A. H. DYSON.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED DEC. 10, 1910.

1,205,943.

Patented Nov. 21, 1916.

6 SHEETS—SHEET 1.

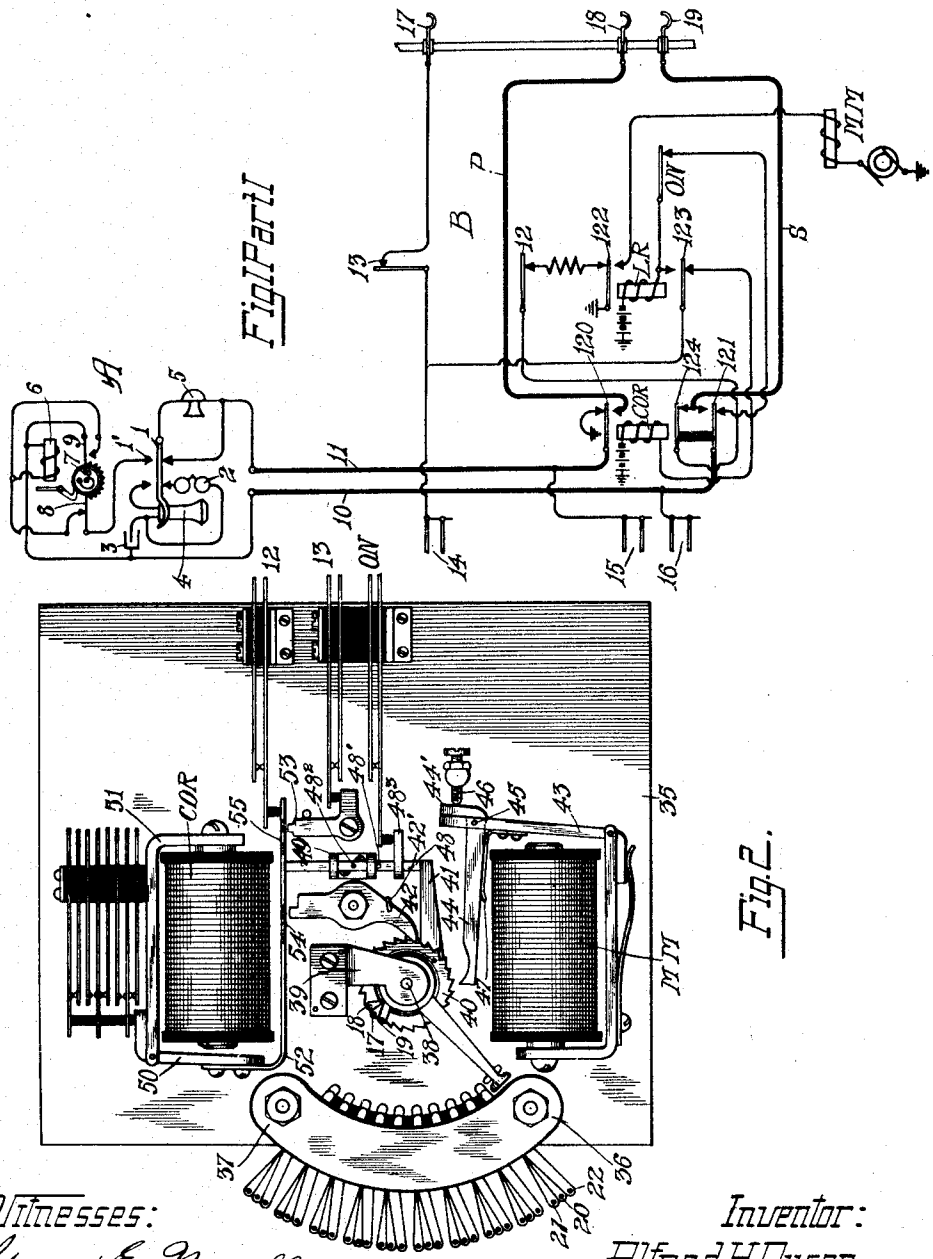

Fig 2.

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6 SHEETS—SHEET 2.

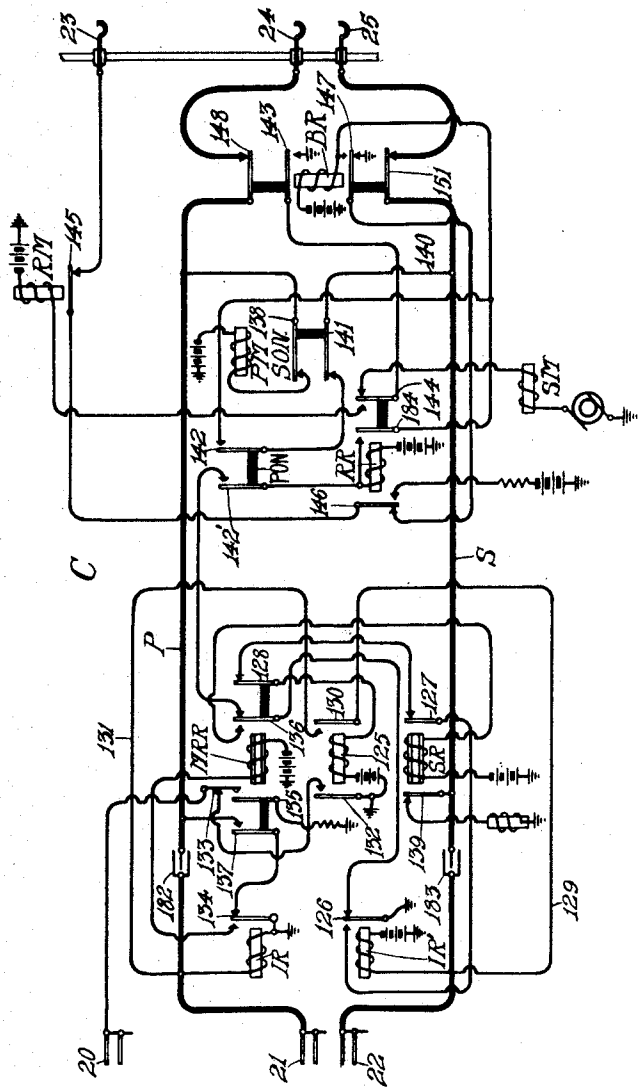

Fig. 1 Part 2.

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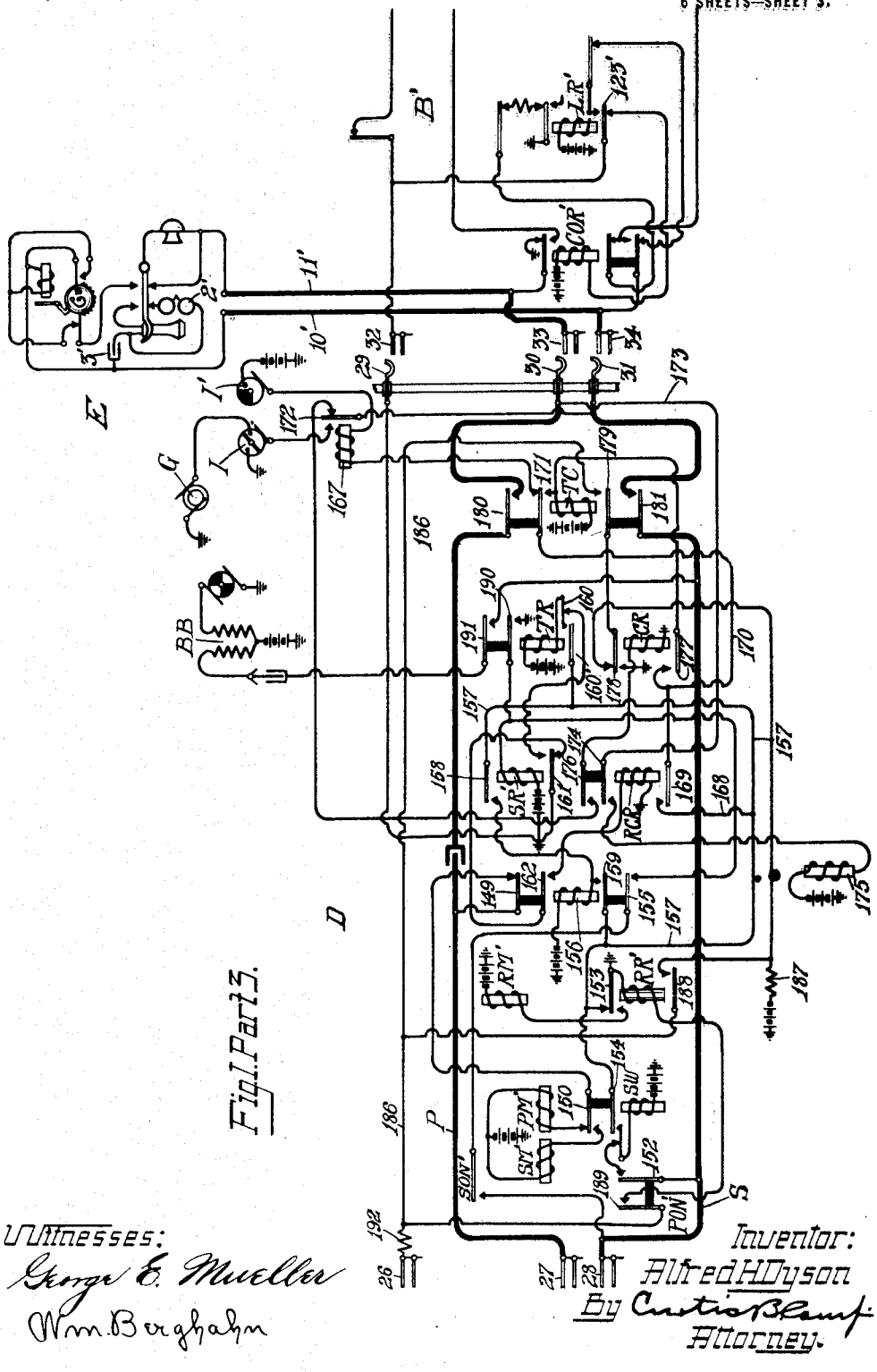

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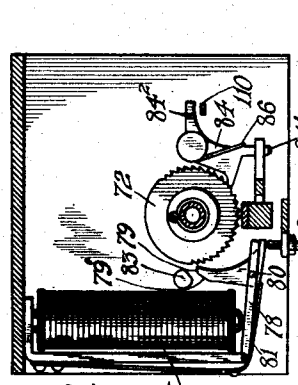

Fig. 7.

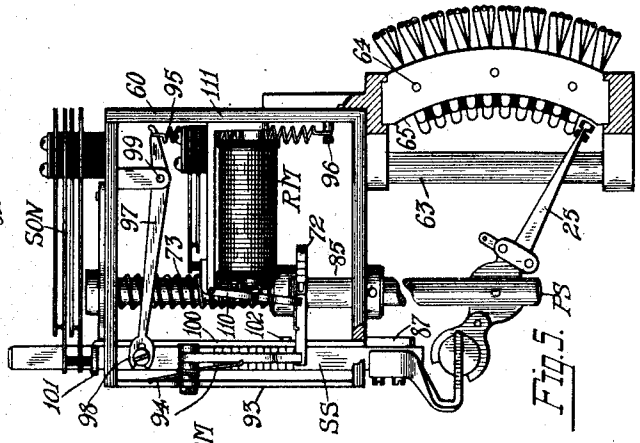

Fig. 5.

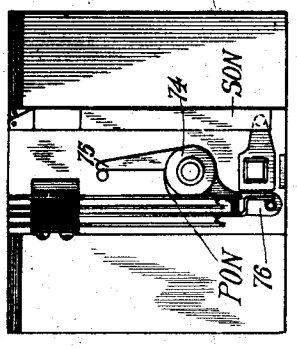

Fig. 6.

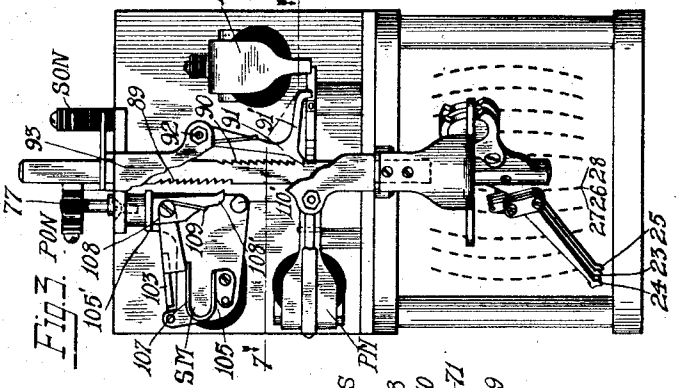

Fig. 3.

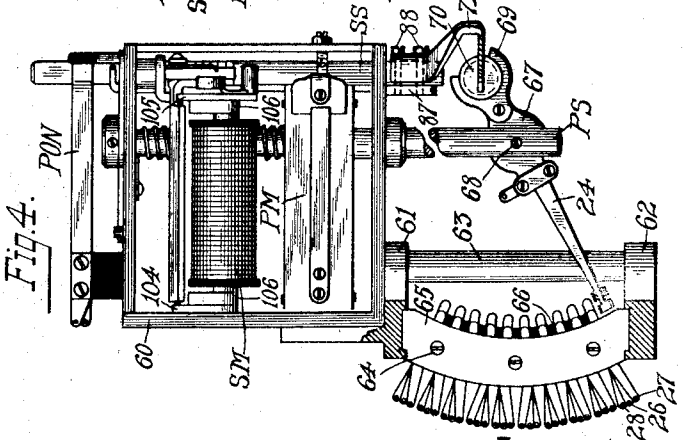

Fig. 4.

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APPLICATION FILED DEC. 10, 1910.

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6 SHEETS—SHEET 5.

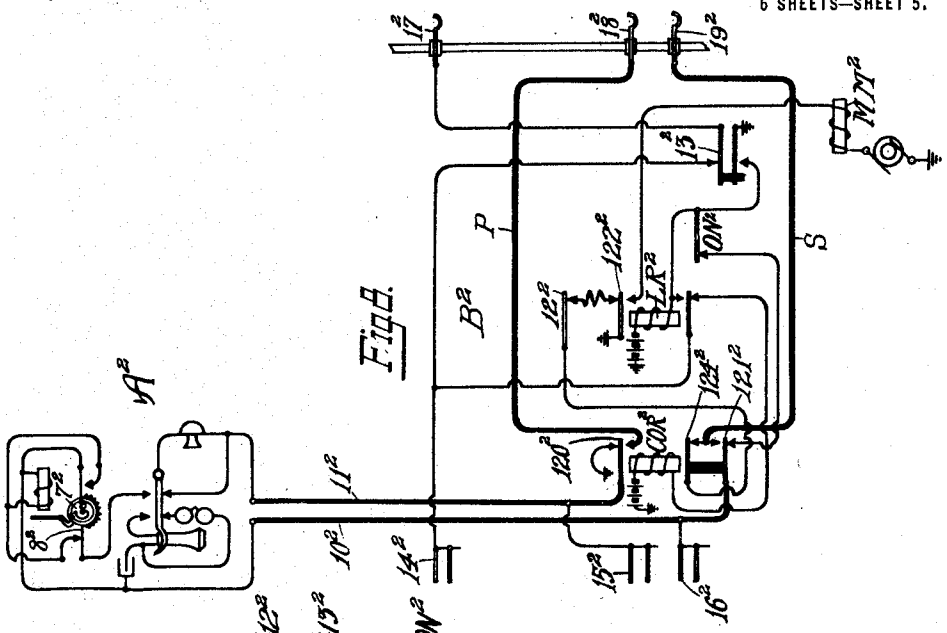

Fig. 8.

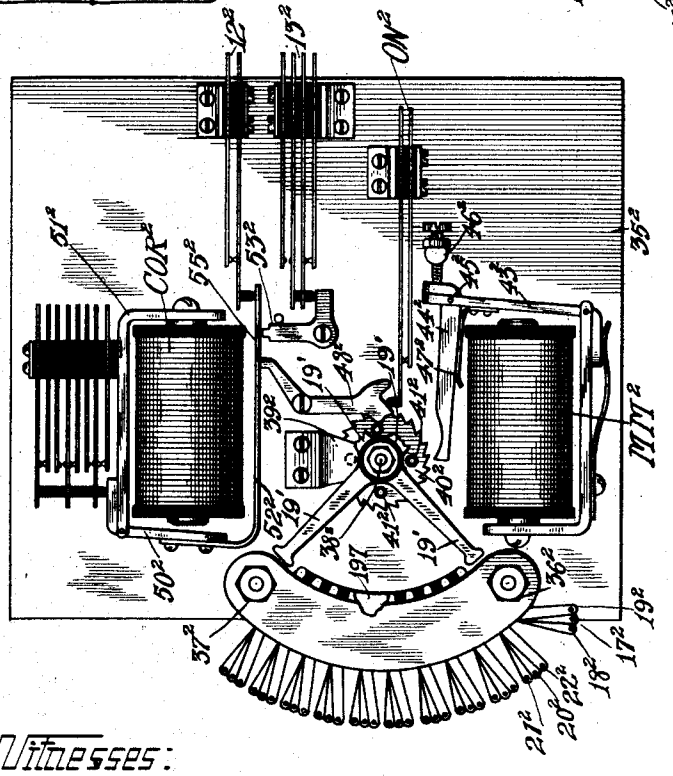

Fig. 9.

Witnesses:

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APPLICATION FILED DEC. 10, 1910.

1,205,943.

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6 SHEETS—SHEET 6.

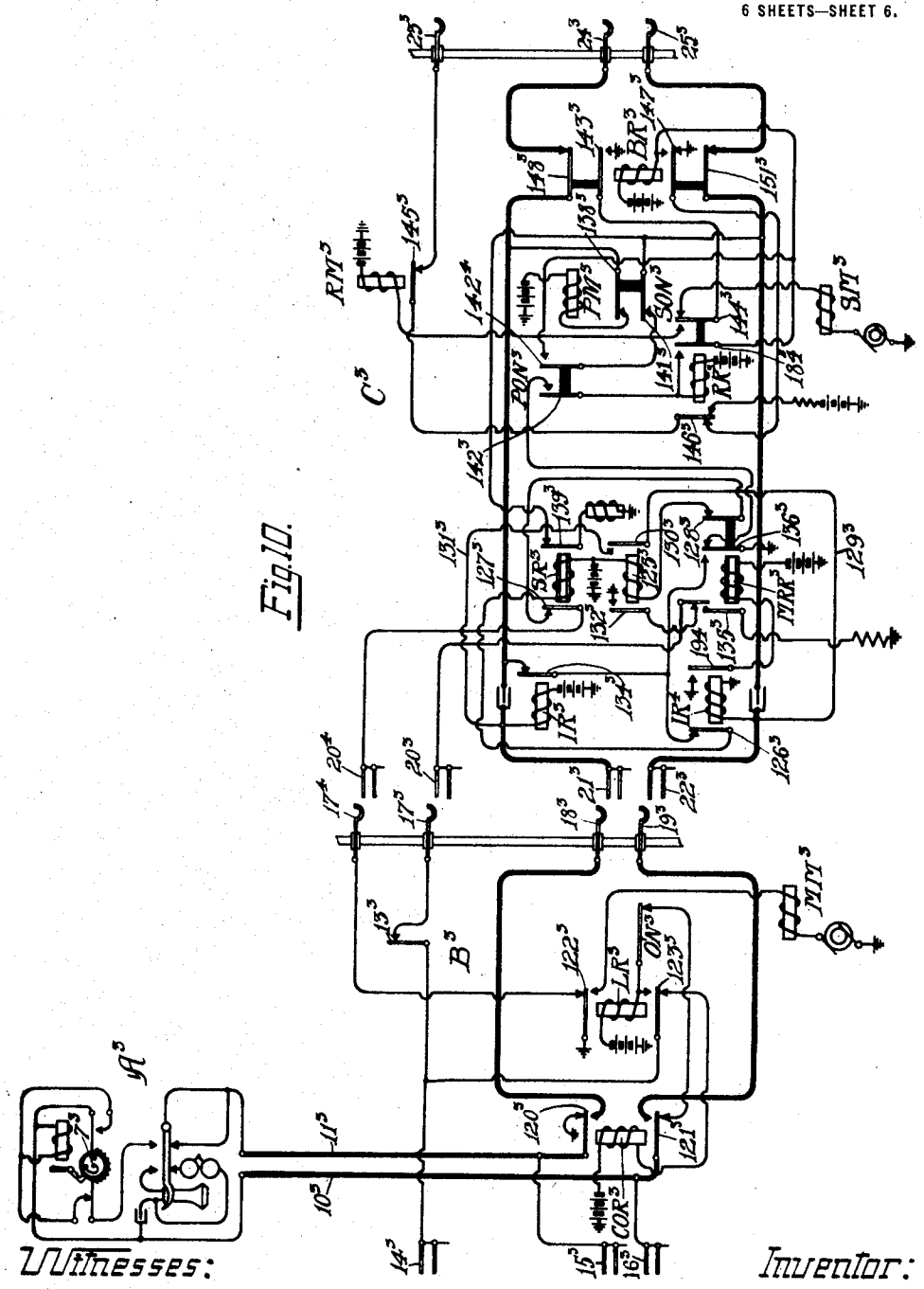

Fig 10.

Witnesses:

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

1,205,943. Specification of Letters Patent. Patented Nov. 21, 1916.

Application filed December 10, 1910. Serial No. 596,652.

To all whom it may concern:

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

My invention relates to automatic telephone systems of the two wire or metallic line type in which directively controlled switches at the exchange are operated responsive to a series of rapid interruptions of the subscribers' line circuits, and without the use of any ground connection at the sub-stations, and to such systems as above outlined, in which upon initiation of a call, a line switch associated with the calling line, automatically extends the circuit of the calling line to an idle directively controlled switch.

An object of my invention is to provide such a system as above outlined, having improved and simplified circuit arrangements, another object being to reduce the number of relays or magnets used on the line switch, one of the features of my invention being the provision of an electromagnet operating as a cut off relay and release magnet.

Referring to the accompanying drawings in which like reference characters indicate like parts, Figure 1 which includes part 1, part 2 and part 3, illustrates diagrammatically an automatic telephone system embodying my invention. Fig. 2 illustrates a line switch adapted to be used in connection with the line switch circuit B, Fig. 1, part 1. Figs. 3, 4 and 5 are front and side elevations respectively of a selector or connector switch, adapted for use with the circuits of my invention. Fig. 6 is a plan view of Fig. 3 showing more particularly the off normal spring arrangement. Fig. 7 is a cross section of Fig. 3 along the line 7—7 as indicated on said Fig. 3. Fig. 8 illustrates a modification of the line switch circuit B of Fig. 1 part 1. Fig. 9 illustrates a line switch adapted for use in connection with the line switch circuit B^2 of Fig. 8. Fig. 10 illustrates diagrammatically a modification of the line switch B and first selector switch C of the system of Fig. 1.

Referring now more particularly to the system as shown in Fig. 1 the sub-station A comprises the usual switch-hook and sub-station equipment, and includes a calling device. The said sub-station A is connected by means of the two line limbs as shown, to a line switch B at the exchange. The said line switch B is adapted, upon the initiation of a call from sub-station A, to automatically connect with an idle first selector C as shown in Fig. 1, part 2. The subscriber at A, by the use of the calling device in connection with his sub-station equipment, may by its actuation, operate the first selector C to extend the connection from the said sub-station A to an idle connector switch D. The subscriber at A then, may by further actuation of his calling device, operate the connector switch D to connect with the terminals of the called for line E. If the called line is idle ringing current is automatically applied to the terminals thereof to signal the called for subscriber. Should the line of the called for subscriber be busy a characteristic busy signal will be automatically transmitted back to the calling subscriber who may by replacing his receiver upon its switch hook release the switches which were used in extending his line to the line of the called for subscriber. If a connection has been completed for conversation between a calling and called subscriber, the calling subscriber controls the release of the line switch and first selector and the release of the connecting switch D is controlled by the called subscriber.

The system as illustrated in Fig. 1 is adapted for use as a thousand line system but by the addition of second selectors or third selectors as illustrated in my application Serial No. 586,817, filed October 11, 1910 the system may be increased to any desired size.

General description of system Fig. 1.—The equipment of sub-station A comprises the usual switch hook 1, which normally closes a circuit through call bell 2 and condenser 3, and which is adapted, upon the removal of receiver 4 therefrom to open the lower contacts, thereby disconnecting the call bell and by closing the upper contacts, connecting in circuit, transmitter 5, impedance coil 6 and the impulse contact springs 8 of calling device 7. Impedance coil 6 also serves as a magnet to unlock the dial of calling device 7, as will be hereinafter more fully explained. To operate calling device 7, to transmit a certain predeter-

mined number of impulses, the operator rotates the dial in a clock-wise direction until a number of insulated projections corresponding to the number of impulses to be transmitted have passed impulse spring 8 but it will be noted that when the dial is advanced the contact springs do not open. The operator then releases the dial which is restored by the spring shown thereon, thereby opening and closing impulse springs 8 the proper number of times. Shunt springs 9 are adapted to be closed while the dial is off normal, thus shunting the winding of coil 6 and reducing the line resistance. The sub-station A is connected by means of line limbs 10 and 11 to terminals of relay COR of line switch B.

The line switch B comprises a line relay LR which is adapted, upon initiation of a call from sub-station A, to automatically start travel of the wipers of line switch B responsive to operation of motor magnet MM, to connect with the terminals of an idle first selector C. Magnet COR of switch B serves as a cutoff relay for the said switch, being adapted upon energization to remove the sub-station control of the line relay LR and also to extend the line conductors of sub-station A to the selected first selector C. The said magnet COR also serves as a release magnet for line switch B, being adapted upon deënergization, to allow the restoration of the wipers of the line switch B. Off normal switch ON is adapted to be moved to its alternate position upon the first step of the wipers of line switch B, and to be restored upon restoration of the said wipers. Switch springs 12 and 13 are controlled by magnet COR, the operation of which will be more fully explained. Terminals 14, 15 and 16 are the multiply connected terminals of the connector switches having access to the line of the sub-station A.

Wipers 17, 18 and 19 of line switch B are adapted to connect with contacts 20, 21 and 22, leading to first selectors such as C. Each sub-station line in the exchange has a line switch B, which by means of wipers 17, 18 and 19 have access to a plurality of first selectors C, preferably ten in number, although the number of first selectors C to which a line has access may be varied to suit existing conditions. The sub-station lines and line switches B are divided into groups of one hundred, and there are ten first selectors C for each group of one hundred lines, therefore on a basis of ten per cent. trunking which is sufficient for ordinary purposes, each subscriber's line switch B would have access to ten first selectors C. Each first selector C is multiply connected to the terminals 20, 21 and 22 of 100 line selectors B, although only two multiple connections are shown.

Each first selector C comprises impulse relays IR and IR′ which are adapted to be bridged across the line of a calling subscriber. Said relays IR and IR′ are controlled over a metallic circuit of a calling subscriber's line, being adapted to be operated by interruptions of the metallic circuit in which they are included by means of a subscriber's calling device. Primary magnet PM is adapted responsive to current impulses from the impulse relays, to move wipers 23, 24, 25 in a primary direction to select a group of bank contacts 26, 27, 28 leading to connector switches D. Secondary relay SR, which is shown as a sluggish or slow acting relay, is adapted to transmit a secondary impulse after the primary impulses have been transmitted, to energize busy relay BR which controls the selection of an idle trunk. The energization of busy relay BR closes a circuit through secondary magnet SM which causes a secondary movement of wipers 23, 24 and 25 along the selected row or group of contacts. Main release relay MRR is a slow acting relay directly under control of a calling subscriber, which controls the release of certain switches, as will hereinafter be more fully explained. Release relay RR controls the operation of release magnet RM which is adapted upon energization to restore wipers 23, 24 and 25 to normal. Primary off normal switch PON is adapted to be moved to its alternate position upon the first primary movement of wipers 23, 24 and 25, and secondary off normal switch SON is adapted to be moved to its alternate position upon the first secondary movement of wipers 23, 24 and 25. The off normal switches are restored to normal upon restoration of said wipers 23, 24 and 25 from their respective movements. The wipers 23, 24 and 25 of each first selector are adapted to be connected with terminals 26, 27 and 28 of one hundred connector switches D, divided into ten groups, there being ten such connector switches D for each group of one hundred lines in the exchange. Each connector switch is multipled connected to bank contacts 26, 27 and 28 of one hundred first selectors C. Therefore, each first selector C has access to ten connectors D in each group of one hundred lines in the exchange.

Each connector switch D includes a primary magnet PM′ which is adapted to move wipers 29, 30 and 31 in a primary direction to any one of ten groups of bank contacts 32, 33 and 34. Secondary magnet SM′ is adapted to move the said wipers 29, 30 and 31 in a secondary direction to connect with one of the sets of contacts 32, 33 and 34 in the selected group. Switch relay SW is adapted to disconnect primary magnet PM′ and connect secondary magnet SM′ with the primary or upper heavily marked conductor

of connector switch D. Release relay RR′ is adapted to control the operation of release magnet RM′ to release the wipers of connector switch D. Test relay TR is adapted to be connected to the private or busy terminal 32 of the called line to test its idle or busy condition, so if idle, ringing current may be applied or a characteristic busy signal from busy back BB may be transmitted to the calling subscriber if the called for line is busy.

Interrupter wheels I and I′ are preferably mounted upon the same shaft in the relative positions shown and are rotated in a clock-wise direction by any suitable motive power. The line switch B′ of the called for subscriber at E is similar to line switch B of the calling subscriber at A, although a portion of the said switch circuit B′ is not illustrated. The requirement of substation E is similar to that of sub-station A.

Referring now to Fig. 2 the switch structure there illustrated is adapted to operate in connection with the circuit of line switch B. The switch of Fig. 2 comprises a main mounting plate 35, to which is secured the contact bank 36. The said bank includes a pair of clamping plates 37 firmly clamping ten sets of bank contacts 20, 21, and 22, suitably insulated from each other. Wipers 17, 18 and 19 which are adapted to coöperate with said bank contacts are suitably secured to shaft 38, the said shaft 38 being journaled in plate 35 and bracket 39. Wipers 18 and 19 are adapted to coöperate with contacts 21 and 22 respectively when shaft 38 is rotated and wiper 17 which is the middle wiper is adapted to coöperate with the contacts 20. The ends or contacting portions of wipers 21 and 22 are so formed that when moving from one set of contacts to another in the bank, they will break contact with one set before making contact with the next set. Wiper 17 has its end or contacting portion so formed that when being advanced along the row of contacts, it makes connection with one contact 26 before breaking connection from the contact it is leaving. Ratchet wheel 40 is rigidly secured to shaft 38 as is also the arm 41. Detent 42 which is pivoted at an intermediate point, normally rests under tension of spring 42′ against ratchet wheel 40, and is adapted to prevent restoration of wipers 17, 18 and 19 until said detent is withdrawn from engagement with said ratchet wheel 40. Motor magnet MM which is suitably mounted on plate 35 has an armature 43, carrying a pawl 44, pivoted to said armature 43 by means of pin 45. Pawl 44 is shown in its normal position with its upwardly extending portion 44′ resting against the adjustable stop screw 46. Tension spring 47 is secured to armature 43 and is adapted to press pawl 44 into engagement with ratchet wheel 40 upon attraction of armature 43. As armature 43 is attracted, pawl 44 is moved toward the left and as it tends to move away from stop screw 46, spring 47 moves it upward into engagement with ratchet wheel 40 and the armature 43 continuing in its movement, pawl 44 rotates ratchet wheel 40 stepping the wipers into engagement with the first set of bank contacts. Upon each deënergization and energization of magnet MM the wipers are advanced one step moving from one contact to the next along the row. Rod 48 which is preferably square is carried in suitable openings in bracket 49, the said rod 48 being adapted to reciprocate in its bearings, but due to its square shape is not rotatable. The pin 48′ in rod 48 due to its engagement with bracket 49 serves as a stop for wiper shaft 38 upon its restoration, due to the engagement of arm 41 with the said rod 48. Off normal springs ON rest under tension against member 48^2, the said member being rigidly secured to rod 48. Thus when the wiper shaft 38 is moved off normal, arm 41 moves away from rod 48, allowing off normal springs ON to move the rod 48 downward, the said springs thus assuming an alternate position. Excessive movement of rod 48 is prevented by stop pin 48^2 engaging the upper surface of the lower extension of bracket 49. Magnet COR which serves as a cutoff relay and release magnet, has an armature 50 pivoted to pole piece 51. Fastened to the said armature 50 is the release catch 52 normally resting under tension against the upper end of rod 48. Said release catch 52 has two holes 54 and 55 therein, which are adapted upon energization of magnet COR to drop over the upper ends of detent 42 and pivoted arm 53. Springs 12 of which the lower one rests under tension against release catch 52, are adapted to have their contacts broken when the release catch 52 drops downward over the ends of detent 42 and arm 53.

It will be noted that when wiper shaft 38 moves off normal and rod 48 moves downward release catch 52 rests on the upper end of arm 53, but the springs 12 are so adjusted that this slight movement of catch 52 does not open their contact. Upon energization of magnet COR, after wiper shaft 38 has moved off normal, the openings of 54 and 55 of catch 52 drop downward over the ends of detent 42 and arm 53 and upon deënergization of magnet COR the said catch 52 moves the upper ends of detent 42 and arm 53 to the left, thereby moving detent 42 out of engagement with ratchet wheel 40, and opening the contacts between springs 13 by means of arm 53.

The operation of line switch Fig. 2 is as follows: When the motor magnet MM is energized and deënergized, pawl 44 engages

the teeth of ratchet wheel 40 thus advancing wipers 17, 18 and 19 along the row of contacts 20, 21 and 22, each energization and deënergization of the said magnet advancing the said wipers one step, or the distance from one set of contacts to the next. Upon the first movement of wiper shaft 38 off normal, arm 41 which is carried thereby, moves downward, thus allowing off normal springs ON to assume an alternate position and also moving rod 48 downward thereby allowing spring member 52 to rest on the upper end of pivoted arm 53. The magnet COR is now energized and upon complete attraction of its armature 50 the openings 54 and 55 in release catch 52 are in a position to drop down over the ends of detent 42 and arm 53. The downward movement of said release catch 52 allows contact springs 12 to assume an alternate position. To release the switch magnet COR is deënergized retracting the armature 50, thus moving the upper ends of detent 42 and arm 53 toward the left. The movement of arm 53 moves the upper spring 13 out of engagement with its lower contact spring. Detent 42 being pivoted at its central portion, has its lower end moved out of engagement with ratchet wheel 40 and the wipers 17, 18 and 19 are restored to normal by means of the spring shown in connection with ratchet wheel 40. Upon restoration of the wipers, arm 41 engages rod 48 moving it upward until pin 48′ engages the lower surface of bracket 49. The restoration of rod 48 restores off normal springs ON and the upper end of rod 48 engages catch 52, lifting it out of engagement with detent 42 and arm 53, allowing the said detent and arm to be restored. The upward movement of catch 52 restores contact springs 12 to normal and the restoration of arm 53 by the upper contact spring 13, allows the said contact spring 13 to assume its normal position in engagement with its lower contact. Upon restoration of detent 42 into engagement with ratchet wheel 40, the switch of Fig. 2 is again at normal.

Selector and connector switch construction.—Referring to the switch illustrated in Figs. 3 to 7, the said switch is adapted to be used either as a selector or a connector switch by arranging the off normal springs, as illustrated in the different circuit diagrams.

The switch illustrated comprises a frame 60, on which are mounted the different actuating magnets. Secured to the lower and back parts of the frame 60 is the bank contact frame comprising the upper member 61 and lower member 62. The said members are connected by posts 63, which are adapted to clamp ten banks of contacts such as 64. Each contact bank 64, comprises two clamping plates 65 which are adapted to hold ten sets of bank contacts 26, 27, 28 in position. The said bank contacts are suitably insulated from each other by the insulation strips 66. In Fig. 3, the ten banks of contacts are illustrated diagrammatically. Each set of contacts 26, 27 and 28, of which there are one hundred sets, is represented by a single short line, having been illustrated in this manner, believing the drawing will be more readily understood. The ten contact banks 64 are radially disposed between the clamping plates 61 and 62 so spaced that the wipers 23, 24, 25, when rotated by the primary shaft PS are stepped along from one contact bank to the next. The primary shaft PS is journaled in the upper and lower horizontal extensions of frame 60 and is adapted to partake of rotary motion only. It will be noticed said shaft is broken, the upper portion being at normal and the lower end carrying the wipers being in a position so that the wipers are below the fifth contact bank. The plate 67 is secured to primary shaft PS by the pivot 68 and wipers 23, 24, 25, are secured to the lower end of said plate 67 and are suitably insulated therefrom. The upper end of plate 67 has fastened to its sides the forked retaining members 69, which are adapted to secure the roller 70 to plate 67. The roller 70 has a slot through its center, which is adapted to receive the horizontal portion of member 71, the said member 71 being loose within the slot of roller 70 so that when shaft PS is rotated slotted roller 70 slides along plate 71. Primary ratchet 72 is suitably fastened to primary shaft PS. The restoring spring 73 is disposed about the primary shaft PS having its upper end secured to the horizontal extension of frame 60 and its lower end secured to the hub of primary ratchet 72. Fastened to the upper end of primary shaft PS is the hub 74 carrying the stop arm 75 and the forwardly extending arm 76. Stop arm 75 normally rests against its engaging stop pin, thus holding the primary shaft PS in its normal position under tension of spring 73. Secured to the end of arm 76 is the insulated stud 77 which is adapted upon the first movement of primary shaft PS, to move in a clock-wise direction away from the primary off-normal springs PON, thus allowing them to move to their alternate position. Primary magnet PM, which is adapted to rotate primary shaft PS thus giving the wipers 23, 24, 25, their primary movement, has an armature 78, suitably pivoted to its pole piece. The said armature 78 carries a pivoted pawl 79 adapted to coöperate with primary ratchet 72. Spring 81, which is suitably secured to armature 78 has a free end resting against the left front portion of pawl 79. The adjustable stop screw 82 acts as a stop for armature 78 and also co-

operates with pawl 79, thus when armature 78 is attracted moving away from stop 82, the spring 81 rotates pawl 79 on its pivot 80, thus bringing it into engagement with a tooth of ratchet 72. The continuation of movement of armature 78 then advances or rotates ratchet 72 until the beveled portion 79′ of pawl 79 engages the beveled portion of stop 83 and it will be seen that the pawl is thus locked in engagement with a tooth of ratchet wheel 72, preventing any overrun of the primary shaft PS, due to the momentum received from its advance. Retaining pawl 84 is pivotally secured to supporting stud 85, being held in engagement with ratchet wheel 72 by spring 86.

Secondary shaft SS, which is preferably square is suitably journaled in the horizontal extensions of frame 60 and is adapted to receive rectilinear movement only. At the lower end of shaft SS is the stop 87 normally resting against the lower surface of frame 60. Screws 88 clamp said stop 87 and member 71 against opposite faces of shaft SS, both of the said members 87 and 71 being adjustable. At the upper left side of shaft SS in Fig. 3, are ratchet teeth 89, the said teeth being adapted to be engaged by pawl 108 of secondary magnet SM. On the right hand side of secondary shaft SS, the teeth 90 are cut, as shown in Fig. 3, the said teeth being engaged by retaining pawl 91 to hold shaft SS in its actuated position. The retaining pawl 91 is pivoted by shaft 92 to the vertical front supporting bar 93. The said pawl 91 is held in engagement with teeth 90 by spring 94. The extension 91′ of pawl 91 is adapted to be engaged by the extension 84′ of pawl 84 when the said pawl 84 is operated upon release of the switch. The secondary shaft restoring spring 95 is secured at its lower end to stud 96 which is fastened to the frame 60, the upper end of spring 95 being hooked over the lever 97. The lever 97 is adjustably fastened to secondary shaft SS by means of screw 98, the said screw 98 working in the slot shown at the forward end of lever 97. The lever 97 is pivoted to the downward extending bracket 99. The said spring 95 holds secondary shaft SS in its normal position with stop 87 resting against the lower surface of frame 60. The off-normal plate 100 extends through openings in the upper and lower extensions of frame 60 being arranged alongside of secondary shaft SS. The said plate 100 is loose in the said frame and is adapted to be carried downward when the secondary shaft SS is actuated upon its first movement. At the upper end of bar 100 is an extension 101 having an opening through which secondary shaft SS extends as shown in Fig. 6. The secondary off-normal springs SON rest under tension on the said extension 101 being held in their normal position thereby. The lower end of plate 100 rests against stop 87 thus when shaft SS is moved downward the springs SON move plate 100 downward until extension 101 rests against the upper surface of the upper extension of frame 60. Upon the restoration of secondary shaft SS, stop 87 again engages the lower end of bar 100 carrying it upward and restoring the springs SON. The small projecting portion or dog 102 of plate 100 is adapted to be moved into engagement with a tooth of the primary ratchet 72 when the plate 100 is moved downward. This is to prevent undue tension or pressure against the sides of the bank contacts when the wipers are being restored from their secondary movement, as will be more fully explained. Secondary magnet SM is mounted on the vertical portion of frame 60 and also secured to the upper horizontal extension 105′ of frame 60 at its forward end. Armature 103 of secondary magnet SM is pivoted at rear plate 104 and front plate 105, the said plates being suitably secured to the core and end pole pieces 106 of magnet SM. Spring 107 is suitably fastened to plate 105 of magnet SM and has its upper end engaging armature 103. Pawl 108 is pivoted to armature 103 normally resting against the lower surface of extension 105′ of plate 105. The said extension 105′ serves as a stop for armature 103, also being adapted to move pawl 108 out of engagement with teeth 89 of secondary shaft SS upon each restoration of armature 103. Upon the attraction of armature 103, pawl 108 moves downward and away from stop 105′ and by means of spring 109 is rotated on its pivot and into engagement with teeth 89 of secondary shaft SS. Continuing it its downward movement pawl 108 moves shaft SS downward until the beveled portion 108′ engages the beveled surface of stop 110′ and as in the case of the primary ratchet, locking the actuating pawl and preventing any overrun of shaft SS due to the momentum received from its advancement.

Release magnet RM is rigidly fastened in a suitable manner to the vertical back of frame 60 and has an armature 110 pivoted at the forward end of pole piece 111. The lower end of armature 110 is adapted when attracted to engage the extension 84^2 of primary retaining pawl 84, this moving said pawl out of engagement with primary ratch 72.

Operation of selector or connector switch.—Having described in general the construction of the switch illustrated in Figs. 3 to 7, the operation of said switch will now be described. The primary magnet PM is first energized and deënergized attracting and detracting its armature 78 and for each operation of said magnet PM pawl

79 engages primary ratchet 72 advancing the wipers 23, 24, 25 one step in a primary direction continuing to a point opposite the desired bank 64. It will be noticed that the wipers travel along below the lowest contact set of the contact banks in their primary movement keeping clear of the said bank contacts. Upon the first primary step of the wipers, arm 76, which is carried by primary shaft PS and secured to its upper end, moves insulated stud 77 toward the left away from the primary off-normal switch PON allowing said switch to assume an alternate position. The secondary magnet SM is now energized and deënergized stepping shaft SS downward, and the wiper carrying plate 67 being connected to plate 71, the said plate 67 is rotated about its pivot 68 stepping the wipers 23, 24, 25, upward along the row of contacts of the selected bank. Upon the first secondary step of shaft SS stop 87, which is secured to its lower end, moves downward, allowing the secondary off-normal springs SON to move the plate 100 downward until extension 101 rests upon the upper surface of the upper horizontal extension of frame 60. The contact springs of secondary off-normal switch SON, due to this movement, have assumed their alternate position. Also, upon the downward movement of plate 100, the dog 102 engages a tooth of primary ratchet 72, locking said primary ratchet until plate 100 is restored.

To release the switch mechanism, release magnet RM is energized attracting its armature 110, which engages extension 84² of pawl 84 rotating said pawl on its pivot and moving it out of engagement with primary ratchet 72. It will be seen that if ratchet 72 were not at this time locked by some auxiliary means, the tension of spring 73 would immediately tend to press wipers 23, 25 against the sides of contacts 26 and 28 and cause undue friction while the wipers are restoring from their secondary movement.

It will be remembered that dog 102 has engaged a tooth of ratchet wheel 72, thus preventing this undue pressure against the sides of the bank contacts until said dog has been released from its engagement with the ratchet wheel 72, which does not occur until the secondary shaft SS reaches normal.

Returning now to the operation of the release magnet, the armature 102 having disengaged pawl 84 from ratchet wheel 72, the extension 84′ engages extension 91′ of secondary pawl 91, moving it away from shaft SS and disengaging the said pawl 91 from the teeth 90 of secondary shaft SS. The primary shaft PS being locked by dog 102, the secondary shaft SS will be the first to restore, this being effected by the restoring spring 95 which acts upon secondary shaft SS through lever 97. Secondary shaft SS now moves upward thus restoring wipers 23, 24, 25 from the secondary movement, the shaft continuing upward until block 87 engages the lower surface of frame 60. The upward movement of block 87 also restores plate 100, thus disengaging dog 102 from ratchet 72 and restoring the secondary off-normal switch SON. As soon as dog 102 disengages from ratchet wheel 72 the restoring spring 73 acts upon primary shaft PS, restoring wipers 23, 24, 25 from their primary movement until the arm 75, which is secured to the upper end of shaft PS, engages its stop pin. The restoration of shaft PS also causes the restoration of the primary off-normal switch, due to the engagement of said switch by the insulated stud 77, which is carried by arm 76. The switch and all its associated mechanism is now at normal.

Operation of system Fig. 1.—Having described in general some of the relays and switch contact springs of the system of Fig. 1 and the switches used in connection therewith, the operation of the said system in completing a connection from a calling to a called subscriber will now be described.

Assuming that the subscriber at sub-station A desires to connect with a subscriber at sub-station E whose number we will assume is 234, the subscriber at A removes receiver 4 from its switch hook 1, allowing said switch hook to move upward and close connection with the upper contacts. A circuit for the line relay LR is thereby established, traced from ground at normal contact 120 of relay COR, line limb 11, transmitter 5, switch hook 1, and contact 1′, contacts 8, winding of coil 6, line limb 10, alternate contact 121, off-normal contact ON through the winding of line relay LR to battery, energizing the said relay. Responsive to the said energization, a circuit for motor magnet MM is established from ground through alternate contact 122 and the winding of motor magnet MM to alternating current generator. The said magnet MM is thereupon energized advancing wipers 17, 18, 19, engaging respectively with the first set of contacts 20, 21, and 22, which are connected to a first selector C. On the first step of wipers 17, 18 and 19, off-normal switch ON is moved to its alternate position thereby opening the initial energizing circuit for relay LR. Assuming that the first selector switch with which contacts 17, 18 and 19 connect is busy, there will be a ground upon private contact 20 and a locking circuit for relay LR will be established from the said ground over wiper 17, switch contact 13, through alternate contact 123 and winding of relay LR to battery. The motor magnet thereupon advances wipers 17, 18 and 19 another step and if the second set of contacts lead to a busy first selector switch, line relay LR remains energized and motor magnet MM continues to advance wipers 17,

18 and 19 until an idle set of contacts 20, 21 and 22, are connected with. Assuming that switch C of Fig. 1, part 2, is the idle switch connected with, there will be no ground upon contact 20 and the locking circuit for relay LR being interrupted its armature will retract opening the energizing circuit for motor magnet MM, thus preventing any further advance of the wipers 17, 18 and 19. Upon the deënergization of relay LR a circuit for impulse relay IR′ of switch C is established from ground at normal contact 122 through normal contact 12, normal contact 124, talking conductor S, wiper 19 and bank contact 22 through the winding of relay IR′ to battery, energizing the said relay. Responsive to the energization of relay IR′ a circuit for relay 125 is established from ground through alternate contact 126 of relay IR′, normal contact 127, normal contact 128, through the winding of relay 125 to battery energizing said relay. Responsive to energization of relay 125, an energizing circuit is established for relay IR from battery through the winding of relay IR′, conductor 129, alternate contact 130, conductor 131 and winding of relay IR to ground energizing said relay IR. Also, upon energization of relay 125 a circuit for cut-off relay COR is established from ground through alternate contact 132, contact 133, bank contact 20, wiper 17, switch contact 13, normal contact 123 and the winding of said cut-off relay COR to battery, energizing said relay COR.

Returning now to relay IR. Upon its energization a circuit for main release relay MRR is established through alternate contact 134 and winding of relay MRR to battery. Relay MRR is thereupon energized establishing a new locking circuit for relay COR from ground at contact 135. The resistance which is connected between ground and contact 135 is for the purpose of reducing the current consumption of the cut-off relay COR, as the said relay remains energized until the calling subscriber restores his receiver to its switch-hook. Upon the energization of relay MRR the energizing circuit for relay 125 is opened at contact 128 thus allowing relay 125 to restore and open the initial energizing circuit for relay IR, at contact 130. But the relay COR having been energized before relay 125 retracted its armature, a new path for energizing relays IR and IR′ was established, the said circuit being traced as follows: from battery through the winding of relay IR′, bank contact 22, wiper 19, alternate contact 121, line limb 10, through the sub-station A, returning over line limb 11, alternate contact 120, wiper 18, bank contact 21, and the winding of relay IR to ground. The said ground from contact 135 also renders all multiples of private contact 20 busy, preventing other line switches from connecting with switch C.

The line of the calling subscriber at A has now been extended to the first selector C, and relays IR and IR′ are energized over the path just traced including sub-station A. This path includes the winding of magnet 6 which is energized by the current in said path, thereby unlocking calling device 7. The subscriber at sub-station A now revolves the dial 7 until two insulated projections have passed impulse springs 8. The subscriber then releases the dial and it is restored, opening and closing impulse springs 8 two times. The opening and closing of the said impulse springs 8 causes two interruptions of the previously described circuit of relays IR and IR′, and they retract and attract their armatures two times. Responsive to the operations of the said relays IR and IR′ two current impulses are transmitted through primary magnet PM and two current impulses are transmitted through secondary relay SR. Although when relay IR is operated, the circuit through relay MRR is interrupted, said relay MRR being sluggish or slow acting, does not retract its armature until its circuit is interrupted for a comparatively long interval. Upon the first deënergization of relay IR′ the first current impulse through relay SR is established from ground through normal contact 126, alternate contact 136 of relay MRR which is maintained actuated, and the winding of relay SR to battery energizing relay SR. Relay IR′ is again immediately energized thus opening this circuit, but relay SR being a slow acting relay, it will be seen that it retains its armature in an attracted position while the circuit of relay IR′ is being interrupted. The impulses which operate primary magnet PM are traced from ground through normal contact 134 of relay IR, alternate contact 137, conductor P, normal contact 138, through the winding of said magnet PM to battery. For each current impulse transmitted from ground at normal contact 134, the primary magnet PM advances wipers 23, 24, 25, one step in a primary direction and, as previously stated, the subscriber having caused two interruptions of the energizing circuit for relays IR and IR′, the wipers 23, 24, 25 are stepped to a point adjacent the second group of bank contacts, which are the contacts leading to connector switches D, which have access to the one hundred line group with which the line of the calling subscriber B is associated.

After the last interruption of the circuit for relays IR and IR′, the said relays remain energized and relay SR has its energizing circuit open long enough at normal contact 126 to allow it to retract its armature. Responsive thereto, a circuit for busy relay BR is established from ground at normal contact 139 of relay SR, conductor S, conductor 140, normal contact 141 of switch

SON, through alternate contact 142 of switch PON, which moved to its alternate position upon the first primary movement of the wipers, then through the winding of relay BR to battery. The said relay BR is thereupon energized and a circuit for secondary magnet SM is established from ground through alternate contact 143 of relay BR, normal contact 144, through winding of secondary magnet SM to alternating current generator. Responsive to current from the said generator, secondary magnet SM steps wipers 23, 24, and 25 into engagement with the first set of contacts 26, 27 and 28 of the selected group. Upon the first secondary step of wipers 23, 24, 25, switch SON moves to its alternate position thereby disconnecting primary magnet PM from conductor P and by means of contact 141 opening the initial energizing circuit for relay BR.

Assuming that the first set of contacts, 26, 27, 28, with which wipers 23, 24, and 25 have connected lead to a busy connector switch D, there will be a ground upon contact 26 as will be hereinafter described, and a locking circuit for relay BR is established from the said ground through wiper 23, normal contact 145, normal contact 146, through alternate contact 147 and the winding of relay BR to battery. The energizing circuit for magnet SM is therefore maintained and its armature is again attracted advancing wipers 23, 24, 25 into engagement with the next set of contacts. Thus, it will be seen that as long as wiper 23 is engaging grounded bank contacts 26 leading to busy connector switches, the busy relay BR is maintained energized and magnet SM continues to advance wipers 23, 24, 25. Assuming now that the connector switch D illustrated in Fig. 1, part 3, is the first idle one of the group, upon connection with its private contact 26 by wiper 23, the locking circuit for relay BR is interrupted and the said relay retracts its armature thus opening the circuit for magnet SM and preventing any further advance of the wipers 23, 24, 25. Upon deënergization of relay BR a busy or ground condition is placed upon bank contact 26 and all of its multiples to prevent the said connector switch D from being selected by any other selector switch. This ground connection is traced from ground at normal contact 147 of relay BR, normal contact 146, normal contact 145, and wiper 23 to bank contacts 26. The line of the calling subscriber has now been extended to the terminals 26, 27, 28 leading to connector switch D. The subscriber at A now operates calling device 7 to cause three interruptions of the energizing circuit for relays IR and IR'. Responsive to the said interruption impulses are transmitted through secondary relay SR which again maintains its armature attracted until after the last impulse of the set has been transmitted, as previously described. Responsive to the three interruptions of the circuit of relay IR, three impulses are transmitted from ground through its normal contact 134, alternate contact 137, conductor P, normal contact 148, wiper 24, bank contact 27, conductor P, normal contact 149, normal contact 150 of switching relay SW, through the winding of primary magnet PM' to battery. Responsive to the said three impulses, primary magnet PM' steps wipers 29, 30 and 31 to a point adjacent the third group of ten bank contacts or line terminals with which the line terminals of the called for sub-station E is associated.

After the last impulse has been transmitted from relays IR and IR' the secondary relay SR retracts its armature as before and a secondary impulse is transmitted from ground through its normal contact 139, normal contact 151, wiper 25, bank contact 28, conductor S, alternate contact 152 of switch PON', which closed upon the first primary movement of wipers 29, 30 and 31, through the winding of switching relay SW to battery. Switching relay SW is thereupon energized and by means of contact 150, primary magnet PM' is disconnected and the secondary magnet SM' is connected to conductor P. A locking circuit for relay SW is also established upon its energization from ground at normal contact 153 of release relay RR', through alternate contact 154 of relay SW to battery. The calling subscriber at sub-station A now operates the calling device 7 to interrupt the circuits of relays IR and IR' four times. Responsive to the said interruptions four impulses are transmitted from relay IR' through secondary relay SR, thus maintaining the armature of said relay SR attracted while the impulses are being transmitted, as previously described.

Due to the four interruptions of the energizing circuit for relay IR, four impulses are transmitted through the secondary magnet SM' of connecter switch D, being traced as follows: from ground through normal contact 134 of relay IR, alternate contact 137, wiper 24, bank contact 27, conductor P of connector D, normal contact 149, alternate contact 150 of switching relay SW, through the winding of secondary magnet SM' to battery. Responsive to the said four current impulses, secondary magnet SM' operates its armature four times stepping wipers 29, 30 and 31 in a secondary direction into engagement with the fourth set of contacts in the selected group which are contacts 32, 33, and 34 and are the terminals of the line of the called for substation E.

After the last one of the four primary impulses has been transmitted a secondary im-

pulse is transmitted from relay SR as previously described, energizing relay SR′ of connector switch D over a path traced from ground through normal contact 139 of relay SR, wiper 25, bank contact 28, off-normal switch SON′ which closed upon the first secondary movement of wipers 29, 30 and 31, through normal contact 155 and winding of relay SR′ to battery. Relay SR′ is thereupon energized and a circuit for relay 156 is established from ground at normal contact 153, conductor 157, through alternate contact 158 of relay SR′ and the winding of relay 156 to battery. Relay 156 is thereupon energized and a locking circuit therefor is established from the same ground at normal contact 153, through alternate contact 159 and the winding of relay 156 to battery. Also, upon energization of relay SR′ the test relay TR is connected to the private wiper 29, the said connection being established over the following path: from said relay TR through normal contact 160, alternate contact 161 of relay SR′ to wiper 29.

Called line idle.—The operation of the switches up to the point just described is the same whether connected to an idle or a busy line, but from this point on the operation is different when connecting to an idle or a busy line. Assuming that the line of the called for subscriber is idle, there will be no ground or busy condition upon its private contact 32, and the test relay TR which was connected to the said contact 32 upon the energization of relay SR′, does not attract its armature as the connection is from battery to battery. It will be remembered that relay 156 became energized as soon as contact 158 of relay SR′ closed and upon energization of said relay 156 the energizing circuit for secondary relay SR′ was interrupted at contact 155 of relay 156. Therefore, secondary relay SR′ deënergized retracting its armature and disconnecting test relay TR from wiper 29. Upon the said deenergization of relay SR′, ringing control relay RCR is connected to wiper 29 and a series energizing circuit for said relay RCR and cut-off relay COR′ is established from ground through the winding of said relay RCR, alternate contact 162, normal contact 161, wiper 29, bank contact 32, normal contact 123′ and the winding of relay COR′ to battery. The ringing control relay RCR and the cut-off relay COR′ are thereupon energized, the energization of the cut-off relay removing the substation control of line relay LR′. The private contact 32 now being grounded through the winding of relay RCR, the multiple bank contacts are of course grounded and thereby prevent any other connector from connecting any other calling subscriber with the subscriber at A.

Responsive to the energization of relay RCR, a circuit for the so called flip-flap relay 167 is established from ground at normal contact 153 of relay RR′, conductor 157, branch conductor 168, alternate contact 169, conductor 170, normal contact 171, the winding of relay 167 and the live segment of interrupter wheel I′ to battery. Relay 167 is thereupon energized connecting ringing current from generator G through the lower segment of interrupter wheel I, alternate contact 172, wiper 31, contact 34, line limb 10′, condenser 3′, call bell 2′, the lower contacts of the switch hook returning over line limb 11′, contact 33, wiper 30, conductor 173, alternate contact 174, impedance coil 175 and through battery to ground. The interrupter wheels I and I′ are being revolved in a clock-wise direction and generator G is disconnected as soon as the insulation strip of wheel I comes into contact with its brush. The wheels continue in their movement, the upper half of wheel I connecting ground to the alternate contact 172. At this time relay 167 is still connected to battery through the live segment of interrupter wheel I′ and ground being connected to alternate contact 172 from the grounded segment of wheel I, any charge which the line or condenser of the called for subscriber may accumulate from the ringing current, is discharged through the said ground connection. This ground connection with the segment of wheel I is only momentary, as the interrupter wheels continuing in their movement, the energizing circuit for relay 167 is interrupted as soon as the dead segment of wheel I′ connects with its brush and it retracts its armature.

Upon deënergization of relay 167, control relay CR, is connected to the line of the called for subscriber, the said connection being traced from ground through the winding of said relay CR, alternate contact 176, normal contact 172, wiper 31 to bank contact 34 and line limb 10′. The other line limb 11′ is connected to battery through impedance coil 175, as previously described, but the subscriber not having responded as yet, condenser 3′ prevents a flow of current from the battery at impedance coil 175 out over the line and back through control relay CR to ground. Thus it will be seen that the interrupter wheels I and I′ continue to revolve, alternately connecting generator G and control relay CR to wiper 31 and terminal 34 of the called for subscriber's line. The subscriber now responding to the call, removes his receiver from its switch hook and as soon as relay 167 deënergizes a circuit for control relay CR is established from ground through the winding of said relay CR, alternate contact 176, normal contact 172, wiper 31, bank contact 34, line limb 10′, sub-station E and line limb 11′, contact 33, wiper 30, conductor 173, alternate contact

174, impedance coil 175 to battery. Control relay CR is thereupon energized and is now under the control of the called for subscriber, as its energizing circuit is established over the line limbs and through the sub-station E.

Responsive to the energization of relay CR, talking control relay TC is energized over a path traced from ground at normal contact 153 or relay RR′, conductor 157, conductor 168, alternate contact 169, alternate contact 177 through the winding of said relay TC to battery. Upon the energization of relay TC, the circuit of relay 167 is interrupted at contact 171 of relay TC, thus rendering relay 167 inert and preventing any further application of ringing current to called line. Also upon energization of relay TC, a ground connection to private contact 26 is established from ground at alternate contact 178 of relay CR, alternate contact 179, relay TC to contact 26. This ground connection is for the purpose of shunting release relay RR′ after the called for subscriber has responded, thus preventing the release of connector switch D by the calling subscriber and rendering the release of the said switch under the control of the called for subscriber. Also, responsive to energization of relay TC, alternate contacts 180, and 181 are closed, thus establishing the continuity of the talking circuit connecting the calling and called subscriber, which is traced along the heavily marked conductors and in which are interposed the condensers 182 and 183 at first selector switch C. The sub-stations are now connected in a conversational circuit, talking current for the calling subscriber is supplied over the previously traced path including relays IR and IR′ and talking current for the called subscriber is supplied from battery through impedance coil 175 returning through control relay CR to ground over the previously described path.

Release of completed connection Fig. 1.— Assuming now that the subscribers have finished conversation, by replacing their receivers upon their respective switch hooks, the switches which were used in establishing the connection will be released. In this instance the release of the line switch B and first selector C is under the control of the calling subscriber and the release of the connector switch D is under the control of the called subscriber. Assuming now that the subscriber at A be the first to replace his receiver upon its switch hook, the previously described energizing circuit for impulse relays IR and IR′, is interrupted at the upper contacts of switch hook 1. The said relays IR and IR′ are thereupon deënergized, restoring their contacts to normal and interrupting the circuit for the main release relay MRR, at alternate contact 134 of relay IR. Main release relay MRR is thereupon deënergized restoring its contacts to normal and establishing an energizing circuit for release relay RR, traced from ground through normal contact 126 of relay IR′, normal contact 136, alternate contact 142′ of switch PON, through the winding of release relay RR to battery. Relay RR is thereupon energized, attracting its armature and closing a circuit from battery through the winding of said relay BR, alternate contact 184 to the ground connection which is established from relay IR′ for energizing relay RR. Relay BR is energized responsive to the said established circuit, thus opening the connections from wipers 24 and 25 at contacts 148 and 151. Responsive to the energization of release relay RR, alternate contact 146 connects battery to wiper 23, but this has no effect upon connector switch D at this time as it will be remembered that private contact 26 is connected to ground at alternate contact 178 of relay CR, thus shunting relay RR′ of connector D.

Returning now to relay BR, upon its energization, a circuit for release magnet RM is established from ground, through alternate contact 143, alternate contact 144, through winding of release magnet RM to battery, energizing said magnet. Upon energization of the said release magnet, the retaining pawls holding wipers 23, 24, 25 in connection with contacts 26, 27, and 28 is withdrawn allowing the said wipers to be restored to normal. Upon restoration of the wipers, secondary off-normal switch SON is first restored to its normal position and thereafter primary off-normal switch PON is restored to normal as previously described. Upon restoration of switch PON, the energizing circuit for relays RR and BR is interrupted at contact 142′ thus allowing said relays BR and RR to deënergize. Upon the deënergization of said relays the circuit for release magnet RM is interrupted allowing the said magnet to deënergize and retract its armature. Switch C and its associated mechanisms are now at normal.

Returning now to main release relay MRR. Upon its deënergization, as previously described, the circuit for magnet COR of line switch B is interrupted at contact 135 of relay MRR. The said magnet COR is thereupon deënergized withdrawing the retaining pawl from connection with the ratchet wheel for wipers 17, 18 and 19, thus allowing the said wipers to be restored to normal as previously described. Upon deenergization of magnet COR, the connection between switch springs 13 is interrupted, thus disconnecting the winding of release magnet COR from wiper 17 while it is restoring and wiping back over bank contacts 20. Upon restoration of the wipers 17, 18 and 19 to normal, the switch springs 13 are

again restored to normal as described in connection with Fig. 2. Also, upon restoration of wipers 17, 18, and 19 to normal, switch springs 12 and off normal springs ON are restored to normal as previously described in connection with the switch of Fig. 2. Line switch B and its associated mechanism having been restored to normal, it is available for again extending the line of sub-station A to an idle first selector upon initiation of another call.

To release the connector switch D, the receiver at sub-station E is replaced upon its switch hook. Upon the restoration of the said receiver the circuit for control relay CR which was previously described as extending over the line limbs and through the sub-station E is interrupted. The said relay CR is thereupon deënergized establishing an energizing circuit for release relay RR′ traced from ground through winding of said relay RR′, the left spring contact of switch PON′ along conductor 186, through alternate contact 179, normal contact 178, through resistance 187 to battery. Release relay RR′ is thereupon energized and interrupts at its normal contact 153, the locking circuit for switch relay SW, relay 156 and talking control relay TC, allowing said relays to deenergize. Upon deënergization of relay TC the wipers 30, and 31 are disconnected from the talking strands thus preventing any interference with any existing connections while the said wipers are wiping back over the bank contacts of the group in restoring. Upon deënergization of relay 156 the series energizing circuit for ringing control relay RCR and cut-off relay COR′ is interrupted at contact 162 allowing the said relays to deenergize.

Returning now to the release relay RR′. Upon its said energization a circuit for release magnet RM′ is established from ground through alternate contact 153 of relay RR′ and through the winding of release magnet RM′ to battery. The release magnet RM′ is thereupon energized withdrawing the retaining pawls and allowing the wipers 29, 30 and 31 to restore to normal. While the wipers are restoring it is necessary to maintain the release magnet energized and therefore a locking circuit for release relay RR′ is established upon its energization, the said locking circuit being traced from battery through resistance 187 and alternate contact 188 to conductor 186 and back through contact 189 and the winding of release relay RR′ to ground. Upon the restoration of the wipers to normal, primary off-normal switch PON′ is restored to its normal position interrupting at contact 189 the locking circuit for release relay RR′ allowing said relay to restore and interrupt the circuit of release magnet RM′. The secondary off-normal switch SON′ having been restored to normal upon restoration of the wipers 29, 30, and 31 from their secondary movement, the switch D and its associated mechanism is now at normal and available for further use in establishing other connections.

Called line busy.—We will assume now that the calling subscriber has extended his line circuit through first selector C and connector D to the terminals 32, 33 and 34 of the line of the called for subscriber at E and that the said called line is busy.

It will be remembered that after wipers 29, 30, and 31 connected to the line terminals 32, 33, 34 respectively, a last secondary impulse was transmitted over the secondary conductor energizing secondary relay SR′ of connector D and thereby connecting test relay TR through alternate contact 161 of relay SR′ to the private wiper 29. The line of the called subscriber at E being busy there will be a ground connection upon contact 32, either from a first selector if the line be calling, or if it be a called line, from a connector switch, which is connected to one of the multiple contact sets 32, 33, 34. Therefore the contact 32 being grounded, a circuit for test relay TR is established from the said ground at contact 32 back over wiper 29 through alternate contact 161, contact 160 and the winding of said relay TR to battery. The relay TR is thereupon energized and a locking circuit therefor is established through its locking contact 160′ down over conductor 157 to ground at normal contact 153 of relay RR′.

It will be remembered that upon the energization of relay SR′ relay 156 was energized thus interrupting the circuit for relay SR′ at contact 155. Therefore, to prevent relay SR′ from again restoring and connecting relay RCR to wiper 29, a locking circuit is established from ground through alternate contact 190 of test relay TR and through the winding of said relay SR′ to battery. Also, responsive to the energization of test relay TR a characteristic busy signal is connected to the secondary conductor S, to notify the calling subscriber that the line of the called subscriber is busy. Thus busy signal may be traced from busy back BB, through alternate contact 191 to secondary talking conductor S, back along the same conductor and out over limb 10, through the receiver of the calling subscriber at A back over the limb 11 and along the primary talking conductor P through the winding of relay IR at first selector C to ground. The subscriber at A receiving the busy signal, may by replacing his receiver upon his switch hook, restore the switches which were used in establishing this connection to normal.

Assuming that the calling subscriber replaces his receiver upon its switch hook, the

circuit for relays IR and IR′ at first selector C is interrupted as previously described. Responsive to the interruption of the said circuit, the relays IR and IR′ are deënergized thus restoring first selector C and line switch B to normal as previously described. But in this case the connector switch is also restored by the calling subscriber, this being accomplished by the battery impulse which was transmitted from alternate contact 146 of relay RR, to wiper 23, bank contact 26, resistance 192 then downward through alternate contact 189 of switch PON′ through the winding of release relay RR′ to ground. The release relay RR′ is thereupon energized establishing a locking circuit and also establishing an energizing circuit for release magnet RM′ as previously described. Also, responsive to energization of relay RR′ the locking circuits for relay 156, switch relay SW, test relay TR, and talking control relay TC, are interrupted, allowing the said relays to restore. Upon deënergization of test relay TR, the energizing circuit for secondary relay SR′ is interrupted at contact 190, allowing said relay to deënergize. The release magnet RM′ having been energized the switch is restored as previously described and all of the relays having been deënergized, switch D and its associated mechanism are now at normal and available for another connection.

Should a subscriber, after starting a call, desire not to complete it, by replacing his receiver upon its switch hook, all of the switch mechanism which had been operated up to this time would be restored. Should the subscriber at A simply remove his receiver from its switch hook and immediately replace it, line switch B would connect with an idle first selector C, and relays IR and IR′ not finding a circuit over the line limbs, would again restore thus interrupting the circuit for magnet COR as previously described. Should a calling subscriber operate a first selector C, and then replace his receiver upon its switch hook, relays IR and IR′ would deënergize thus interrupting the circuit for magnet COR and establish an energizing circuit for release relay RR, thereby restoring switch C and line switch B as previously described. Should a subscriber extend his line circuit to connector switch D and then operate the said connector switch, he may then, by replacing his receiver upon its switch hook, release all of the switches.

Line switch B^2 of Fig. 8 illustrates diagrammatically a modification of the line switch B of Fig. 1. The said switch B^2 is adapted to operate in connection with first selector C and connector switch D of Fig. 1. The different controlling magnets and mechanism of line switch B^2 have reference numerals to correspond with the corresponding parts of line switch B but the reference numerals of switch B^2 have the suffix ^{2} added. The operation of the switch is somewhat different than the line switch of Fig. 1 being illustrated in Fig. 9.

Line switch Fig. 9 illustrates a preferred mechanical arrangement of switch mechanism adapted to operate in connection with the circuit arrangement of line switch B^2. The corresponding parts, or parts having substantially the same functions in the switches of Fig. 2, and Fig. 9 have the same reference characters but in Fig. 9 the reference characters have the suffix ^{2} added. The switch of Fig. 9 operates differently from that of the switch of Fig. 2 in that the wipers when being released, are advanced to a normal position instead of being restored by a spring, as are the wipers of switch Fig. 2. In Fig. 9 motor magnet MM^2 operates the same as motor magnet MM. Wiper shaft 38^2 is journaled in frame 35^2 and bracket 39^2, and by means of ratchet wheel 40^2 is adapted to be rotated to advance the wipers along the bank of contacts. Contact bank 36^2 is different than contact bank 36 and comprises a pair of clamping plates 37^2 holding ten sets of contacts 20^2, 21^2, and 22^2. Each row of contacts has a plate 197 arranged in parallel with the row of contacts and insulated therefrom. There are three such plates 197, one for each row of contacts in the bank, each plate having a terminal 17^2, 18^2 or 19^2. The plate 197 having terminal 19^2 is arranged below and insulated from the top row of contacts 22^2, the plate 197 having terminal 17^2 is the plate of the middle row of contacts and the plate 197 having terminals 18^2 is the plate of the lower row of contacts 21^2. There are three sets of wipers 19′ mounted on shaft 38^2, one set for each row of bank contacts. Each wiper set comprises two plates in contact and having four projecting arms, the upper part of each arm 19′ being adapted to engage its bank contacts and its lower arm being adapted to engage the corresponding plate 197. Thus when a wiper 19′ is advanced into engagement with a bank contact the upper and lower arm electrically connect the engaged contact with its plate 197 through the connecting wipers. Thus it will be seen that the trunks leading to the first selectors are connected to bank contacts 20^2, 21^2 and 22^2 while the talking conductors and private conductor leading from the subscriber's line, are connected to terminals 17^2, 18^2 and 19^2 of the plates 197, so in this switch the wipers simply act to connect the bank contacts 20^2, 21^2 and 22^2 to their plates 197. The pivoted member 48^2 is held against an off-normal stud 41^2, due to the action of off normal spring ON^2 pressing against its bottom inclined surface, and also due to release catch

52² resting against its upper arm. When ratchet wheel 40² is moved off normal the stud 41² engaging member 48², moves away from and out of engagement with member 48², thus allowing off normal spring ON² to assume an alternate position due to the upper spring ON² moving upward, thereby moving the lower arm of member 48² toward the left. Spring member 52² has an opening 55² which is adapted to hook over the end of pivoted arm 53² when magnet COR² is energized, thereby allowing springs 12² to assume an alternate position. On retraction of armature 50², release catch 52² is moved toward the left and the vertical arm of member 53² is moved thereby, this moving switch springs 13² to their alternate position. To again lift catch 52² out of engagement with arm 53², the wiper shaft 38² is rotated by motor magnet MM² until the next stud 41² engages the lower lefthand projection of member 48², moving the lower arm of member 48² toward the right, thereby causing the upper arm of said member 48² to engage catch 52², lifting it out of engagement with pivoted member 53², and allowing springs 13² and 12² to again assume their normal position. At this time the wipers are in a position corresponding to that shown in Fig. 9 and magnet MM² being disconnected by action of springs 13² the switch wipers remain in this position until initiation of another call.

Operation of system including line switch Fig. 8.—The line switch B² of Fig. 8, as previously stated, is adapted to operate in connection with first selector C and connector switch D, the operation being as follows: Assuming a subscriber at the sub-station A² desires a connection with another subscriber he will remove his receiver from its switch hook, thereby establishing an energizing circuit for line relay LR² traced from ground at normal contact 120² out over the line limbs and through sub-station A², back over normal contact 121², contact ON², winding of relay, LR² to battery. Line relay LR² is thereby energized, closing an energizing circuit for motor magnet MM² which steps the wipers forward into engagement with the first set of contacts, thus connecting line switch B² with terminals 20, 21 and 22 leading to a first selector C. If the first first-selector switch of the group is busy, there will be ground upon contact 20, and line relay LR² remains energized over a locking circuit established from the said ground, motor magnet MM² advancing the wipers to the next set of contacts. If the second set of contacts lead to a busy first selector switch, line relay LR² remains energized and magnet MM² continues to advance the wipers until terminals 20, 21 and 22 of an idle first selector switch are connected with.

As previously stated, an idle first selector switch has no ground or busy connection to its private terminal 20 and therefore line relay LR² deënergizers, interrupting the energizing circuit for motor magnet MM². Upon deënergization of line relay LR² an energizing circuit for impulse relay LR′ is established from the ground at normal contact 122² at relay LR², contact 12², normal contact 124² to lower heavily marked conductor, wiper 19², contact 22 through the winding of relay IR′ to battery. Responsive to the energization of relay IR′, relays 125, IR and MMR are energized as previously described. Upon energization of relay 125 magnet COR² is energized over a path from ground at contact 132 of said relay 125, as previously described thus energizing the said magnet COR². Upon complete energization of magnet COR² contact spring 12² is moved to its alternate position, the said spring 12² remaining in its alternate position until the wipers of switch B² have been restored to a normal position. The calling subscriber at A² desiring to extend his line to a called for subscriber, operates calling device 7² the proper number of times as previously described, thereby operating a first selector C and connecting switch D to connect with the called for line.

The operation of the first selector switch C and connector switch D in this instance is the same as previously described. After the subscribers have finished conversation the called for subscriber may, by replacing his receiver upon its switch hook restore connector switch D as previously described, and the calling subscriber, by replacing his receiver upon its switch hook, interrupts the circuit of relays IR and IR′, thus causing the restoration of first selector switch C as previously described. Upon the deënergization of the main release relay MMR of first selector C the locking circuit for magnet COR² is interrupted at contact 135, allowing the said magnet to deënergize and retract its armature. Upon deënergization of said magnet COR², switch springs 13² are moved to their alternate position and an energizing circuit for relay LR² is established from ground at the lower spring contact of switch 13², through the winding of relay LR² to battery. On energization of relay LR² a circuit is again closed through magnet MM² from ground at alternate contact 122² and motor magnet MM² advances the wipers until they assume a position as shown in Fig. 9. When the wipers are moved into this position, switch springs 13² are restored to normal through the operation of arm 48² and thereby interrupt the energizing circuit for relay LR² which deënergizes and interrupts the energizing circuit for motor magnet MM². Also upon movement of the wipers into a normal position, off normal spring ON² is restored to its normal position. The

line switch B^2 and its associated mechanism are now at normal and available for further use.

System including Fig. 10.—The line switch B^3 and first selector C^3 of Fig. 10 are adapted to operate in connection with a connector switch D of Fig. 1. As a switch structure for line switch B^3, I preferably employ the switch illustrated in Fig. 2 but without the use of the switch springs 12. I also provide four wipers instead of three as illustrated in switch of Fig. 2, and also four rows of bank contacts. The relays, magnets and switch contact springs of the line switch B^3, and first selector C^3 of Fig. 10 are indicated by reference characters corresponding to the like parts, or parts having substantially the same functions of the line switch and first selector shown in Fig. 1, but in Fig. 10 the reference characters have the suffix ^{3}.

In view of the general description of line switch B and first selector C of Fig. 1 it is believed a general description of line switch B^3 and first selector C^3 of Fig. 10 is not necessary.

Operation Fig. 10.—Assuming a subscriber at sub-station A^3 desires connection with another subscriber, he will remove his receiver from its switch hook, thereby establishing an energizing circuit for line relay LR^3 over the previously described path. Line relay LR^3 is thereby energized closing an energizing circuit through motor magnet MM^3 and advancing wipers 17^3, 17^4, 18^3 and 19^3 into engagement with the first set of contacts 20^3, 20^4, 21^3, 22^3 respectively, leading to a first selector switch C^3. If this first selector switch is busy, a locking circuit for relay LR^3 is established from ground through wiper 17^3, over a path as previously described, maintaining relay LR^3 energized and motor magnet MM^3 therefor, advances the wipers until the terminals of an idle first selector C^3 are connected with. As indicated at first selector switch C^3, which is an idle switch, the private terminal 20^3 has no ground connection, and therefore when wiper 17^3 connects with contact 20^3 of switch C^3, relay LR^3 is deënergized interrupting the circuit for motor magnet MM^3 and preventing any further advance of the wipers. Upon deënergization of relay LR^3, an energizing circuit for relay 125^3 of switch C^3 is established from ground through normal contact 122^3, wiper 17^4, contact 20^4, normal contact 127^3, normal contact 128^3, through the winding of said relay 125^3 to battery. Relay 125^3 is thereupon energized establishing a circuit for magnet COR^3 from ground through alternate contact 132^3, normal contact of relay MRR^3, bank contact 20^3, wiper 17^3, switch springs 13^3, normal contact 123^3, through winding of magnet COR^3 to battery, energizing the said magnet and thereby extending the line of the calling subscriber to the terminals 21^3 and 22^3 of first selector switch C^3. Returning now to relay 125^3, upon its energization a circuit for relays IR^3 and IR^4 is established through contact 130^3, thereby energizing relays IR^3 and IR^4. Responsive to energization of relay IR^4, a circuit for relay MRR^3 is established from ground, through contact 194 and the winding of relay MRR^3 to battery. Relay MRR^3 is thereupon energized and by means of contact 135^3 a new locking circuit for magnet COR^3 is established. Also upon energization of relay MRR^3, the energizing circuit for relay 125^3 is interrupted at contact 128^3, allowing said relay 125^3 to deenergize, again interrupting the initial energizing circuit for relays IR^3 and IR^4 which are now maintained energized over a circuit including the line limbs and sub-station as previously described.

To extend connection to a called for subscriber the calling subscriber at sub-station A^3 now operates calling device 7^3, thereby interrupting the circuit for impulse relays IR^3 and IR^4. The operation of relay IR^4 interrupts the circuit for relay MMR^3 at contact 194, but said relay MMR^3 being sluggish it maintains its armature in an attracted position. Also responsive to the operation of relay IR^4, secondary relay SR^3 is energized and being a sluggish relay maintains its armature attracted while relay IR^4 is operating, as previously described.

Responsive to the operations of relay IR^3 current impulses are transmitted through primary magnet PM^3 from ground through alternate contact 136^3 of relay MRR^3, normal contact 134^3, along the upper heavily marked conductor to contact 138^3 of switch SON^3 and the winding of primary magnet PM^3 to battery. Responsive to the impulses, the primary magnet PM^3 steps the wipers in a primary direction to the proper group, as previously described. After the last operation of relays IR^3 and IR^4, secondary relay SR^3 has its circuit interrupted long enough for it to retract its armature and a secondary impulse is thereby transmitted from ground, through normal contact 139^3 to normal contact 141^3 of switch SON^3, then over the previously described path, to relay BR^3. Relay BR^3 is thereupon energized closing a circuit through secondary magnet SM^3, and wipers 23^3, 24^3 and 25^3 are now advanced to connect with an idle connector switch D as previously described. The operation of the connector switch in connection with a called for line is as previously described.

After the subscribers have finished conversation the called for subscriber controls the release of the connector switch and the calling subscriber by replacing his receiver upon its switch hook interrupts the ener-

gizing circuit for relays IR³ and IR⁴. Responsive to the deënergization of said relays IR³ and IR⁴ the energizing circuit for main release relay MRR³ is interrupted at contact 194 and the said relay MRR³ retracts its armature closing an energizing circuit for release relay RR³ from ground at normal contact 136³. The release of the first selector switch responsive to the operation of the release relay RR³ is accomplished as previously described. Also upon deënergization of main release relay MMR³, the energizing circuit for magnet COR³ is interrupted, allowing the said magnet to deenergize and restore line switch B³ to normal as previously described in connection with the release of the line switch B of Fig. 1. The first selector C³ and line switch B³ and their associated mechanisms are now at normal and available for further use.

While I have shown a number of batteries, it is to be understood that in each system, there may be one battery, and the same is also true with respect to the alternating current generators.

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

1. In a telephone system the combination with a substation telephone line, of trunk lines, an automatic spring restored line switch for said line operated upon initiation of a call from said line, to select an idle one of said trunks, a cutoff relay for said line energized after connection with said trunk and means associated with a selected trunk and controlled at said sub-station for deenergizing said relay, whereby said switch is released.

2. In a telephone system the combination with a substation telephone line, of an automatic line switch therefor, a line relay for said line energized upon initiation of a call from said sub-station, said switch being adapted responsive to said energization of the line relay to extend the connection of said line, means for deënergizing the line relay, a cutoff relay, energized responsive to said connection and deënergization of the line relay, and means operated responsive to deënergization of said cutoff relay whereby said switch is restored.

3. In a telephone system the combination with a substation telephone line, of an automatic spring restored line switch therefor, a line relay for controlling the selecting operation of the switch, a cut-off relay for said switch for rendering the line relay inoperative, and mechanism controlled by said cut-off relay for restoring said switch when said switch is operated.

4. In a telephone system the combination with a substation telephone line, of an automatic line switch therefor, a private wiper for said switch, means controlled at the substation for operating said wiper, switch contacts in a normally closed circuit with said wiper, a cutoff relay adapted to be energized after said wiper has been operated and means adapted to be actuated upon deënergization of said cutoff relay, whereby said contacts are operated to place said wiper on open circuit and then release the said wiper.

5. In a telephone system the combination with a substation telephone line, of an automatic line switch therefor, a private wiper for said switch, means controlled at the substation for operating said wiper, switching contacts in circuit with said wiper, a cutoff relay adapted to be energized after said wiper has been operated, and mechanical release means operated by deënergization of said cutoff relay, whereby said wiper is restored and means also operated by the deenergization of said relay, whereby said switch contacts interrupt the circuit of said wiper while restoring.

6. In a telephone system the combination with a substation telephone line, of an automatic line switch therefor, a private wiper for said switch, means controlled at the substation for operating said wiper, switching contacts in circuit with said wiper, a cutoff relay adapted to be energized after said wiper has been operated and means adapted to be operated by deënergization of said cutoff relay, whereby said wiper is restored and means also adapted to be operated by the deenergization of said relay, whereby said switch contacts interrupt the circuit of said wiper while restoring, and means actuated upon restoration of said wipers whereby said contacts again close said circuit.

7. A telephone system comprising a pair of quick acting relays, a source of current, means for closing a circuit to energize said relays, a slow acting relay energized responsive to energization of one of said quick acting relays, means for rapidly interrupting the circuit of said relays, whereby their armatures are vibrated while said slow acting relay maintains its armature attracted, an impulse circuit closed through an alternate contact of said slow acting relay upon each vibration of said quick relays, a secondary slow acting relay energized upon the first vibration of the second quick acting relay and adapted to maintain its armature attracted while said second quick acting relay is vibrating, said secondary relay being adapted to then release its armature to transmit a secondary impulse.

8. In a telephone system, the combination with a metallic line circuit, of a pair of quick acting relays in bridge thereof, a source of current for energizing said relays over said circuit, means for rapidly interrupting said circuit whereby said relays vibrate their armatures, a slow acting relay energized responsive to said energization of one of said quick acting relays, said slow

acting relay being adapted to maintain its armature attracted while said quick acting relay is vibrated, a second slow acting relay energized responsive to the first deënergization of the second quick acting relay, said second slow acting relay being adapted to maintain its armature attracted, while said second quick acting relay is vibrating, an automatic switch operated responsive to the vibration of the armature of one of said quick acting relays and one of said slow acting relays, and release means for said switch controlled by the other slow acting relay.

9. A telephone system comprising a metallic line circuit, a pair of quick acting relays and a source of current in bridge thereof, means for closing the circuit whereby said relays are energized, a slow acting relay energized responsive to said energization of one of said quick acting relays, means for rapidly interrupting said circuit whereby said quick acting relays rapidly retract and attract their armatures while said slow acting relay maintains its armature attracted, an impulse circuit closed through contacts of one of said quick acting relays upon each retraction and through contacts of said slow acting relay, while said slow acting relay maintains its armature attracted, and a secondary slow acting relay energized responsive to the retraction of the second quick acting relay, said secondary relay being adapted to maintain its armature attracted, while said second quick acting relay is rapidly retracting its armature, said secondary relay thereafter retracting its armature to transmit a secondary impulse.

10. A telephone system comprising a substation telephone line, trunk lines, an automatic spring restored line switch for said line operated responsive to initiation of a call over said line to select an idle one of said trunks, a cut-off relay for said line, means associated with said trunk for energizing said cut-off relay responsive to said selection, said means being controlled from the calling substation to deënergize said relay, and release means for said switch thereby rendered effective.

11. A line switch for telephone systems comprising contacts and coöperating wipers, spring restoring means for said wipers, a motor magnet for operating said wipers, a cut-off relay, a line relay, an energizing circuit for the line relay including normally closed contacts of the cut-off relay whereby when the cut-off relay is energized the line relay is not energized, and means mechanically associated with said cut-off relay for controlling a restoration of the wipers.

12. A line switch for telephone systems comprising contacts and coöperating wipers, spring restoring means for the wipers, a motor magnet for operating the wipers, a cut-off relay, a line relay, an energizing circuit for the cut-off relay including normally closed contacts of the line relay whereby when the line relay is energized the cut-off relay cannot be energized, an energizing circuit for the line relay including normally closed contacts of the cut-off relay whereby when the cut-off relay is energized the line relay cannot be energized, and means mechanically associated with said cut-off relay for controlling the restoration of the wipers.

13. A telephone system comprising a substation telephone line, trunk lines, a line relay for said line, an automatic line switch for said line operated responsive to said line relay to select an idle one of said trunks, a cut-off relay for said line, means associated with said trunk for energizing said cut-off relay responsive to such selection, said means being controlled from the calling substation to deënergize said cut-off relay, and manually operated release means for said switch thereby rendered effective.

14. In a telephone system the combination with a substation telephone line, of an automatic switch therefor, spring restoring means for the switch, a plurality of trunk lines, a line relay for controlling the selection of an idle one of said trunk lines by said switch, a cut-off relay for said switch for rendering the line relay inoperative after a trunk is selected, and mechanism controlled by said cut-off relay for operating said first means to restore said switch to normal when disconnection is desired.

15. A telephone system comprising a substation telephone line, trunk lines, a control relay for said line, a non-numerical spring restored switch for said line operated responsive to said control relay to select an idle one of said trunks, a cut-off relay for said line, a circuit including a conductor of said trunks for energizing said cut-off relay, and means controlled from the calling substation to deënergize said cut-off relay to release said switch.

16. A line switch for telephone systems comprising contacts and coöperating wipers, restoring means for said wipers, trunk lines, a motor magnet for operating said wipers to select an idle one of said trunk lines, a cut-off relay energized over a conductor of said selected trunk, and means mechanically associated with said cut-off relay for controlling the restoration of the wipers when said relay deënergizes.

17. In a telephone system the combination with a substation telephone line, of trunk lines, an automatic line switch for said line operated upon initiation of a call from said line to select an idle one of said trunks, holding means for maintaining said switch in its advanced position, a cut-off relay for said line energized over a conductor of said trunk after connection with said

trunk, and means controlled at said substation for deënergizing said relay whereby said holding means is operated to permit the said switch to restore.

18. In a telephone system the combination with a substation telephone line, an automatic spring restored switch individual thereto, a control relay for said line energized upon initiation of a call at said substation, said switch being responsive to the energization of the said control relay to extend the circuit of said line to an idle trunk line, a cut-off relay for said line energized over a conductor of said trunk upon the extension of said line, and means controlled from said substation for deënergizing said cut-off relay whereby the switch is released.

19. A telephone system comprising a subscriber's line provided with a non-numerical trunking switch, a group of trunk lines accessible to said switch, means controlled over said line for operating said switch to automatically select an idle one of said trunk lines, a cut-off relay for said switch energized upon the connection of said switch to an idle one of said trunk lines over a conductor of said trunk independent of the talking conductors, means controlled over the said line for deënergizing said cut-off relay, and mechanical means controlled by the deenergization of said cut off relay to restore said switch.

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

ALFRED H. DYSON.

Witnesses:
GEORGE E. MUELLER,
WM. BERGHAHN.

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