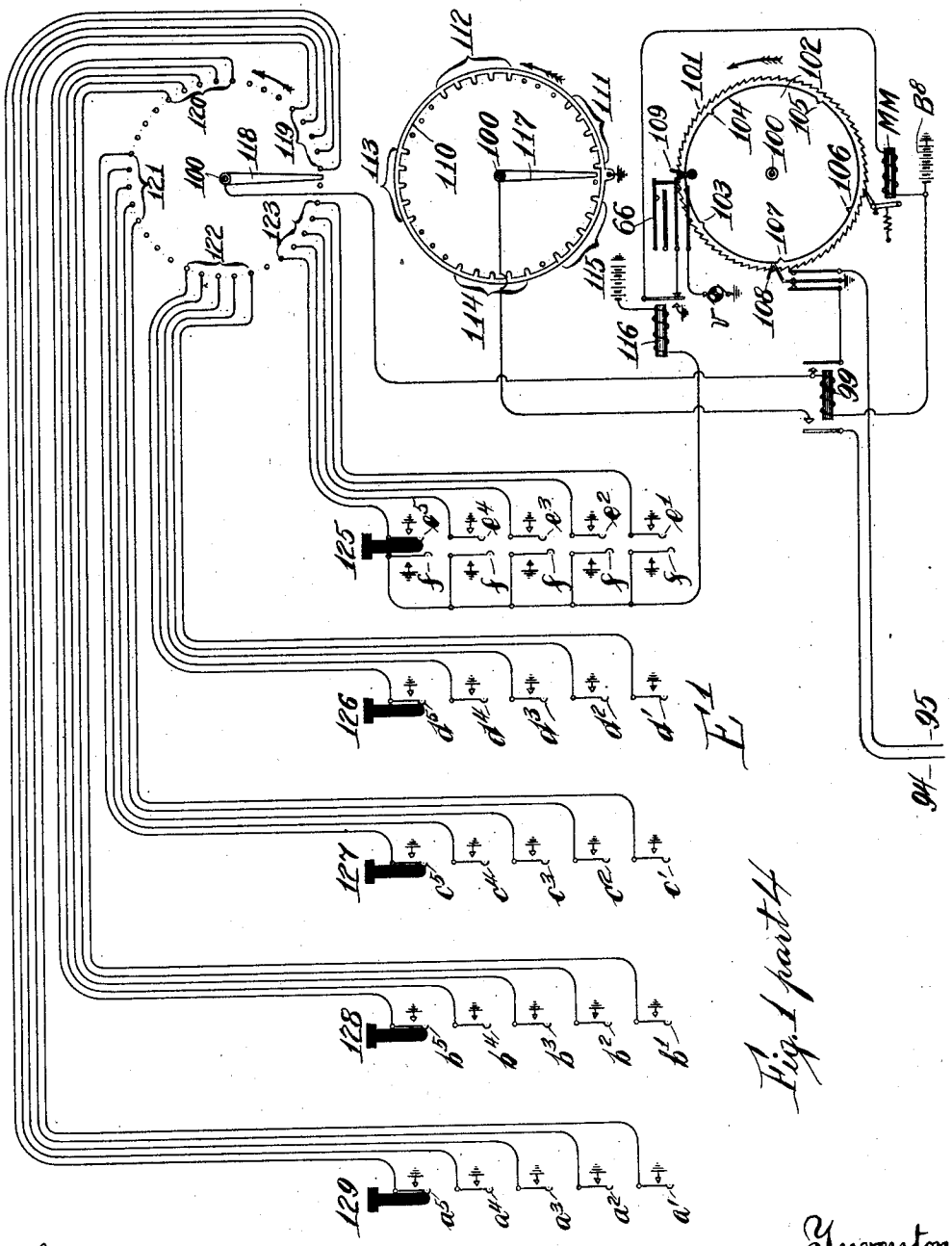

Fig. 1 part 4

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6 SHEETS—SHEET 5.

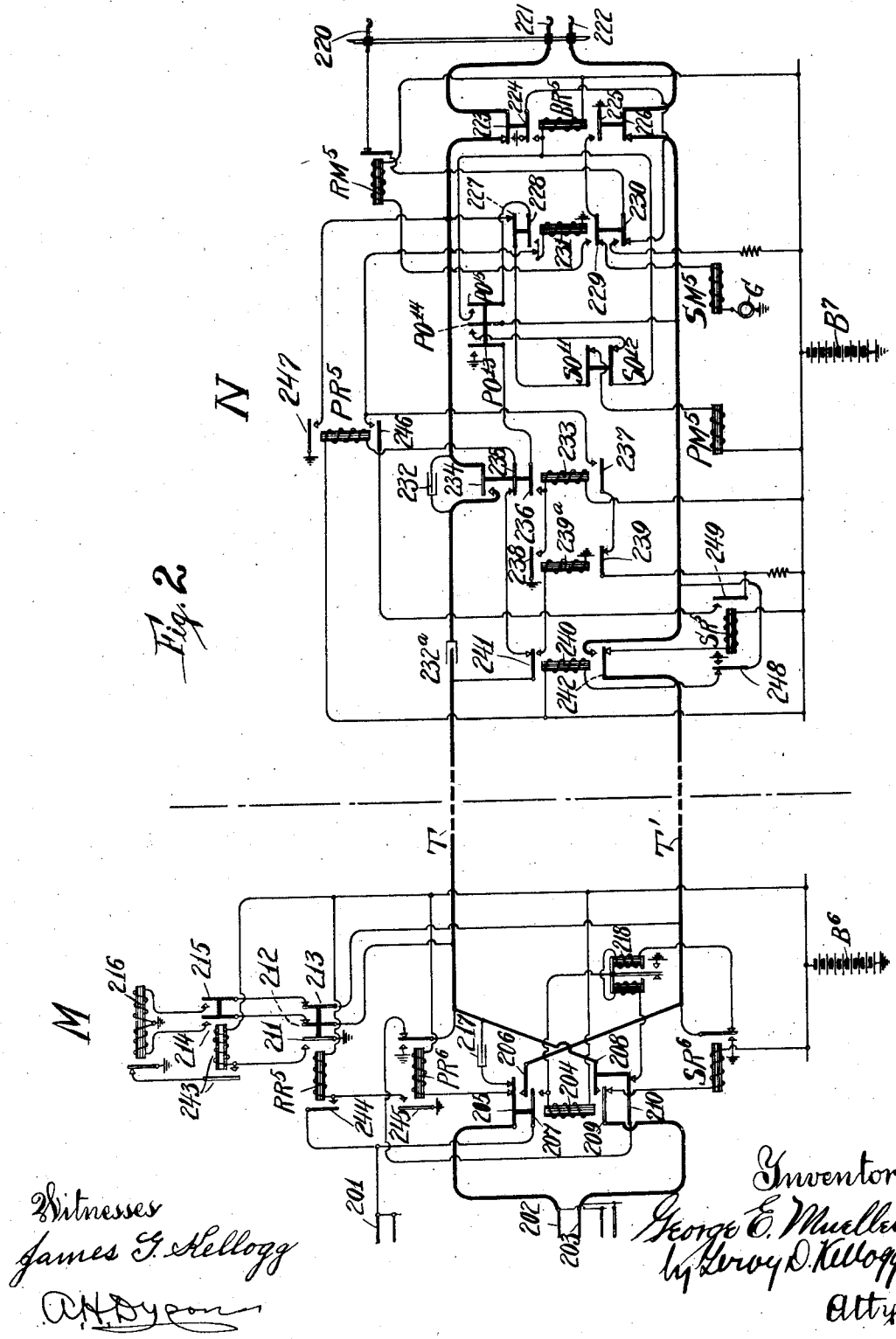

Fig. 2

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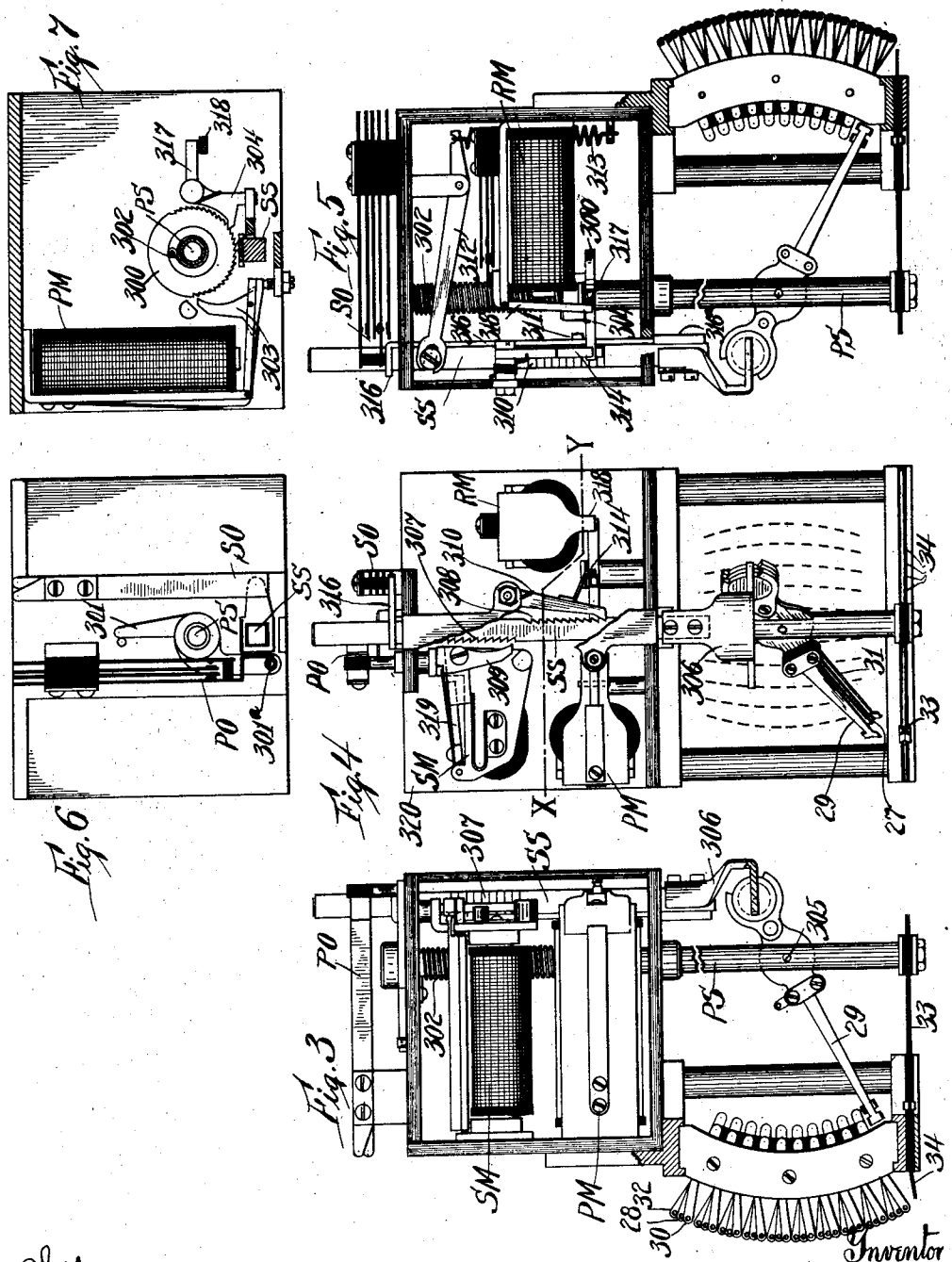
6 SHEETS—SHEET 6.



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UNITED STATES PATENT OFFICE.

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SEMI-AUTOMATIC TELEPHONE SYSTEM.

1,391,135. Specification of Letters Patent. Patented Sept. 20, 1921.

Application filed November 16, 1907. Serial No. 402,443.

To all whom it may concern:

Be it known that I, GEORGE E. MUELLER, residing in Aurora, in the county of Kane and State of Illinois, have invented new and useful Improvements in Semi-Automatic Telephone Systems, of which the following is a specification.

My invention relates to a system in which the substations are provided with telephonic outfits similar to those customarily used in manual telephone practice, electro-magnetically controlled mechanism being employed at the exchange to interchangeably connect calling subscribers' lines with idle operators' positions, the in-coming calls being automatically distributed to the different positions of the switchboard according as they are idle or busy. When a calling line has been connected to an idle operator's position, a suitable signal is displayed and the operator, having thereupon ascertained in the usual manner the want of the subscriber, completes the connection to the called line by operating a suitably arranged impulse controlling device which actuates directively operable selective switches in a manner generally similar to that employed in automatic telephone practice.

One of the objects of the present invention is to provide a relatively simple means for distributing the incoming calls, which I accomplish by means of selective switches less in number than the number of calling lines. The switches for this purpose are preferably arranged in permanently associated pairs and for each initiated call, a pair of switches is set into actuation, one of which will select the calling line while the other will select a link-circuit at an idle operator's position. Another object of the invention is to provide a structure wherein all the switches used in the connection are restored to their normal position as soon as the two subscribers have replaced their receivers, although the scope of the invention is not limited to this precise arrangement. Other objects of the invention are found in certain details of arrangement and mechanism which will be more particularly pointed out in the detailed description and the claims.

Referring to the drawings, Parts 1, 2 and 3 of Figure 1 when arranged in consecutive order with Part 4 above Part 2, illustrate a preferred circuit arrangement embodying the invention. Fig. 1ª illustrates a plane view of an operator's impulse-transmitting key-board; Fig. 2 illustrates a circuit arrangement adapted to be inserted between Parts 2 and 3 of Fig. 1, whereby interconnection of two distant exchanges may be accomplished by the use of a pair of conductors only; Fig. 3 is a left elevation of a selective switch that may be employed in connecting circuits, the contact bank being shown in section, while Fig. 4 is a front elevation thereof, and Fig. 5 is a right elevation thereof. Fig. 6 shows the off-normal switch combination of the mechanism of Figs. 3 to 5. Fig. 7 is a sectional view on line XY of Fig. 4 showing the arrangement of the primary magnet PM with relation to the switch shafts. Referring first to Fig. 1, I show at A, a subscriber's telephone station including the hook-lever 1, controlling in the usual manner, the signaling and talking circuits of line limbs 2—3, which extend to the exchange and are there provided with multiple called contacts 13, 14, 15, appearing in the banks of a suitable number of connectors as is customary in automatic telephone practice. Each subscriber's line is also provided with multiple calling contacts 28, 30, 32, individual to the line, which are multiplied at the banks of a suitable number of line selectors, the circuits of one of which are shown at C. These line selectors have the wipers 27, 29, 31, of which 27 is the so-called private wiper, while wipers 29 and 31 serve to connect the talking conductors to the contacts of a calling line.

Throughout the circuit diagrams, the conductors forming part of the talking circuit to be established between the calling station A and the called station K, are indicated by the heavy lines. Each line selector at C preferably has linked with it a trunk selector D before whose wipers 52, 54, 56, appear multiple contacts 53, 55, 57, of a number of link-circuits E extending to different operators' positions, each link-circuit being preferably provided with an impulse transmitting switch of the character shown in Fig. 1, Part 4, although the invention is not limited to this specific arrangement. Each link-circuit E is also provided with a call signal 90 and supervisory signal 91 together with the listening key levers 92 and 93 serving, when actuated, to connect the

operator's telephone set with the link-circuit.

Each link-circuit also has preferably a first or thousands selector F responsive to the operator's impulse transmitting mechanism to select a group of second or hundreds selectors H and then an idle selector of the group, the second selectors being assigned for connections to the different thousands of the exchange, by groups, according to the well known automatic telephone practice. The second selectors H are operable responsive to the impulse transmitting mechanism to select a desired group of connectors and then an idle connector, the connectors being assigned in groups for connections to each hundred of the thousands which the second selector serves, in the well known manner. Each connector will have before it multiple terminals of one hundred subscribers' lines and each connector will be operable responsive to the impulse transmitting mechanism to select first a group of terminals containing those of the wanted subscriber and then the particular terminals of the wanted line out of the selected group.

The mechanism illustrated in Figs. 3 to 7 is specifically that of the line selector at C in Fig. 1, and comprises the adjustable wipers 27, 29, 31, before which are arranged one hundred sets of individual terminals 30, 28, 32, arranged in ten groups of ten contacts sets each. Fig. 4, showing best the arrangement of these groups as a whole, has each contact set 30, 28, 32, represented by a single short line. In Fig. 3, the ten sets of contacts 30, 28, 32, constitute a group.

It will be apparent from an inspection of Figs. 3 and 4 that the contacts are arranged as though projecting through the inner surface of a section of a sphere. In order to select a group of contacts, the wipers 27, 29, 31, will accordingly be rotated from left to right, their ends adjacent to the contact bank being thereafter moved step-by-step upward over the contacts of the selected group. The first adjustment, that from left to right, may be called the "primary adjustment" and the second may be called the "secondary adjustment."

To secure the primary adjustment, the wipers are pivotally attached to the primary shaft PS, which is suitably journaled to the main frame of the switch and which also has attached to it the rotary ratchet 300 (Fig. 7), which is adapted to be actuated step-by-step in a rotary clock-wise direction by the pawl 303 controlled by the armature of primary magnet PM. Thus, when successive actuations of the said primary magnet PM are produced, the pawl 303 will step the ratchet 300 and shaft PS and wipers 29, 27, 31, step-by-step, the said wipers, with each step, being brought immediately beneath a different vertically disposed group of contacts 30, 28, 32. This rotary stepping is against the tension of the spring 302, one end of which may be attached to the frame of the switch and the other to the shaft PS, the retaining pawl 317 being provided to prevent premature return movement of the primary shaft.

For securing the secondary adjustment of the wipers, which is produced by rotating them about the pivot 305, a secondary shaft SS is provided, having at its lower extremity a suitable piece 306, interlocking a suitable anti-friction bearing at the extremity of the wipers distant from the contact bank, said piece 306, as shown in Fig. 4, being sufficiently broad that when the wipers are primarily adjusted, their distant ends cannot be rotated far enough to disengage said piece 306. The secondary shaft SS passes through the upper and lower plates of the main frame and has the ratchet 307 adapted to be engaged by the pawl 309 carried by the armature 319 of secondary magnet SM; successive actuations of said secondary magnet SM effecting, by pawl 309, successful downward steps of shaft SS; each such downward step rotating the wipers about pivot 305 so that their contact ends move step-by-step upward over the contact sets of the selected group. As shown in Fig. 5, a suitable pivotally supported lever 312 engages loosely by its longer arm a screw inserted in secondary shaft SS, the shorter arm of said lever 312 being held under tension by a restoring spring 313 so that the tension of said spring resists the downward movements of the shaft SS. To prevent back movements under the influence of the said spring, the secondary retaining pawl 310 is provided engaging the ratchet 308 of the shaft SS, as shown in Fig. 4.

As when the magnets PM and SM are inert, their respective pawls 303, 309 are out of engagement with their associated ratchets, it is apparent that to release the switch, it is only necessary to cause the retaining pawls 317 and 310 to be disengaged from the respective ratchets 300 and 308 whereupon the spring 302 will exert its tension to restore the primary shaft PS, while spring 313 will exert its tension to restore the secondary shaft SS. To accomplish these withdrawals, a release magnet RM is provided having its armature 318 arranged to engage an extension 317 of the pivoted pawl 304, as shown in Figs. 7 and 5. Thus, when the magnet RM is energized, the armature 318 engages the piece 317 and rotates pawl 304 free of ratchet 300. As the said pawl 304 interlocks with the spring arm 314 attached to the secondary retaining pawl 310, as shown in Figs. 4 and 5, the rotation of pawl 304 is effective to withdraw the pawl 310 so that the secondary shaft

may be restored under the influence of spring 313. In order to prevent friction of the wipers upon the contacts of the selected group while the secondary shaft is being restored by spring 313, an arm 316 is provided extending through the upper and lower plates of the main switch frame, the said arm being normally held in the position shown in Fig. 5 by the piece 316[a] attached to the shaft SS. As soon, however, as the first downward step of the shaft SS is effected, the piece 316 is free to descend by gravity and the tension of the springs SO until its upper or bent portion rests upon the top surface of the main frame. By its descent, the pawl 311 of piece 316 engages whatever tooth of the ratchet 300 has been brought opposite to it by the primary stepping of the switch so that the primary shaft PS is locked in its rotated position. Thus, while the secondary shaft SS is being restored upward, the pawl 311 holds the primary shaft, although retaining pawl 304 has been withdrawn from ratchet 300. As the shaft SS reaches its normal position, piece 316[a] engages piece 316 and lifts pawl 311 free from ratchet 300, when spring 302 is effective to bring the primary shaft PS back to its normal position. It will be seen that the return movements of shaft SS is limited by piece 316[a] engaging the lower surface of the main switch frame. The return movement of primary shaft PS is limited by the arm 301 fastened to said shaft, as shown in Fig. 6 engaging its associated pin projecting from the top surface of the switch frame.

From the description given, it is apparent that the primary off-normal springs PO shown in Fig. 6 are allowed to shift by their tension to assume their alternate positions on the first primary step of shaft PS, stud 301[a] fastened to shaft PS, moving free of spring PO, and are restored when said shaft reaches normal. The secondary off-normal switch springs SO, whose mechanism is best illustrated in Figs. 4 and 5, are controlled by the piece 316, being shifted on the first secondary movement of shaft SS and being restored as soon as the shaft reaches normal.

It will of course be understood that the armatures of the various magnets are provided with suitable restoring springs and that the pawls have the usual pivot springs. Various minor mechanical details of the switch mechanism are apparent from an inspection of the drawings and a minute specifying of them is considered unnecessary to a full understanding of the mechanical figures which it will be understood are diagrammatic to a certain extent.

For the line selector, the group of ten horizontally disposed contacts 34 is provided with which the wiper 33 engages, said wiper engaging a different contact 34 with each primary step of shaft PS. It is apparent that the wiper 33, while partaking of the primary movements of the switch, does not partake of the secondary movements, but will remain engaging whatever contact 34 it may be brought to engage by the operation of shaft PS.

Referring now to Fig. 1, a telephone system organized in accordance with the invention may comprise, as a whole, a number of subscribers' lines extending to substations such as A or K, said lines at the exchange being divided into groups of one hundred, as calling lines, the multiple calling terminals 28, 30, 32, of each group appearing in the banks of a number of line selectors C of which ten may be sufficient for each group of one hundred lines. At the line selectors the line terminals 28, 30, 32, will be arranged in sub-groups of ten contact sets each, and for each sub-group there will be provided a group contact 34, located as described, in connection with the mechanical drawings. The wipers 27, 29, 31, set in travel when a call is initiated over a line of a group, are controlled in their primary movements to select the sub-group of contact sets, including that of the calling line, by the group wiper 33 engaging the group contacts 34 successively until one is found in an abnormal electrical condition, this condition having been caused by the removal of the receiver at the calling substation. Thereupon the line wipers 27, 29, 31, commence their secondary movements up over the contact sets of the sub-group of lines until they reach the contacts of the calling line.

The removal of a receiver at a calling substation not only starts into operation an idle line selector C to select the calling line, but also starts simultaneously, a trunk selector D whose wipers 52, 54, 56, 58, coöperate with the contacts 53, 55, 57, 59, to select an idle link, or trunk circuit E at some operator's position. The operator's circuits E are preferably arranged in groups of one hundred, having multiple contacts 53, 55, 57, appearing in the banks of a number of trunk selectors D. These multiple contact sets are also preferably sub-divided into ten sub-groups, each sub-group having a group contact 59, the group contacts serving a similar purpose in the operation of the switches D to that served by the group contact 34 at the line selectors, namely, to enable the selecting switch D to select a sub-group of contacts 53, 55, 57; the trunk wipers 52, 54, 56, then automatically picking out the desired set of contacts 53, 55, 57, which will be the first set encountered which is idle.

The group contacts 59 differ from the group contacts 34 in their electrical characteristics, being normally selectable by the group wiper 58, the arrangement being such that the wiper 58 will stop engaging any con-

tact 59 in its normal condition, the said contacts 59 being rendered unselectable only when all the operators's trunk circuits E of their respective sub-groups have been selected by trunk selectors D.

Of course the operator's circuit E need be in number only a small percentage of the number of lines in the exchange as is usual in strictly manual telephone practice, ten per cent. being an ordinary proportion of operators' circuits. Thus, in a ten thousand line exchange, one thousand operators' circuits E would be expected to be sufficient to handle the maximum traffic. As the trunk selectors D are preferably similar to the line selector already described, each containing one hundred contact sets arranged in ten sub-groups, the one thousand operators' circuits E would be divided into ten groups of one hundred circuits each, and these groups of one hundred would be multiplied before the wipers 52, 54, 56 of trunk selectors D paired with line selectors C for one-tenth of the number of lines in the exchange, that is to say, one thousand lines. As before mentioned, ten line selectors are to serve one hundred subscribers' lines, and therefore, the multiple contacts 53, 55, 57 of each group of operator's trunks would be multipled before one hundred trunk selectors D connected by tens with the respective line selectors C of ten one-hundred-line line groups.

It is thus apparent that one thousand lines may have access to a common group of one hundred operators' circuits, and in the ten thousand line exchange supposed, there would be ten such groups of one thousand lines each, each group having access to a particular one hundred operators' circuits E.

In distributing the operators' circuits E among the different operators, any of a variety of arrangements may be employed, it being assumed in the present description that each operator is able to handle proficiently ten operaors' circuits, E. One arrangement would be to have a different group of ten operators for each group of one hundred operators' circuits. In this case, the first sub-group of operators' circuits would preferably be assigned to a first operator, a second sub-group of circuits to a second operator, and so on for the ten sub-groups of the one hundred operators' circuits E serving a one thousand line group of subscribers, and a similar arrangement could be made with respect to the other group of operators' circuits for the other thousands. By this means, the first ten calls of any line group would be concentrated before a first operator. As soon as more than ten co-existing calls existed, the additional ones would be distributed to the second operator, and when more than twenty calls co-existed, the additional ones would be given to the third operator, and so on to the other operators' positions. Another arrangement that might be satisfactorily employed would be to have a first operator have before her the first circuit E of the first sub-group of each one-hundred group of operators' circuits, there being ten such groups, and therefore ten cords before this first operator. Therefore there would reach this first operator's position, the first call from each of the one-thousand-line line groups. The second operator would have the second operator's circuits of the first sub-group of each one hundred circuit group, and so on up until the tenth operator would have the tenth circuits of the first sub-groups. The eleventh operator would have the first circuits of the second sub-groups, and so on to the other sub-groups.

It is obvious that other assignments of operators' circuits might be made with the same general object in view of concentrating the calls at one end of the board, or before certain operators. For instance, there are many combinations intermediate of the two more specifically before referred to that might be employed.

As called lines, the subscribers' lines are divided into groups of one hundred, according to the directory numbers assigned to the different subscribers' stations. Each group of one hundred group lines has in addition to its calling multiple terminals 28, 30, 32 before described, called multiple terminals 13, 14, 15, appearing in the banks of a suitable number of connectors I. In ordinary practice, ten such connectors for each one hundred line groups would be adequate, the subscribers' lines at the connectors I being divided into ten sub-groups, the operation of the connector being first directively controlled to select the sub-group of contact sets containing terminals of the desired line, and then directively adjusted over the contact sets of the sub-group to find the contacts forming individual terminals of the wanted subscriber's line.

The connectors I, by their terminals 143, 144, 145, are divided into groups according to the thousands which they serve, the connectors serving each one hundred of the one thousand having their terminals 143, 144, 145, appearing as a sub-group of contact sets in the banks of a suitable number of second, or hundreds, selectors H which are directively adjusted to select the sub-group of contacts forming the terminals of the wanted connectors, the second selector being then automatically adjusted to select an idle connector of the selected sub-group. The second, or hundreds selectors H have their multiple terminals 130, 131, 132, arranged in sub-groups before first, or thousands, selectors F, second selectors H of each different one thousand having their

terminals appearing as a sub-group before the wipers 96, 97, 98, of first selectors F, it being understood that the first selectors F with their wipers 96, 97, 98, constitute the out-going end of the operators' circuits E.

Each operator's circuit E has preferably its individual impulse transmitting mechanism E′ diagrammatically illustrated in Fig. 1, Part 4, although it will be understood that it would be within the scope of the invention for an operator to have a single calling device for all of the operators' circuits E with means for interchangeably connecting this device with any operator's circuit she desired, in a manner similar to that in which the operator's talking set is caused to be connected with the different cords at will.

I will now briefly describe the impulse transmitting mechanism illustrated at E′ in Fig. 1. The arrangement illustrated at E′ is capable of transmitting five sets of current impulses, springs *a* having the exponents prime, square, cube, etc., being for transmitting the ten thousands digits, with springs *b* for transmitting the thousands digits, the springs *c* for transmitting the hundreds digits, the springs *d* for the tens digits, and the springs *e* for the units digits. It will be understood of course, that in the ten thousand line system, the numbers would all be four digit numbers, the highest numbered line being line 9999, so that the device at E′ actually provides for the transmission of one digit more than would be required for the system heretofore specifically referred to.

Each of these springs a', a^2, etc., will have its actuating button 129 arranged in a linear group, as shown in Fig. 1ª. When a button 129 is depressed, it will remain in its depressed condition holding its respective spring *a* engaging the associated grounded contact. When however, some other button 129 is depressed, a previously actuated one will be automatically restored to its normal position in a well known manner, this being similar to the ordinary well known arrangement used in four-party line manual ringing practice as exemplified in patent to M. Setter, No. 799,019, dated September 5, 1905. Similarly, the buttons 128, one being provided for each spring *b*, are arranged in a linear group, as shown in Fig. 1ª, and the same is true of the buttons 127 for the springs *c*, the buttons 126 for the springs *d*, and the buttons 125 for for the springs *e*. With reference to the buttons 125, each of these has associated with it an additional spring *f*, arranged to be actuated when a button is depressed to close contact to ground, the arrangement being such that when a button 125 is thereafter released, it will be raised sufficiently to allow the spring *f* to disengage its contact, but not sufficiently to allow the spring *e* to disengage its contact. The springs *f* are only required to make a momentary contact to initiate travel of the rotary switch shaft 100. The exponents of the springs *a*, *b*, *c*, *d*, and *e*, indicate the number of impulses each spring is effective to cause the transmission of, when actuated, it being understood that for a complete system, as indicated in Fig. 1ª, there would be ten buttons 129, one for each digit, and consequently ten springs *a*, and so on for the other springs and buttons.

To exemplify the employment of the impulse transmitter E′, let it be assumed that the number 33,333 is to be transmitted. The operator will actuate the keys suitable to cause the grounding of springs a^3, b^3, c^3, d^3, and e^3, thus grounding the middle contacts 119, 120, 121, 122 and 123, which are circularly arranged for engagement by the wiper 118 carried by the shaft 100 to which are also fastened the wiper 117 and the ratchet 101. The impulse transmitter proper is a step-by-step switch comprising the shaft 100, the magnet MM by its associated armature-controlled pawl being arranged to drive the ratchet 101 carrying with it the shaft 100, the notched disk 102 and the wipers 117 and 118, circuit connections being provided, as hereafter specified, to cause the magnet MM to actuate its pawl to effect a complete rotation of the shaft each time the impulse mechanism is operated.

The actuation of the button 125 to connect the spring e^3 to ground was effective to produce a momentary grounding of spring *f*, associated with spring e^3, whereupon an impulse of current was caused to flow from ground through the spring *f* through relay 116 and to battery, said relay attracting and then releasing its armature. The attraction of the armature transmitted an impulse to ground through magnet MM to battery B^8, causing the magnet MM to attract and release its armature and to move ratchet 101 and shaft 100 a rotary step in the direction of the arrow, whereby the stud of insulating material upon disk 102 is brought to free spring 109, and said spring 109 and spring 66 assume their alternate positions. Thus, when the armature of relay 116 is retracted on the cessation of the momentary impulse transmitted by spring *f*, constantly rotating interrupter V begins to send impulses through spring 109, retracted armature of relay 116, magnet MM to battery B^8, each impulse causing an actuation of said magnet and a rotary step of ratchet and shaft. Interrupter V will continue to transmit impulses until a complete revolution of shaft and ratchet has been effected, when the stud of insulating material will again engage the spring 109 and lift it free of its contact, when the opening of the circuit of magnet

MM will cause the switch to come to rest, spring 66 being simultaneously shifted to normal.

110 is a grounded ring of conducting material having five sets of projections 111, 112, 113, 114, 115. As the shaft 100 is rotated by magnet MM, the wiper 117 will obviously rotate over the contacts 111, 112, etc., said wiper being connected to ground once for each projection engaged by it. 94 is a conductor over which the directive impulses are transmitted to the mechanism of the operator's circuit E. It is obvious, however, that until the relay 99 is energized, the engagement of wiper 117 with the grounded projections in ineffective to transmit impulses over conductor 94, but that as soon as relay 99 is operated, the wiper 117 will transmit as many impulses over 94 as it thereafter engages projections, while relay 99 is held energized. It is also evident that the energization of relay 99 is dependent upon the engagement of wiper 118 with a grounded one of its contacts 119 or 120, etc. Thus with the travel of ratchet 101 and shaft 100, impulses will begin to be transmitted by wiper 117 over conductor 94 as soon as wiper 118 engages a grounded contact 119. The actuation of spring a^3 previously described, having grounded the middle contact 119, relay 99 will be operated when wiper 118 engages said contact from ground at spring a^3 through middle contact 119, wiper 118, the said relay 99 to battery B^8, whereon wiper 117 having traveled coincidently with wiper 118 will transmit three impulses over conductor 94, one impulse from ground at the middle projection 111, and two other impulses when it engages the two projections at the right of the middle one. Relay 99, when operated, locks itself to ground at spring 108 and will continue in its locked condition until the spring 108 engages the notch 103 which notch will be brought opposite the said spring 108 when wiper 117 passes beyond the last contact 111. When spring 108 engages notch 103, it opens the locking-circuit of relay 99 and, by engaging its alternate contact, said spring transmits a single impulse over conductor 95. The said spring is, on further rotation of disk 102, brought out of notch 103 to again rest upon the periphery of the disk, whereby normal contact 108 is again closed. It is apparent that with the continued rotation of the shaft 100, another set of impulses will begin to be transmitted through the projections 112 and wiper 117 as soon as wiper 118 engages a grounded contact 120 to cause the energization and locking of relay 99, the impulses transmitted being followed by a single impulse over conductor 95 by engagement of spring 108 with notch 104, and that additional sets of impulses will be transmitted by means of the projections 113, 114, 115, as wiper 118 engages contacts 121, 122, 123, each set of impulses being followed by one over conductor 95 as spring 108 engages the respective notches 105, 106, 107. In the case supposed, in which the middle contacts 121, 122, 123, were grounded, each set will obviously consist of three impulses over conductor 94 followed by one over conductor 95, the switch being stopped as before described, when it completes a revolution.

For convenience of the drawing, the off-normal spring 66 and its contact are shown both at E in Fig. 1, Part 2, in its electrical association and also at E′ in Fig. 1, Part 4, mechanically connected with spring 109, its electrical connection in the latter case being omitted.

Assuming that subscriber A desires his line to be connected with that of the subscriber's line K whose telephone number is assumed to be 3333, the subscriber at A removes his receiver, whereupon hook-lever 1 engages its upper contacts thereby completing a conductive bridge of line limbs 2 and 3 to produce a flow of current from battery B through normal contact 12 over the limb 3, hook-lever 1, limb 2, normal contact 9, line relay 4 to ground, said relay attracting its armatures and locking itself through alternate contact 7, normal contact 11, relay 17 of master-switch-mechanism BB to battery B. Attracted armature 6 places ground upon the private multiples 13 at the connectors, rendering line A busy against incoming calls. Armature 5 energizes the group relay 16 by grounding the common conductor 16^a which has a branch to all the line relays 4 of the lines of the sub-group among which A is included. The attracted armature of relay 16 removes ground from the second set of multiple group-contacts 34 to render the group selectable by the group private wiper 33. Attracted armature 5 also removes ground from the multiple private contact 28, 28′ of the line of A at the line selectors to render the same selectable by the private wiper 27.

Each pair of switches CD, serving the one hundred lines among which A is included, have their respective contacts 22, for switch D, and 24 for switch C, and the contact 26 at the master-switch mechanism BB, the wipers 21, 23, 25, being arranged to successively engage the contact sets 22, 24, 26 of the different switch pairs CD.

No mechanical illustration of the master-switch is considered necessary for an understanding of the case, the said switch being preferably a rotary device having the wipers 21, 23, 25, mounted upon a rotary shaft driven by a magnet M, travel being always in the same direction.

The wipers 21, 23, 25, normally rest engaging contacts 22, 24, 26, of an idle switch pair CD, their control being hereafter de-

scribed. By the energization of the relay 17, effected by current transmitted over the common conductor 17ª, (which has a branch to each armature 7 of the line relays 4 of the one-hundred-line group of lines among which A is included), the armatures 18 and 19 were attracted to close circuits from ground through armature 20, said armatures 18 and 19, contacts 21—22 and 23—24, respectively.

The grounding of contact 24 energizes primary relay PR whose attracted upper armature causes actuations of primary magnet PM by current from generator G, said magnet stepping the wipers 33, 31, 29, 27, on their primary movements. The lower armature of relay PR connected the relay's winding from battery B to the group private wiper 33, said wiper engaging successive contacts 34 and establishing successive locking circuits for relay PR to ground at armatures of relays 16 until said wiper 33 engages a contact 34, whose group relay 16 has been energized by the initiation of a call over one of the lines of its sub-group. When this occurs, (the primary off-normal switch springs PO having been shifted on the first primary step of switch C) the locking-circuit through PR is broken, the relay deënergized, and the actuations of magnet PM cease on the retraction of the armatures of relay PR. Wiper 33 thus stops, engaging the ungrounded group contact 34, wipers 27, 29, 31, being then opposite a group or section of contacts 28, 30, 32, including those of the calling line A.

When relay PR is deënergized, its upper contact connects ground through the shifted primary off-normal spring PO, secondary off-normal contact SO with the winding of secondary relay SR and battery B, energizing said relay SR, which attracts its armature whereof 41 connects generator G through secondary magnet SM and normal contact 37 with ground, said magnet SM being successively actuated while relay SR continues energized to step the wipers 27, 29, 31, up over the line contact sets of the selected sub-group. Armature 40 of relay SR connects the relay's winding through normal contact of magnet RM with the private wiper 27, which wiper moves over the contacts 28 of the different lines, the contacts of non-calling lines being grounded through armatures 10 and 5 of their respective line circuits. Thus successive locking circuits for relay SR will be established holding it energized until wiper 27 engages contact 28 of the calling line A which contact will be ungrounded because of the attraction of armature 5 of line relay 4. Secondary off-normal spring SO being shifted with the first secondary step of switch C, relay SR will be deënergized when wiper 27 engages the ungrounded contact, its armatures retracted and the circuit of magnet SM opened whereby the wipers 27, 29, 31, rest engaging the contacts 28, 30, 32, of the line of A.

The grounding of contact 22, before described, extends ground over conductor 50 through normal contact PO′, primary relay PR′ of trunk selector D to battery, energizing said relay PR′ which, by its left armature, causes magnet PM′ to effect primary steps of wipers 52, 54, 56, 58, under the influence of generator G, and by its right armature, connects the winding of said relay PR′ with the group private wiper 58. PO^2 is a primary off-normal switch on the first selector F connected to the operator's circuit E, PO^3 and PO^4 being primary off-normal switches on other first selectors F of operators' circuits E, having their contacts in the same sub-group as that circuit shown at E. Thus it will be seen that when all the first selectors F have been moved off-normal, the group contact 59 of that sub-group will be grounded through the successive primary off-normal springs PO^2, PO^3, PO^4, etc., of the link selectors of the link-circuits of the sub-group. In this connection, it should be observed that branch circuits connecting the successive springs PO^2, PO^3, etc., are provided through the armatures 70 of the secondary relays SR^2, of the operators' circuits E, and as these relays SR^2 are held energized from the time a circuit E is selected by a switch D until the first selector F is moved off-normal, the electrical condition of the group contact 59 has protection from the moment of selection. It is also apparent that unless all the first selectors F of the sub-group are off-normal, or the relays SR^2 of the operators' circuits E of a sub-group are energized, the group contact 59 will not be grounded, so that as long as one link-circuit E of a sub-group is idle, the sub-group contact 59 will be selectable.

In the condition shown in Fig. 1, it is assumed that the first contact 59 pertains to a sub-group of operators' circuits all of which are busy, the said contract 59 being therefore grounded, while the second contact 59, shown in connection with primary off-normal spring PO^2, is, as shown, in its normal underground condition. Primary relay PR′, by its right-hand or locking armature, will therefore continue energized, while magnet PM′ is moving wiper 58 and also the other wipers of switch D two steps. On the second step however, when wiper 58 engages the second contact 59, the circuit of relay PR′ will be opened and the relay deënergized, its armatures falling back, the left armature closing the circuit from ground through its normal contact, shifted contact PO′, the contacts PO′ having been shifted with the first primary movement of the switch D, through the normal secondary off-normal switch contact SO^3, secondary relay

SR′ to battery B^2, energizing relay SR′ which, by armature 47, completes a circuit for generator G through secondary magnet SM′ to ground. Said magnet SM′, responsive to impulses received, now steps the wipers 52, 54, 56, step-by-step up over the contact sets 53, 55, 57, of the selected subgroup of the operators' circuits E, and as contacts 53, of busy circuits will be grounded, as hereafter explained, relay SR′ will continue energized (thus keeping closed the circiut of secondary magnet SM′) over successive locking-circuits extending from battery B^2, relay SR′, attracted armature 45, wiper 52, and successive grounded contacts 53 until the said wiper 52 reaches an ungrounded contact assumed to be that operator's circuit E shown in Fig. 1. Such contact 53 will be ungrounded as an inspection of Fig. 1 will show, relay SR′ will be deënergized and its armatures will fall back whereof 47 opens the circuit of magnet SM′ preventing the further stepping of the wipers 52, 54, 56, which thus remain engaging the respective contacts 53, 55, 57, of the operator's circuit E shown in Fig. 1.

The secondary off-normal springs SO and SO′ of switch C were shifted on the first secondary movement of said switch and the springs SO^2 and SO^3 of switch D were shifted on the first secondary movement of switch D. Thus, as soon as the two switches C and D have completed their selection, and relays SR and SR′ are accordingly deënergized, a circuit will be completed as follows: from ground through normal contact 37 at switch C, through normal contact 41, contacts SO′, SO^2, now closed, normal contact 46, and over conductor 51 to contact 26 of the swhich pair CD at master-switch BB, through wiper 25, relay R, to battery B, energizing relay R which attracts its armature 20 to complete a circuit including generator G, and magnet M of master-switch BB, which magnet now receives impulses causing it to step wipers 21, 23, 25, step-by-step in a rotary direction over the contacts 22, 24, 26. The contacts 26 pertaining to busy switch pairs will be grounded through circuits of their respective switch pairs similar to that just described, wherefore, relay R will have succesive energizing circuits completed maintaining it energized, and the circuit of magnet M closed, until wiper 25 encounters a contact 26 pertaining to an idle switch pair which will be ungrounded as shown in Fig. 1. Thereon, relay R is deënergized, magnet M has its circuit opened, and the wipers 25, 23, 21, remain engaging the contacts respectively, 26, 24, 22, of the idle switch pair ready to start said pair as soon as a new call is initiated over a line of the line group served by master-switch BB.

The two switches CD having completed their selections, a circuit for energizing the cut-off relay 8 of line A is now first completed extending from battery B through said relay 8, through contact 30—29, over the heavy marked conductor, through armature 43, contact 54—55, contact 62, the normal contact at 79, relay PR^2 to battery B^3, energizing said relay PR^2 and relay 8. The latter, by attracting armature 10, opens the original energizing circuit and completes a locking-circuit extending through contact 28—27, and to ground through normal contact 40. Attracted armature 11 of relay 8 opened the circuit of, and deënergized relays 4 and 17, armature 12 opened the normal battery connection to line limb 3, and armature 9, connected line limb 2 to the talking conductor connected to contact 30. It will be observed that contact 13 at the connectors has a ground maintained upon it over a branch of the maintaining circuit of relay 8 which extends through normal contact 6 of relay 4 and attracted armature 10 to ground at armature 40. Relay 16 is deenergized on the retraction of armature 5.

As soon as relay 8 attracts its armatures, a circuit is completed as follows: from battery B^3, relay PR^2, through normal contact at 79, normal contact 62, contact 55—54, over the upper talking conductor to line limb 2, (contact 9 having been closed in time to prevent the deënergization of relay PR^2 already energized, as before described) over the line limb 2, raised hook-lever 1, returning over line limb 3, the lower talking conductor, through contact 56—57, normal contact 65, normal contact at 80, relay SR^2 to battery B^4, whereby relays PR^2 and SR^2 are simultaneously energized to attract their armatures.

It should be observed that, had switch D completed the selection of an idle operator's circuit E during the period when switch C was performing its secondary travel, relays PR^2 and SR^2 would have been energized over a circuit extending from the upper talking conductor at switch C through alternate contact 39, normal contact 38, alternate contact 42, returning over the lower talking conductor. Owing to the make-before-break arrangement of armature contacts 39 and 42 effective on both their attractive and retractive movements, relays PR^2 and SR^2 would, upon the completion of selection of switch C, under the conditions just assumed, not be deënergized because, on the deënergization of relay SR of switch C, the before traced energizing circuit for the relays extending over the line limbs 2—3, would be completed when armatures 39—42 were retracted before the relays PR^2 and SR^2 could be deënergized.

Relays PR^2 and SR^2 having been energized as soon as the switch D completed its selection whether switch C has completed its

selection or not, a ground will have been placed upon the multiple contacts 53 of the selected operator's circuit E as soon as it has selected which ground will render the circuit busy. When relays PR^2 and SR^2 are energized, they are not again simultaneously deënergized until the restoration to normal of switches is to be effected and the ground upon multiple contact 53 will exist through attracted armature 67 when relay PR^2 is energized, or through retracted armature 67 and attracted armature 71 when relay PR^2 is deënergized and SR^2 is energized. A further ground may be traced through wiper 52 engaging busy contact 53, normal contact 45, and relay RR′ to ground, the previously described ground however, serving as a short-circuit about the winding of RR′.

The relay 49 is provided, arranged (as for instance, by a copper shell disposed about its core) to be quite slow in allowing the retraction of its armature, which relay 49 has energized, while switch D was performing its secondary steps through attracted armature 44, thus holding open a contact in the circuit of release relay RR′; which circuit extends through normal contact 45, and contact 52—53, normal contacts 67—71, relay RR^2 to battery, for the purpose of energizing the said relay RR′, which is a release relay, when its operation is desired. The slowness of the deënergization of relay 49 prevents, when selection is made, premature closing of the above-mentioned circuit by holding the said circuit open at the armature switch of relay 49 until relays PR^2 and SR^2 have had time to be energized over their previously described energizing circuits.

When relays PR^2 and SR^2 were energized, circuit was completed from ground through attracted armatures 72—68, primary off-normal spring PO^{77}, call signal lamp 90 to battery, the lamp glowing and advising the operator that a call has come in over the circuit E. The operator now actuates levers 92—93 to connect her talking set in circuit with the calling substation A, the said talking set being thus bridged across the upper and lower talking conductors of circuit E, and learns the number of the subscriber with whom subscriber A desires to converse. This being assumed to be 3333, the operator will actuate the buttons of the springs b^3, c^3, d^3, e^3, in Fig. 1, Part 4, and the switch E′ will then transmit sets of impulses as before described. In the present case, the spring a^3 is not actuated by the operator as the system now being described is a system employing four digits to a subscriber's number only. Each set of impulses coming over conductor 94 will cause three energizations of relay 60 and each impulse coming over conductor 95, at the conclusion of an impulse set sent over the conductor 94, will cause the energization of relay 63. Armatures 61 and 64 of said relays have make-before-break arrangements of contact springs on both their attractions and retractions.

The first set of three impulses transmitted energizes relay 60 three times, which relay, by actuating its armature 61, opens and closes three times the circuit of relay PR^2, causing it to be deënergized and then energized a corresponding number of times. Relay SR^2, however, continues energized while relay PR^2 is being operated, as described, by current through normal contact 65, the shifted off-normal contact 66, before described as associated with E′, to ground at 61 when 61 is attracted, and to ground through relay PR^2 and battery B^3 when 61 is retracted. When an impulse comes over conductor 95, the resulting energization of relay 63 causing it to attract and retract armature 64, thus deënergizing relay SR^2 by opening its circuit at contact 65. This does not however, deënergize relay PR^2 since circuit is completed therefore through normal contact 62, contact 66, contact 65—64, while relay 63 is energized. Spring 65 closes the circuit including PR^2 and SR^2 and contact 66 before contact 64—65 is broken on the deënergization of relay 63. It will be seen that while the switching device E′ is transmitting these impulses, the closure of contact 66 has short-circuited the energizing circuit for relay PR^2 and SR^2 previously described, as extending over the line of A whereby there will be no impulse noises noticeable in the subscriber's telephone receiver at the substation.

Each of the three deënergizations of the relay PR^2 causes a current impulse from ground through attracted armature 72, normal contact 68, primary magnet PM^2 to battery B^2, said magnet then effecting three primary movements of switch wipers 96, 97, 98, bringing them adjacent to a group of terminals 130, 131, 132, of hundreds selectors H assigned for connection to the third thousands group of lines including those numbered from 3,000 to 3,999 inclusive.

The first primary step of switch F shifts spring PO^{77} to put out lamp 90 and spring PO^7 to display supervisory signal 91 which will remain lighted until the called subscriber answers. Spring PO^2 is also shifted to the end hereinbefore described, and spring PO^6 is also shifted for purposes to be hereafter specified.

The deënergization of relay SR^2 produced by energized relay 63 following the three deënergizations of relay PR^2, causes a current flow as follows: from ground through attracted armature 69, normal contact 73, secondary normal contact SO^4, primary off-normal contact PO^5, heretofore shifted, busy relay BR^2 to battery B^2, which energizes said relay BR^2 whose attracted arma-

ture 88 completes a circuit including generator G and secondary magnet SM^2, which magnet is actuated by successive impulses as long as relay BR^2 remains energized, stepping wipers 96, 97, 98, step-by-step over the contact sets 130, 131, 132, of the selected group. Relay BR^2, by armature 87, has established a locking-circuit for itself extending through normal contact 84, normal contact of armature switch of release magnet RM^2 and wiper 96 to successive busy contacts 130, engaged by said wiper 96, contacts 130 of the busy hundreds selectors being characterized by a ground connection placed on them in a manner hereafter specified. Thus, relay BR^2 will continue energized until wiper 96 engages an ungrounded contact 130 when the absence of ground will deënergize relay BR^2, its armatures will be retracted and the further actuations of magnet SM^2 prevented, whereby wipers 96, 97, 98, will remain engaging the contacts of the selected idle hundreds selector of the third thousands group. It will be observed that the wipers 97, 98, are on open circuit at armatures 86, 89 during the secondary movements of the switch, so that interference with existing conversations will be prevented. As soon as relay BR^2 was deënergized, its armature 87, by engaging its normal contact, grounded the wiper 96, which being in engagement with contact 130 of hundreds selector H, renders the multiples of said contact at other thousands selectors F busy against such selectors seeking connection with them.

The next three deënergizations of relay PR^2 cause current impulses to be transmitted from ground through attracted armature 72, normal contact 68, normal contact 86, contact 97—131, contact SO^6, primary magnet PM^3 to battery B^5, causing three energizations of magnet PM^3 and three primary steps of the wipers 140, 141, 142 to select the group of contacts 143, 144, 145, forming terminals of the connectors I assigned to the third hundreds group of the third thousands group including lines 3300 to 3399. The subsequent single deënergization of relay SR^2 transmitted a current impulse from ground through attracted armature 69, normal contact 73, contacts 89, 98–132, SO^7, shifted primary off-normal spring PO^8, busy relay BR^3 to battery B^5. Relay BR^3 attracts its armature 138 to close a circuit including generator G and secondary magnet SM^3, which steps the wipers 140, 141, 142, over the contacts of the selected group as long as relay BR^3 is maintained locked by successive energizing circuits extending from battery through said relay BR^3, attracted armature 137, wiper 140 to ground at successive private contacts 143 of connectors I of the group, contacts 143 of busy connectors having ground upon them as hereafter explained. When an idle, that is an ungrounded contact 143 is reached, circuit through relay BR^3 is opened, the relay deënergized, and further operation of the magnet SM^3 prevented, wipers 140, 141, 142, remaining in engaging contacts 143, 144, 145, of the selected idle connector. It is understood, of course, that all primary off-normal PO contact springs and all secondary off-normal SO contact springs of the second selector H were shifted on the first primary and secondary steps of such switch respectively. Armature 138 falling back grounds wiper 140 and the engaged contact 143 rendering its multiples busy.

The next three deënergizations of relay PR^2 transmit three current impulses, as before described, through contact 97—131, normal contact 136, contact 141—144, normal contact SO^9, primary magnet PM^4 to battery B^5, energizing said magnet PM^4 three times, which steps the wipers 165, 166, 167, around opposite the sub-group of contact sets forming terminal of lines numbered from 3331 to 3339 inclusive, followed by terminal of lines 3330, zero being represented by ten impulses in automatic telephone practice. A single impulse transmitted by the subsequent deënergizing of relay SR^2 passes through contact 98—132, contact 139, contact 142—145, normal contact SO^{10}, shifted spring PO^{12}, secondary magnet SM^4 to battery, energizing said magnet which causes a step of the wipers 165, 166, 167, to a position one step from the edge of the contact bank, it being understood that in a connector, the position of the switch wipers during primary adjustment is two steps distant from the edge of the bank. This first actuation of magnet SM^4 causes spring SO^9 to engage its alternate contact, and spring SO^{10} to leave its normal contact, the latter spring however, not being shifted sufficiently to engage its alternate contact.

The fourth and final three deënergizations of relay PR^2 transmit three impulses through contact 97—131, 141—144, alternate contact SO^9, contact 147, secondary magnet SM^4 to battery, causing three secondary steps of the wipers 165, 166, 167, to engage the third contact sets 13, 14, 15, of the selected group, which are terminals of line 3333 or that of subscriber K. The secondary impulse produced upon the deënergization of relay SR^2, following the three primary impulses, will pass through contacts 98—132, 142—145, alternate contact SO^{10} (contact SO^{10} engaging its alternate contact on the second secondary step of switch I) through contact 150, lower winding of test relay TR to battery B^5, energizing said relay. Assuming, first, that the called line is idle, in which case its multiple contact 13 will be connected to battery, as shown at L, through cut-off relay 8 and will have no

operative earth connection; relay TR will, on the cessation of the impulse initially energizing it, have both ends of its upper winding, by the attraction of armature 156, connected with the active side of battery B^5 so that the relay TR will become deënergized. When said relay became energized, however, the attraction of its lower armature energized the relay 146 over a circuit which may be traced from the upper grounded armature of relay RR^4, its contact, and through the lower armature of relay TR to battery through relay 146, the armature 149 now locking relay 146 to ground at armature of relay RR^4. When, now, relay TR is deënergized, a circuit is completed from ground through relay 152, attracted armature 148, normal contact 156, contact 165—13, armature 6 of relay 4, relay 8 to battery, relay 8 being then energized to attract armature 10 and connect the ground through contact 165—13 to the multiple private contacts 28 of the line circuit of the line of K, continuing them busy to line selectors that may be started. The energization of relay 152, as described, by armature 154 connects interrupter I through contact 160 to the winding of relay 157 and battery, said interrupter I now alternately energizing and deënergizing the relay 157 whereby the ringing current from generator G is applied to the called-for line periodically, passing through contact 166—14, over limb 2, the call-bell and condenser at the substation K returning over limb 3 through contact 15—167, through lower attracted armature of relay 152 and the inductive resistance 168 to ground through battery B^5, whereby the bell at substation K is rung and the subscriber notified that his attention is desired.

When subscriber K answers and removes his receiver from the hook-lever, a conductive bridge of limbs 2 and 3 is completed, whereby current is permitted to flow, as soon as the armature of relay 157 is retracted, from ground through relay 151, attracted armature 153, said armature of 157, contact 166—14 over limb 2, returning over limb 3, through contact 15—167, resistance 168 to battery B^5, energizing relay 151 whose armatures are simultaneously attracted. The upper armature, by engaging its contact, completes a circuit from ground through relay 158 to battery B^5, said relay 158 then locking itself to ground through armature 161 and the upper armature of relay RR^4. Armatures 159 and 164 close contact in the talking circuit of a connector, while armature 160 prevents further operation of relay 157 and armature 162 places an additional ground through primary off-normal contact PO^{10} upon the multiple contact 143 to hold the connector I busy in case switch H should by means independent of the called subscriber, be disconnected from the connector I, the release of said connector being solely controlled by the subscriber K after he has answered the call.

By the attraction of armature 164, a branch of the described circuit extending from ground through relay 151, is completed, which branch extends through attracted armature 164, contacts 145—142, 132—98, alternate contact 73, relay 77 to battery B^2, thus energizing said relay 77 whose upper armature completes an energizing circuit for relay 76, which relay, by armature 78, locks itself to ground at shifted contact PO^7. By make-before-break armatures 79 and 80, the connections of relays PR^2 and SR^2 to the limbs of the line of subscriber A are reversed, thus rendering the system available in connection with polarized register or coin control mechanisms of characters known in the art.

Subscribers A and K are now in conversation, the talking circuit being indicated throughout the drawings by the heavily marked conductors; the transmitter of A being supplied by current from battery B^3 through relay PR^2, alternate contact 80, over limb 3, through impedance coil and transmitter at the substation, returning over limb 2, alternate contact 79 and to battery through relay SR^2; while battery is supplied to the transmitter of subscriber K through an inductive resistance 168, lower attracted armature of relay 152, over limb 3, through impedance coil and transmitter at the substation, returning over limb 2, armature of relay 157, contact 153, relay 151 to ground.

It will be noted that the before described circuit causing lamp 91 to glow, continued uninterrupted until, on the response of the called subscriber, armature 78 was attracted; through conversation, the lamp will, of course, not glow because relay 76 is energized.

When the subscribers replace their receivers at the conclusion of conversation, this act on the part of subscriber K restores to normal the connector I only, while the act of subscriber A restores to normal switches C, D, F and H.

Assuming that subscriber K first replaces his receiver resulting in deënergization of relay 151, said relay, by its lower armature, closes a circuit from battery B^5 through attracted armature 163, relay RR^4 to ground, which relay, by attracting its upper armature, energizes release magnet RM^4, which thereupon disengages the retaining pawls of the switch shafts, and the switch I is automatically restored both as to its wipers and as to its primary off-normal (PO) and secondary (SO) switch contacts, when all apparatus of the connector will be in its original position. When subscriber A replaces his receiver, relays PR^2 and SR^2 will, for the first time, be simultaneously deëner-

gized since the operator's circuit E was selected. Current will then flow from ground at switch B, through the lower winding of relay RR′, armature contact of relay 49, normal contact 45, armature of magnet RM′, contact 52—53, normal contacts 67, 71, through release relay RR^2 of switch F to battery B^2. Relay RR^2 being energized, by its armature 82^a locks itself to ground at contact PO^6. The armature 82 completes an energizing circuit for busy relay BR^2 extending through contact PO^5 to the end that said relay may be energized and wipers 97, 98, may be on open circuit while the switch is restoring. Current now flows from grounded armature 88, through its opposed contact, through alternate contact 85, release magnet RM^2 to battery, energizing said release magnet to cause the restoration of switch F. But before said magnet attracts its armature, a current impulse will have passed from battery B^2 through attracted armature 84, armature of magnet RM^2, contact 96—130, contact PO^9, relay RR^3 at switch H to ground energizing said relay RR^3 which locks itself by armature at 133 through contact PO^8 and relay BR^3 to battery B^5, thus causing the relay BR^3 to be also energized. Said relay places wipers 141, 142, on open circuit, and by attracting armature 138, completes a circuit from ground through said armature and its alternate contact, armature 134 and its alternate contact, release magnet RM^3 to battery, energizing said magnet which causes the restoration to normal of switch H, both as to its wipers and as to its primary and off-normal switch springs.

Returning now to switch D, the energization of release relay RR′ closes a circuit from ground through the lower armature of said relay, through alternate contact SO^3, secondary relay SR′ to battery, which relay SR′ is energized in order that wipers 54, 56 may be on open circuit while switch D is restoring, which the switch now does because release magnet RM′ is energized by current from battery B^2 flowing through attracted upper armature of relay RR′, there joining current already flowing through the upper or locking winding of said relay to ground through primary off-normal contact PO′ and the armature of relay PR′.

When relay RR′ was energized, its lower armature also closed a circuit from ground over conductor 35, through the lower winding of release relay RR to battery B, which relay is thereupon energized, and by its armature 37, causes the energization of secondary relay SR, while its upper armature 36, in addition to locking the relay RR, completes an energizing circuit for release magnet RM extending from ground through primary off-normal contact PO and its alternate contact and the upper armature of relay PR. On the energization of release magnet RM, the switch C is restored to normal both as to its wipers and its primary and secondary off-normal springs, when all its apparatus will be in its normal idle condition.

While switch C is being restored, ground is maintained upon grounded contact 26 at the master switch by a circuit extending from alternate contact of release magnet RM, attracted armature 40, and shifted contact SO and attracted armature 37. Similarly, while switch D was being restored, ground was maintained upon said contact 26 over a circuit extending through attracted armature 45, contact SO^3 and its alternate contact, and attracted lower armature of release relay RR′, so that until both switches of the pair CD are restored, and the mechanism thus made ready for use in putting through an additional call, the contact 26 pertaining to the switch pairs will test busy to wiper 25 of master switch BB.

When the wipers of switch I disengage the contacts of the line K, circuit through the cut-off relay 8 was opened and the line circuit restored to its normal condition. Similarly, when the wipers of switch C leave the contacts of the line of A, cut-off relay 8 was deënergized and the circuit of the line restored to its normal position.

Let it be assumed that subscriber K had failed to answer the call. In such case, relay 158 would not have been energized. Thus when in consequence of the replacing of the receiver at substation A, relay RR^3 at switch H operated, circuit would be completed from battery B^5 extending through attracted armature 135, normal contact of armature of magnet RM^3 before said magnet attracted its armature, through contact 140, 143, shifted spring PO^{10}, normal contact 162 and through release relay RR^4 to ground, energizing the said relay RR^4, which would then as before, cause the restoration of the connector I. Thus, until the called subscriber answers, the calling subscriber controls the release of the connector I as well as all the other switches.

It will be thus seen that the work of the operator consists merely in learning the number of the called subscriber wanted and connecting out that number upon a keyboard corresponding to the lamp upon which the call came in, and thereafter the entire operation of the system, including the ringing up of the called-for subscriber and the restoration of all apparatus to normal, is accomplished entirely without requiring any attention from the operator whatever.

If it be assumed that the called-for line was busy at the time the connector I had its wipers applied to the contacts of said line and its relay TR was energized by the last

secondary impulse, then the multiple contact 13 of the called-for line would have had a ground connection placed there, in case the line was busy because it was a calling line, over a connection extending (see Fig. 1, Part 1) through normal contact 6, alternate contact 10, contact 28—27 to ground through normal contact 40; or, if the line of K were busy as a called-for line, said contact 13 would be grounded over a circuit extending through wiper 165 of some other connector already engaging a multiple of said contact 13, through normal contact 156 of said connector, through its closed contact 148, and its relay 152 to ground. In either case of the called-for line of K being busy, relay TR, when once energized, would have continued energized over a circuit extending from battery B^5 through the upper winding of said relay TR, its attracted armature 156, the wiper 165, and the grounded multiple contact 13 of the called-for line. Since the relay TR would thus be locked, the interrupter I', by the attraction of armature 155, would be maintained connected operatively with the calling line over a circuit extending through said attracted armature 155, contacts 144—141, 131—97, through condenser 74, contact 55—54, 29—30, alternate contact 9, over limb 2, through the receiver giving the customary busy tone, returning through contacts 32—31, 56—57, and to ground through normal contact at 80, secondary relay SR^2 and battery B^4. Hearing the busy signal, subscriber A will replace his receiver and the entire switch mechanism, including connector I, will be automatically restored to normal, in the manner hereinbefore indicated.

The mechanism, shown in Fig. 2, shows means by which the system of my invention may be employed in connection with two exchanges located at a distance from each other, while requiring but two conductor trunks to secure the proper operation of the system.

The said Fig. 2 is to be placed intermediate of Fig. 1, Part 2, and Fig. 1, Part 3, in the consideration of the trunking features, and the additional selector N being introduced into the system, a system employing five digits for subscribers' numbers will be produced, there being then the first or ten thousands selector F to select the ten thousands group, the second or thousands selector N to select the thousands group, the third or hundreds selector H to select the hundreds group, and the connector I operating in the usual manner to select tens and units.

Said Fig. 2 being interpolated as mentioned, T, T' are the trunking conductors extending from an exchange in which the operator's circuit E is located to a distant exchange in which now the second selector N, third selector H and connector I are supposed to be located. At M, is shown a so-called repeater circuit and at N, the circuit of a trunking second selector.

When the trunking mechanism of Fig. 2 is used, one level of multiple contacts at the first selectors F will be assigned for connections to the lines in the distant exchange. If it be assumed that the distant exchange is a ten thousand line exchange, such as that already described as illustrated in Fig. 1, then for example, the fourth levels of the first selectors at the first exchange may have connected to them multiple contacts 201, 202, 203 (Fig. 2) of two-wire trunk circuits T, T', with the mechanism provided in Fig. 2 accompanying each such trunk circuit. If the fourth levels of the first selectors are assigned for such purpose, it is apparent that the directory numbers 4,000 to 4,999 inclusive in the first exchange must fall away so that the said first exchange would be available in fact but for nine thousand subscribers' lines. In order to provide a sufficiently great number of trunks for the trunking connections to be expected between the two exchanges, the multiple terminals 201, 202, 203, may, of course, be multiplied but a relatively small number of times before the wipers 96, 97, 98, of the various first selectors as compared with the number of times the terminals 130, 131, 132, of the local exchange second selectors would be multiplied.

It is for trunking uses that the buttons 129 in Fig. 1, Part 4, are provided as five sets of digit impulses will be used in trunking connections. In this connection I contemplate, where a number of ten thousand line exchanges are to be interconnected differentially, naming the various exchanges in the usual manner and giving to the impulse buttons 129 that are used for trunking purposes names according to the exchanges. If this method of assigning directory numbers is pursued, one of the buttons 129 may be assigned by the name local to the exchange in which the operator employing it works. In such case, a subscriber calling for his own exchange would, in the usual manner, give the prefix and number of the subscriber wanted and the operator might be allowed to actuate the full number of five buttons, but in such case the button 129 of her own exchange would have its spring *a* unprovided with means for causing it to be connected to ground when actuated by the associated button for the reason of course that but four digit set of impulses would be required to complete the connection desired. All distant exchange buttons 129 however, would have their springs *a* provided with grounded opposed contacts.

It is thus seen that for local purposes, the system operates as a ten thousand line

system, whereas when trunking between distant exchanges is required, the trunk calls may go through what is practically a one hundred thousand line system. As far as I am aware, such a system as that above specified wherein a selector such as F, in certain cases of its employment, is operated as a thousands selector, and in other cases of employment, is used as a ten thousands selector, is novel and I shall claim this structure broadly.

To illustrate the employment of the structure shown in Fig. 2, let it be assumed that the calling subscriber A calls for the subscriber K whose number will be now assumed to be 43333, or if the subscribers are to be listed according to exchange names, the forty thousands may, for example, be called "Main" in which case the number of subscriber K would be "Main 3333." In such case the calling subscriber A, by removing his receiver, would be connected with the operator's circuit E and give his order in the manner before described, the operator then actuating the proper button 129 to close contact a^4, and buttons 128, 127, 126, 125, to close contacts b^3, c^3, d^3, and e^3 whereon the automatic impulse transmitter of Fig. 1, Part 4, will proceed to transmit impulses as follows: 4, 3, 3, 3, 3, and relays 60 and 63 will operate upon relays PR^2 and SR^2 as hereinbefore explained. Four deenergizations of relay PR^2 will first be effected which will operate upon magnet PM^2 to cause primary movements of wipers 96, 97, 98, to select the fourth group of contact sets which will comprise multiple contacts 201, 202, 203, terminals of trunk circuits T, T'. The single deënergization of relay SR^2 thereon follows, and will cause the selector F, by its wipers 96, 97, 98, to select the first idle contacts 201, 202, 203 in a manner which will be understood from the preceding description.

Thereafter, three deënergizations of relay PR^2 will occur whereby three impulses of current will be transmitted from ground through attracted armature 72, retracted amarture 68, contact 86, contact 97—202, contact 205, relay PR^6 to battery, energizing and deënergizing said relay three times. With the first energization, armature 245 energizes release relay RR^5 which locks itself from battery B^6 through armature 244 and contact 201—96 to ground through normal contacts 84 and 87. Each energization of relay PR^6 attracts its right-had armature to transmit an impulse of current from ground over trunk conductor T, through contact 241, 235, relay PR^5 to battery B^7 in the distant exchange, which relay PR^5, by its armature 247 transmits three impulses through contacts 227, SO^{11}, primary magnet PM^5 to battery B^7, energizing said magnet PM^5 three times, which steps the wipers 220, 221, 222 of the thousands selectors N in the distant exchange three primary steps to select a group of hundreds selectors H assigned to the third thousands group of the distant exchange. Primary off-normal contacts PO^{13}, PO^{14}, PO^{15}, are shifted on the first primary movement of selector N. The deënergization of relay SR^2 following the last deënergization of relay PR^2 transmits a current impulse from ground through attracted armature 69, normal contact 73, contacts 89, 98—203, normal contact 209, secondary relay SR^6 to battery B^6, said relay attracting and releasing its armature to transmit a current impulse from ground over truck conductor T', normal contact 242, secondary relay SR^5 to battery B^7 which relay attracts and releases its armature 248 to transmit a current impulse from ground through closed contact PO^{14}, contact SO^{12}, busy relay BR^5 to battery B^7, said relay then attracting its armatures 223, 226, to place wipers 221, 222, on open circuit, armature 225 to complete a circuit for generator G and secondary magnet SM^5, while armature 224 connects relay BR^5 through normal contact 230 and armature of magnet RM^5 with wiper 220, which wiper will engage successive contacts 130 of hundreds selectors H, establishing successive locking-circuits for relay BR^5 until an idle or ungrounded contact 130 is reached, when relay BR^5 will be deënergized and its armatures retracted, armature 225 preventing further actuations of magnet SM^5, while armature 224 places a busy ground potential upon wiper 226 and the multiple contacts 130 of the selected hundreds selectors H.

The next set of three impulses deënergizes and energizes relay PR^2 three times whereon relays PR^6 and PR^5 will be energized and deënergized three times, relay PR^5 transmitting three impulses from ground through armature 247 through contact 223, contact 221—131, magnet PM^3 to battery B^5 operating hundreds selectors H in precisely the same manner as described in connection with the first system diagram.

The deënergization of relay SR^2 following the three deënergizations of relay PR^2 will result in the energization and deënergization of relays SR^6 and SR^5 as before described, relay SR^5 now transmitting a current impulse from ground through armature 248, contact 226, contact 222—132, contact SO^7, contact PO^8 now closed, relay BR^3 to battery B^5. This will cause the hundreds selector H to select the first idle connecter of the group.

It will be apparent that the succeeding impulse sets transmitted from E' will result in the transmission of impulses through contacts 131—132, operating the selected con-

nector I in the same manner as that before described in connection with the first system including Fig. 1 only, to make connection with and test the line of the called-for subscriber K.

Assuming this line to be idle, the ringing of the called subscriber will proceed in the same manner as that before described. When the called subscriber answers the call, current will find its way from ground through relay 151, armature 153, over the calling line L, returning through contact 15—167 as before described, attracted armature 164, contacts 145—142, 139, 132—222, 226, normal contact 248, relay 240 to battery B^7, energizing said relay 240. Armatures 241—242 complete a circuit for current from battery B^5, impedance coil 168 at I, through attracted armature 164 to the left over the lower talking conductor T through alternate contact 242, there joining current from battery B^7 through relay 240 and contact 248, normal contact of relay SR^6 through the polarized relay 218, said current flowing in a direction to tilt the armature of said relay 218 to the right, thence through contact 210, through armature of relay PR^6, trunk conductor T, alternate contact 241, relay 239^a to ground. The actuation of relay 218 energizes relay 204 which attracts its armatures and locks itself by armature 207 to ground through wiper 201, while armature 210 opened the circuit of relay 218 causing its deënergization. Before the now energized relay 239^a has time to be deënergized, armature 209 engages its opposed contact whereby circuit through relay 239^a is closed from ground through said relay, alternate contact 241, over trunk conductor T, alternate contact 209, contact 203—98, alternate contact 73, relay 77, to battery whereon relay 77 is energized and is effective to produce the circuit changes at operator's circuit E, before described, whereby the connections of battery B^3 and B^4 to the limbs of the calling line are reversed. Armature 205 of relay 204 completes the talking circuit of trunk conductor T. Upon the energization of relay 239^a, the relay 233 was operated by the attraction of armature 238, which relay by the armature 236 locks itself to ground at the now closed contact PO^{13}, armature 234, closing a normally open contact in the upper heavily marked talking conductor.

It will be seen that primary relay PR^5 has now had its winding disconnected from the trunk conductor T at contacts 241 and 235, while relay SR^5 has had its winding disconnected from trunk conductor T′ at contact 242.

The two subscribers A and K are now in conversation, their transmitters receiving current as described in connection with the first circuit diagram, the intermediate talking link including the trunk conductors T, T′, and the condenser 232^a being readily traceable by the heavily marked lines.

When the subscribers have finished their conversation, the replacing of his receiver by subscriber K causes the restoration of the connector I in the manner before described.

Assuming now that the called line was busy when a connector I connected therewith, the busy interrupter I′ would be connected with the calling line over a circuit as follows: through alternate contact 155, through contacts 144, 141, 131—221, through condensers 232, 232^a, and 217, contacts 202—97, condenser 74 and over the upper talking conductor through substation A and returning through normal contact 80, relay SR^2 to battery B^4. The calling subscriber A knowing that the line wanted was busy would replace his receiver. The release, under these circumstances, would, however, proceed in a manner different from that before described, the release operations being the same as those to be now described under the assumption that the called subscriber failed to respond.

The restoration of the connector I does not, however, in any way affect the relays of the selector N, since relay 240 will remain operated by current through contact 248 and over trunk conductor T′.

When, however, the calling subscriber replaces his receiver, the switches C, D and F are restored to normal in a manner already described. The resulting opening of contact 97—202 deënergizes the relay 239^a, by whose retracted armature 239 circuit is closed from battery B^7, through said armature, attracted armature 237, the release relay 231 to ground, which relay, by armature 228, locks itself through primary off-normal contact PO^{15} and busy relay BR^5 to battery. The energizations of relays 231 and BR^5 close circuit from ground through attracted armatures 225 and 229 and release magnet RM^5 to battery, which magnet withdraws the retaining pawls of switch N, whose wipers and primary and secondary off-normal contacts are restored to normal, when the entire mechanism at N will be placed in its original idle condition. When on the restoration of switch F, contact 96—201 is opened, the locking-circuits of relay RR^5 and 204 were opened and the relays restored to normal.

In the release operation of switch N, a circuit will be completed from battery B^7, alternate contact 230, closed armature contact of release magnet RM^5, contact 220—130, PO^9, relay RR^3 to ground, to energize said relay RR^3, before the attraction of the armature of magnet RM^5 occurs, so that the hundreds selector H will be restored to normal in the manner heretofore described.

If the calling subscriber A had replaced his receiver in advance of the called subscriber K, the restoration of the switches C, D, F, N, H and the mechanism at M would have proceeded in the manner just described, the mechanism of switch I remaining to be restored to normal when the called subscriber K replaced his receiver.

It is apparent that if the called subscriber K had failed to answer the call, relay 240 would have remained deënergized and consequently relays 239^a and 233, so that the releasing circuit (before traced through attracted armature 237) would not have been available when the calling subscriber replaced his receiver. In case the called subscriber fails to respond, the release is accomplished in the following manner. First, it should be observed that when relay RR^5 at the mechanism M was energized, it produced the energization of the relay 243, which relay is arranged so as to be quite sluggish in releasing its armatures when deenergized, as for instance by placing a copper shell about its core. When, in response to the replacing of the receiver at substation A, the switch F is restored, the opening of contact 96—201 will deënergize the relay RR^5, whose armatures 212—213 will be quickly retracted, closing their contacts, while armatures 214—215 of relay 243 will continue closed because said relay is locked to ground at armature of relay 216, through its left-hand armature. Current will now flow from ground, through the windings of relay 216, closed contacts 214—215 and 212—213 to limbs T and T′ of the trunk circuit, over limb T, through contacts 241—235, relay PR^5 to battery, energizing said relay, current also flowing over conductor T′, normal contact 242, secondary relay SR^5 to battery B^7. Relay 216 will be energized and its attraced armature will deënergize relay 243. Circuit may now be traced from ground through the release relay 231 of switch N, through attracted armatures 246 and 249 to battery B^7, the release of switch M now proceeding in the manner before described, switchs H and I being also restored in a manner which will be understood from the description heretofore given in connection with the system of Fig. 1 alone, a circuit for release relay RR^4 of switch I being completed from battery B^5, through attracted armature 135 at switch H, armature contact of magnet RM^3 before said magnet is energized, contacts 140—143, PO^{10}, 162, RR^4 to ground.

It is apparent, since relays RR^5 and 243 are energized as soon as a switch F connects with the mechanism M, that at any time before the call is completed by means of a connector to the called line, the calling subscriber, by replacing his receiver, will cause all switches that he has operated from normal during the process of putting up the connection, to be restored to normal.

It will be understood that the various battery symbols shown in Fig. 1, are preferably the same source of current and that this is also true of the various alternating current source symbols indicated at G in Fig. 1. When trunking between exchanges is practised, the various batteries to the right of the trunk conductors T, T′ are preferably a single source in one exchange, while those to the left of said conductors are preferably a single source in another exchange. Of course the battery B^3, as shown at E in Fig. 1, is a separate battery from the others, inasmuch as it is required that its earth connection be made at its negative terminal, rather than at its positive terminal, as in the case of the other batteries.

It will be understood that the illustrations of the circuit structure are entirely diagrammatic in character and no specific types of mechanical structures are intended to be indicated.

The system of my invention is capable of modification without departing from the substance of the invention and is not limited to the precise structures shown and described in this specification, but what I do claim and desire to secure by Letters Patent of the United States is:—

1. A telephone system including a selective switch, a group of auxiliary selective switches common for connections to a great group of subscribers' lines, a second group of auxiliary switches common for connections to a small group of subscribers' lines, and means for causing said first mentioned switch to select an idle switch of either of said groups.

2. A telephone system including subscribers' lines, a selector operable responsive to digit impulse sets, two groups of contact sets at said selector, trunk lines leading from the contact sets of one group common for connections to a group of subscribers' lines, said trunk lines requiring transmission of a plurality of sets of impulses to complete connections, trunk lines leading from the contact sets of another group common for connections to a group of subscribers' lines, said trunk lines requiring transmission of a less number of impulse sets than said first-mentioned trunk lines to complete connections, means for electrically adjusting said selector to select either group of contact sets desired, and test means for said selector enabling it to select an idle contact set of the selected group.

3. A semi-automatic telephone system including telephone lines, an operator's circuit, selective switching mechanism at the calling end of said circuit, operator's means for transmitting directive currents to said switches to extend the calling end of said

circuit to desired lines, a calling telephone line, and a pair of electrically connected step by step traveling switches between said line and the answering end of said circuit, one of said switches, serving on initiation of the call, to connect with said calling line and the other to connect with said operator's circuit.

4. A semi-automatic telephone system including telephone lines, an operator's circuit, selective switching mechanism at the calling end of said circuit, operator's means for transmitting directive currents to said switching mechanisms to extend the calling end of said circuit to desired lines, a calling telephone line, and a pair of electrically connected switches between said line and the answering end of said circuit, one of said switches, serving on initiation of the call, to connect with said calling line and the other to connect with said operator's circuit, and means controlled by connected subscribers for restoring all exchange mechanisms used in a connection to normal.

5. A telephone system including telephone lines, operators' signals, link circuits intermediate of said lines and signals, traveling selective switches at the opposite ends of said link circuits, said switches having bank contacts arranged in groups and coöperating traveling wiper contacts movable primarily to groups and secondarily to contacts in the groups, the bank contacts at the answering ends of said link circuits being connected in multiple and pertaining to said lines, the bank contacts at the other ends of said link circuits being connected in multiple and pertaining to said signals, means effective upon the initiation of a call to start the primary travel of the switches of an idle link circuit, means for stopping the primary travel of the answering switch of the link circuit when its wipers reach the group of a calling line, means for thereupon advancing the wipers of said answering switch over the bank contacts of the selected calling line group and bringing them to rest upon the contacts of a calling line, means for stopping the primary travel of the calling switch of said link circuit when its wipers reach the group of an idle signal, and means for thereupon advancing the wipers of said calling switch over the bank contacts of the selected group and bringing them to rest upon the contacts of an idle signal.

6. A telephone system including telephone lines, trunk circuits having selective switching mechanisms at their ends, operators' signals, link circuits intermediate of said lines and signals, traveling selective switches at the opposite ends of said link circuits, said switches having bank contacts arranged in groups and coöperating traveling wiper contacts movable primarily to groups and secondarily to contacts in the groups, the bank contacts at the answering ends of said link circuits being connected in multiple and pertaining to said lines, the bank contacts at the other ends of said link circuits being connected in multiple and pertaining to said signals, means effective upon the initiation of a call to start the primary travel of the switches of an idle link circuit, means for stopping the primary travel of the answering switch of said link circuit when its wipers reach the group of a calling line, means for thereupon advancing the wipers of said answering switch over the bank contacts of the selected calling line group and bringing them to rest upon the contacts of a calling line, means for stopping the primary travel of the calling switch of said link circuit when its wipers reach the group of an idle signal, means for thereupon advancing the wipers of said calling switch over the bank contacts of the selected group and bringing them to rest upon the contacts of an idle signal, and apparatus for electrically adjusting selective switching mechanism associated with a trunk circuit to connect said idle link circuit with a called line.

7. A telephone system including telephone lines, trunk circuits having selecting switching mechanisms at their ends, operators' signals, link circuits intermediate of said lines and signals, traveling selective switches at the opposite ends of said link circuits, said switches having bank contacts arranged in groups and coöperating traveling wiper contacts movable primarily to groups and secondarily to contacts in the groups, the bank contacts at the answering ends of said link circuits being connected in multiple and pertaining to said lines, the bank contacts at the other ends of said link circuits being connected in multiple and pertaining to said signals, means effective upon the initiation of a call to start the primary travel of the switches of an idle link circuit, means for stopping the primary travel of the answering switch of said link circuit when its wipers reach the group of a calling line, means for thereupon advancing the wipers of said answering switch over the bank contacts of the selected calling line group and bringing them to rest upon the contacts of a calling line, means for stopping the primary travel of the calling switch of said link circuit when its wipers reach the group of an idle signal, means for thereupon advancing the wipers of said calling switch over the bank contacts of the selected group and bringing them to rest upon the contacts of an idle signal, apparatus for electrically adjusting selective switching mechanism associated with a trunk circuit to connect said idle link circuit with a called line, and mechanism for automatically applying ringing current to the called line.

8. A telephone system including telephone lines, trunk-circuits having selective switching mechanism at the ends thereof, operators' signals, link-circuits having selective switches at both their ends intermediate of said signals and said lines, multiple terminals pertaining to said lines at the answering ends of said link-circuits, multiple terminals pertaining to said signals at the other ends of said link-circuits, means effective on initiation of a call to start travel of the switches of an idle link-circuit, means for stopping travel of one of said switches when engaging contacts of the calling line, means for stopping travel of the other of said switches when engaging contacts of an idle signal, apparatus for electrically adjusting selective switching mechanism associated with a trunk-circuit to connect said idle link-circuit with a called line, mechanism for automatically applying ringing current to the called line, and a signal controlled by the response of the called subscriber.

9. A telephone system including telephone lines, trunk-circuits having selective switching mechanisms at the ends thereof, operators' signals, link-circuits having selective switches at both their ends intermediate of said signals and said lines, multiple terminals pertaining to said lines at the answering ends of said link-circuits, multiple terminals pertaining to said signals at the other ends of said link-circuits, means effective on initiation of a call to start travel of the switches of an idle link-circuit, means for stopping travel of one of said switches when engaging contacts of the calling line, means for stopping travel of the other of said switches when engaging contacts of an idle signal, apparatus for electrically adjusting selective switching mechanism associated with a trunk-circuit to connect said idle link-circuit with a called line, mechanism for automatically applying ringing current to the called line, a signal controlled by the response of the called subscriber, and release means responsive to the replacing of receivers at subscribers' stations serving to restore to normal the switches used in a connection.

10. A telephone system including a selector, auxiliary selective switches associated therewith arranged in groups, multiple terminals of said switches at said selector arranged in corresponding groups, a group contact for each group of terminals at said selector for determining the groups to be selected by it when started, a normally open circuit extending serially from the group contact of a group through a normally open contact of each selective switch of its group, and a movable portion of the switch for mechanically closing said normally open contact upon the primary selecting movement of the switch whereby, when all switches of a group are moved from normal, the closing of said contacts alters the electrical condition of said group contact to render it unselectable.

11. A telephone system including a selector, auxiliary selective switches associated therewith arranged in groups, multiple terminals of said switches at said selector arranged in corresponding groups, a group contact for each group of terminals at said selector for determining the groups to be selected by it when started, a normally open circuit extending serially from the group contact of a group through a normally open contact for each selective switch of its group, a movable portion of the switch for mechanically closing said normally open contact upon the primary selecting movement of the switch whereby, when all switches of a group are moved from normal, the closing of said contacts alters the electrical condition of said group contact to render it unselectable, other selectors having multiple terminals of said auxiliary switches arranged as described, and means for causing any of said selectors to select a group whose group contact is idle and thereafter idle contacts from the group.

12. A telephone system including a selector, auxiliary selective switches associated therewith arranged in groups, multiple terminals of said switches at said selector arranged in corresponding groups, a group contact for each group of terminals at said selector for determining the groups to be selected by it when started, a normally open circuit extending serially from the group contact of a group through a normally open contact of each selective switch of its group, a movable portion of the switch for mechanically closing said normally open contact upon the primary selecting movement of the switch whereby, when all switches of a group are moved from normal, the closing of said contacts alters the electrical condition of said group contact to render it unselectable, other selectors having multiple terminals of said auxiliary switches arranged as described, means for causing any of said selectors to select a group whose group contact is idle and thereafter idle contacts from the group, and connections automatically altered on selection made serving to close a branch circuit about the off-normal contact of the selected switch.

13. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select

a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, and a starting circuit adapted to simultaneously start said switches.

14. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, and means operable responsive to current over any of said lines for simultaneously starting said switches.

15. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, means operable responsive to current over any of said lines for simultaneously starting said switches, and master-switch mechanism controlling the operative relation of said means with said switch pair.

16. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, means operable responsive to current over any of said lines for simultaneously starting said switches, master-switch mechanism controlling the operative relation of said means with said switch pair, selective switch mechanism connected with the distant ends of said link-circuits, and operator-controlled impulse transmitting means for electrically adjusting said switches to complete connections.

17. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, a line relay for each said line, and common starting means operable by any of said line relays to simultaneously start said switches.

18. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, a line relay for each said line, common starting means operable by any of said line relays to simultaneously start said switches, and cut-off relays, one corresponding to each line relay, arranged on operation to operatively dissociate their respective line relays from said common means.

19. A telephone system including telephone lines and link-circuits for use in interconnecting the same, multiple terminals of said lines arranged in groups, multiple terminals of said link-circuits arranged in groups, a pair of selective switches between said terminals of said lines and said terminals of said circuits, said switches being in electrical connection, adjusting mechanism for one of said switches to cause it to select a group of line terminals and then terminals of a calling line from said group, adjusting mechanism for the other switch to cause it to select a group of link-circuit terminals and then terminals of an idle link-circuit from said group, a line relay for each said line, common starting means oper-

able by any of said line relays to simultaneously start said switches, a cut-off relay for each line adapted for operation on selection of its line's terminals to operatively dissociate said line from said common means, and a call signal for each said link-circuit adapted for display on selection of its respective link-circuit's terminals.

20. A telephone system comprising a calling line and a called line, directively adjustable selective switches for use in interconnecting said lines, an impulse device for supplying predetermined numbers of impulses to directively adjust said switches, and means actuated by said impulse device to short-circuit the calling line while a switch is operating.

21. A telephone system including a calling line and a called line, a traveling switch at the exchange, automatic means controlled from the substation of the calling line for interconnecting said line and said switch, and means effective at a definite point in the operation of said switch to short circuit said line.

22. A telephone system including a calling line and a called line, a traveling switch at the exchange, a central source of current connected to the two limbs of said calling line, a magnet adapted to adjust said switch while said switch is connected with the calling line, and means effective at a definite point in the operation of said switch to establish a conductive bridge of inappreciable resistance between the limbs of said calling line at the exchange.

23. The combination with a telephone line and an electrically adjustable selective switch connected therewith, of means controlled by said switch for short circuiting said line.

24. The combination with a telephone line and a selective switch connected therewith, of a magnet controlling adjustment of said switch, means effective when said magnet first operates to short-circuit said telephone line, and means for initially operating said magnet over a circuit independent of said telephone line.

25. In a telephone exchange system, the combination with a plurality of exchanges, of a plurality of subscribers' lines connected with each of said exchanges, each of said exchanges comprising automatic switches for effecting connections between subscribers' lines, talking trunks extending between said exchanges, operators' equipments comprising means for controlling said automatic switches and grouped at an office separate from said exchanges, operators' trunks extending from said office to said exchanges, means whereby calling lines may utilize certain automatic switches to select idle operators' equipments, and means whereby other automatic switches are controlled from said equipments by current over paths wholly outside of the switches by which said equipments were selected.

26. In a telephone exchange system, the combination with an exchange, of a plurality of subscribers' lines connected thereto, said exchanges comprising automatic switches and talking trunks for connecting subscribers' lines, operators' equipments comprising means for controlling said automatic switches and located at an office separate from said exchange, trunks extending from said office to said exchange, means including certain automatic switches located at said exchange for automatically selecting an idle operator's equipment, and means whereby other automatic switches are controlled from said equipments by current over paths wholly outside of the switches by which said equipments were selected.

27. In a telephone exchange system, the combination with a plurality of exchanges; of a plurality of subscribers' lines connected to each of said exchanges; each of said exchanges comprising a plurality of talking trunks, means for connecting a calling subscriber with an idle talking trunk, and automatic selector switches; operators' equipment comprising means for controlling certain of said selector switches and located at an office separate from said exchanges; operators' trunks extending from said office to each of said exchanges; means including other automatic switches located at each of said exchanges for selecting an idle operator's trunk; and means whereby the operator's control of said certain selector switches is exercised over paths outside of the automatic switches employed in the selection of the operator's equipment.

28. In a telephone exchange system, the combination with a plurality of exchanges, of a plurality of subscribers' lines connected with each of said exchanges, automatic selector and connector switches and talking trunks at each of said exchanges, talking trunks extending between said exchanges, a plurality of operators' equipments, each comprising means for operating certain of said selector and connector switches and located at an office removed from said exchanges, trunks extending from said office to each of said exchanges, means including other of said automatic switches at each of said exchanges for selecting an idle trunk extending to said office, and means whereby the operator's control of said certain selector and connector switches is exercised over paths outside of the automatic switches by which said idle trunk is selected.

29. A telephone exchange system comprising a plurality of groups of subscribers' lines, a group of automatic switches and as-

sociated talking trunks for each group of said lines operative to establish conversational circuits between calling and called ones of said lines in its group, talking trunks between said groups of switches operative therewith to establish conversational circuits between calling and called ones of said lines in different groups, each of certain of said talking trunks consisting of only two wires throughout a considerable portion of its length, a control trunk extending to each group of switches, and means for controlling certain of the switches of each group over its control trunk.

30. A telephone exchange system comprising a plurality of subscribers' lines, automatic switches and associated trunks operative to establish conversational circuits between calling and called ones of said lines, each of certain of said trunks consisting of only two wires throughout a considerable portion of its length, a control trunk, and operator's equipment comprising means for controlling certain of said switches over said control trunk and over said first-mentioned trunks to establish such conversational circuits.

31. A telephone exchange system comprising subscribers' lines, talking trunks, automatic switches for uniting said lines and talking trunks into conversational circuits, a control trunk, means whereby a calling subscriber may communicate his order to an operator over said control trunk, and means whereby an operator may directively control the operation of certain of said switches over said control trunk to establish connection with one called line and of a different number of switches for another called line.

32. A telephone system comprising telephone lines terminating in a plurality of exchanges, a switchboard having operators' positions, automatic means at said plurality of exchanges for extending calling lines to said switchboard and displaying signals thereat, operator's impulse controlling means at said switchboard, selective switches operable responsive to said means in completing connections from calling lines to called lines, two-wire trunks for interconnecting telephone lines of the different exchanges responsive to currents over said trunks, the connections with called lines over said two-wire trunks including a different number of switches than the connections with called lines which do not include said two-wire trunks.

33. A telephone system comprising telephone lines extending to a plurality of exchanges, an operator's exchange, trunk lines adapted for use in interconnecting lines of said first-mentioned exchanges, and means under the control of the operator at said operator's exchange for automatically linking together trunk lines to interconnect any line of any exchange with any line of any other exchange.

34. A telephone system comprising telephone lines extending to a plurality of exchanges, two-wire trunks between said exchanges, each of said trunks consisting of only two wires throughout a considerable portion of its length, an operator's exchange, operators' trunks extending from said operator's exchange to each of said plurality of exchanges, automatic means, including two-dimension line-finding switches, for establishing connections between calling lines and the operator's exchange over said operators' trunks, and automatic means under the control of the operator for extending the circuits of calling lines to called lines in the same and different exchanges, the connections between different exchanges including two-wire trunks.

35. A semi-automatic telephone system including telephone lines, a main exchange in which a portion of said lines terminate, a branch exchange in which a portion of said lines terminate, trunk lines interconnecting said exchanges, means for automatically connecting a calling line of said branch exchange over an idle one of said trunks with said main exchange, operator's impulse controlling mechanism at said main exchange for transmitting directive currents back over said same trunk to link the calling line to the called line, operator's means for listening into the talking circuit at any time during conversation, and means for releasing the automatic interconnecting means independently of the operator.

36. A semi-automatic telephone system including telephone lines extending to an exchange, operators' impulse controlling mechanisms, switch mechanism and trunk lines responsive to the removal of a calling party's receiver to connect his line with an idle one of said impulse controlling mechanisms, two-wire trunk lines each consisting of only two wires throughout a considerable portion of its length, means responsive to the selected impulse controlling mechanism to extend the circuit of the calling line over one of said two-wire trunk lines to a called line, operator's means for listening into the talking circuit between the connected lines at any time during conversation; and means under subscriber control for restoring all the switches of the conversational circuit to normal.

37. A semi-automatic telephone system including telephone lines, a main exchange in which a portion of said lines terminate, a branch exchange in which a portion of said lines terminate, trunk lines interconnecting said exchanges, means for automatically connecting a calling line of said branch exchange over an idle one of said trunks with said main exchange, impulse controlling

mechanism at said main exchange for transmitting directive currents back over said same trunk to link the calling line to the called line, said impulse controlling mechanism being permanently associated with said selected trunk, and switches at the substations of lines so connected for rendering them idle when disconnection is desired.

38. A telephone system including telephone lines, two telephone exchanges, terminals of part of said lines at each exchange, trunk lines interconnecting said exchanges, operator's equipment, link circuits associated with said equipment, switch mechanism for automatically extending a call from a calling line through an idle link circuit to said equipment, said equipment including means for working through the selected link circuit independently of said switch mechanism to further automatically extend the circuit by way of one of said trunk lines to the terminals of a called line, and subscriber controlled means for releasing an established connection.

39. In a telephone exchange system, the combination with an exchange, of a plurality of subscribers' lines connected thereto, said exchange comprising talking trunks for connecting subscribers' lines and automatic switches, operators' equipments comprising means for controlling said automatic switches and located at an office separate from said exchange, trunks extending from said office to said exchange, each of said trunks being permanently associated with one of said equipments, means located at said exchange for automatically selecting an idle operator's equipment, and means for utilizing a portion of the trunk associated with the selected operator's equipment in the complete connection between calling and called lines.

40. In a telephone exchange system, the combination of a plurality of subscribers' lines extending to an exchange, automatic switches at the exchange, two-wire talking trunks each consisting of only two wires throughout a considerable portion of its length, operators' equipments comprising means for controlling said automatic switches, said equipments being located at an office separate from the exchange, trunks extending from the exchange to the office and there each being permanently associated with one of said equipments, means at the exchange operative in response to a call to connect the calling line with an idle operator's equipment, means for including a portion of the trunk associated with the selected operator's equipment and one of said two-wire talking trunks in a complete connection between calling and called lines, and means for restoring all parts of the operator's equipment to normal during the pendency of said complete connection.

41. In a telephone exchange system, the combination with a plurality of exchanges, of a plurality of subscribers' lines extending to each of said exchanges, a plurality of talking trunks at each of said exchanges, means at each exchange for connecting a calling line with an idle talking trunk, selector switches at each exchange, operators' equipments comprising means for controlling said selector switches, an office separate from said exchanges in which said equipments are located, operators' trunks extending from each of said exchanges to said office and there being permanently associated each with one particular equipment, two-wire talking trunks each having at one point in its length a maximum of two wires, means at each exchange for selecting an idle operator's trunk, and means for bringing a portion of each selected operator's trunk and one of said two-wire talking trunks into a conversational circuit wholly outside of said office between calling and called lines.

42. In a telephone exchange system, a plurality of subscribers' lines, a number of trunks less in number than the number of lines, an operator's circuit including a telephone set and an impulse sending device, means for automatically connecting a calling line with any one of said trunks, thereby rendering the said trunk busy, means for automatically connecting the operator's sending device with said busy trunk, automatic switches for extending the circuits of said trunk to a wanted line in response to the operation of said sending device, and means for short-circuiting the calling line while said sending device is thus operated.

43. In a telephone exchange system, a number of subscribers' lines, a number of trunks less than the number of lines for interconnecting said lines, an operator's impulse sending device associated with said trunks, means associated with said sending device for automatically connecting with any busy trunk, together with restoring means for said connecting means, and means for short-circuiting the calling line during the operation of said sending device.

44. In a telephone exchange system, a number of subscribers' lines, a number of trunks less than the number of lines for interconnecting said lines, an operator's impulse sending device associated with said trunks, means associated with said operator's sending device and becoming active when a trunk is appropriated by a calling line for automatically connecting the operator's sending device with said appropriated trunk, means for restoring said connecting means, and means for short-circuiting the calling line during the operation of said sending device.

45. In a telephone exchange system, subscribers' lines, a number of trunks less than

the number of lines, an operator's impulse sending device, means for automatically connecting a calling line with a trunk, means for automatically connecting the operator's sending device with the busy trunk, automatic switches for completing the connection to a wanted subscriber, said switches being controlled by impulses from the operator's sending device, together with restoring means for the connecting means, and means for short-circuiting the calling line during the operation of said sending device.

46. A telephone system including telephone lines, an operator's position, trunk lines, automatic mechanism for connecting a line over an idle trunk line with, and signaling said operator's position, operators' means for working back over said trunk line and selectively connecting said line with another wanted line, an operator's signal displayed to indicate the establishment of the connection, and means for short-circuiting the calling line during the operation of said sending device.

47. A telephone exchange system comprising a plurality of groups of subscribers' lines, a group of automatic switches and associated talking trunks for each group of said lines operative to establish conversational circuits between calling and called ones of said lines in its group, talking trunks between said groups of switches operative therewith to establish conversational circuits between calling and called ones of said lines in different groups, a control trunk extending to each group of switches, means for controlling certain of the switches of each group over its control trunk, means whereby the connected parties may release the switches employed in establishing a conversational circuit, independently of said control trunk, and means whereby the operator may listen into connected lines at any time during conversation.

48. A telephone exchange system comprising a plurality of subscribers' lines, automatic switches and associated trunks operative to establish conversational circuits between calling and called ones of said lines, a control trunk, an operator's equipment comprising means for controlling certain of said switches over said control trunk in establishing each such conversational circuit, means whereby the connected parties may release the switches employed in establishing a conversational circuit, independently of said control trunk, and means whereby the operator may listen into connected lines at any time during conversation.

49. A telephone system comprising telephone lines terminating in a plurality of exchanges, an operator's exchange, trunk lines and automatic switches for establishing subscriber-to-subscriber conversational circuits wholly within any one of said first-mentioned exchanges and between any two of said first-mentioned exchanges wholly outside of said operator's exchange, means at the latter exchange under the operator's control for actuating certain of said automatic switches to establish said conversational circuits, means whereby an operator may listen into conversational circuits at any time during their duration, and means under subscriber control for releasing all the parts included in each such conversational circuit.

50. In a telephone exchange system, a calling substation including a transmitter and receiver, a calling device, means for short-circuiting said transmitter and receiver during the operation of said calling device, and automatic switching mechanism operated in response to the operation of said calling device.

51. In a telephone exchange system, a calling line having substation equipment, automatic step-by-step switches and associated trunks for use in extending the circuit of said line, a calling device for supplying predetermined numbers of current impulses to step said switches, and means actuated by said calling device to short-circuit portions of said equipment while said calling device is in operation.

52. In a telephone exchange system, a calling circuit having two talking conductors, a calling device for sending impulses over said conductors, an automatic switch responsive to said impulses to extend said calling circuit, substation elements in circuit with said talking conductors, and means responsive to said calling device to short-circuit said substation elements while impulses are being sent over said conductors.

53. In a telephone system, an automatic switch, a control circuit therefor extending in two conductors from a substation, a substation transmitter and receiver, a bridge between said conductors at a point intermediate of said switch on the one hand and said transmitter and receiver on the other, means for sending predetermined numbers of current impulses over said conductors to operate said switch predetermined amounts, and means responsive to the operation of said sending means to open and close said bridge.

54. In a telephone system, an automatic switch, a control circuit for said switch extending from a substation in two conductors, a transmitter and receiver and switchhook at the substation in circuit with said conductors, a bridge independent of said switchhook between said conductors at a point intermediate of said switch on the one hand and said transmitter and receiver on the other hand, a source of current, and means

for variously connecting said source to said bridge to send current at one time over said bridge and one conductor to give said switch one movement and at another time over said bridge and the other conductor to give said switch another movement.

55. A semi-automatic telephone system including telephone lines, an operator's circuit, selective switching mechanism at the calling end of said circuit, operator's means for transmitting directive currents to said switching mechanism to extend the calling end of said circuit to desired lines, a calling telephone line, and a pair of electrically connected switches between said line and the answering end of said circuit, one of said switches serving on initiation of the call to connect with said calling line and the other to connect with said operator's circuit, and means controlled by connected subscribers for restoring all exchange mechanisms used in a connection to normal.

56. A telephone system including telephone lines, trunk-circuits having selective switching mechanisms at the ends thereof, operators' signals, link-circuits having selective switches at both their ends intermediate of said signals and said lines, multiple terminals pertaining to said lines at the answering ends of said link-circuits, multiple terminals pertaining to said signals at the other ends of said link-circuits, means effective on initiation of a call to start travel of the switches of an idle link-circuit, means for stopping travel of one of said switches when engaging contacts of the calling line, means for stopping travel of the other of said switches when engaging contacts of an idle signal, and apparatus for electrically adjusting selective switching mechanism associated with a trunk-circuit to connect said idle link-circuit with a called line through the associated signal selecting selective switch.

57. A telephone system including telephone lines, trunk-circuits having selective switching mechanisms at the ends thereof, operator's signals, link-circuits having selective switches at both their ends intermediate of said signals and said lines, multiple terminals pertaining to said lines at the answering ends of said link-circuits, multiple terminals pertaining to said signals at the other ends of said link-circuits, means effective on initiation of a call to start travel of the switches of an idle link-circuit, means for stopping travel of one of said switches when engaging contacts of the calling line, means for stopping travel of the other of said switches when engaging contacts of an idle signal, apparatus for electrically adjusting selective switching mechanism associated with a trunk-circuit to connect said idle link-circuit with a called line, and mechanism for automatically applying ringing current to the called line through the associated signal selecting selective switch.

58. A telephone system including telephone lines, operators' signals, link-circuits having selective switches at both their ends intermediate of said signals and said lines, multiple terminals pertaining to said lines at the answering ends of said link-circuits, multiple terminals pertaining to said signals at the other ends of said link circuits, means effective on initiation of a call to start travel of the switches of an idle link-circuit, means for stopping travel of one of said switches when engaging contacts of the calling line, means for stopping travel of the other of said switches when engaging contacts of an idle signal, trunk circuits having selective switching mechanisms at their distant ends, and operator's means for transmitting directive current impulses to said switching mechanisms over said trunk circuits independently of said selective switches, to extend said trunk circuits to desired lines.

In witness whereof, I hereunto subscribed my name this 13th day of November, 1907.

GEORGE E. MUELLER.

Witnesses:
J. G. KELLOGG,
W. W. TOWNSEND.