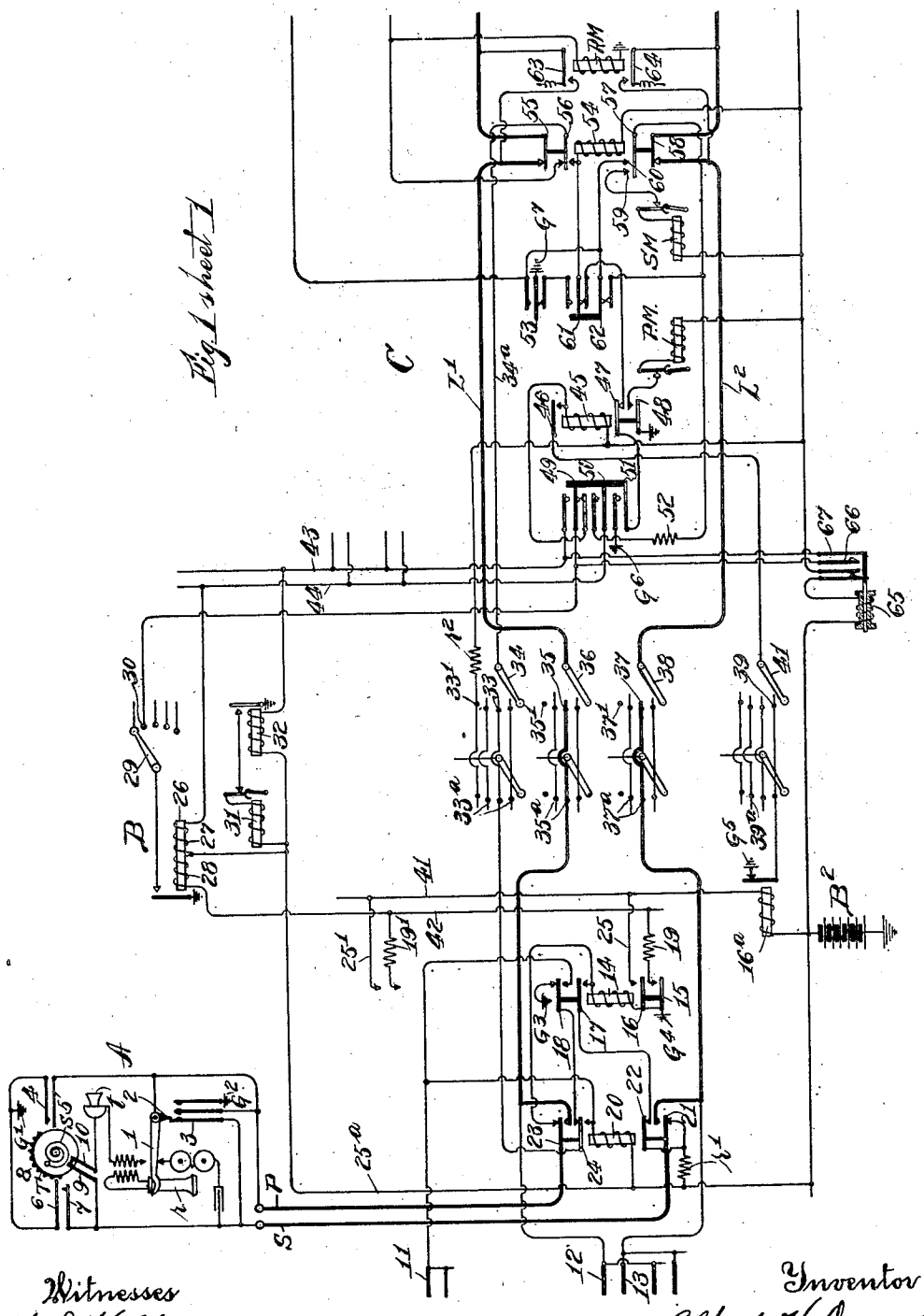
Oct. 20, 1925. 1,557,992

A. H. DYSON

TELEPHONE SYSTEM

Filed June 4, 1906 9 Sheets-Sheet 1



Witnesses
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Oct. 20, 1925. 1,557,992

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TELEPHONE SYSTEM

Filed June 4, 1906 9 Sheets-Sheet 2

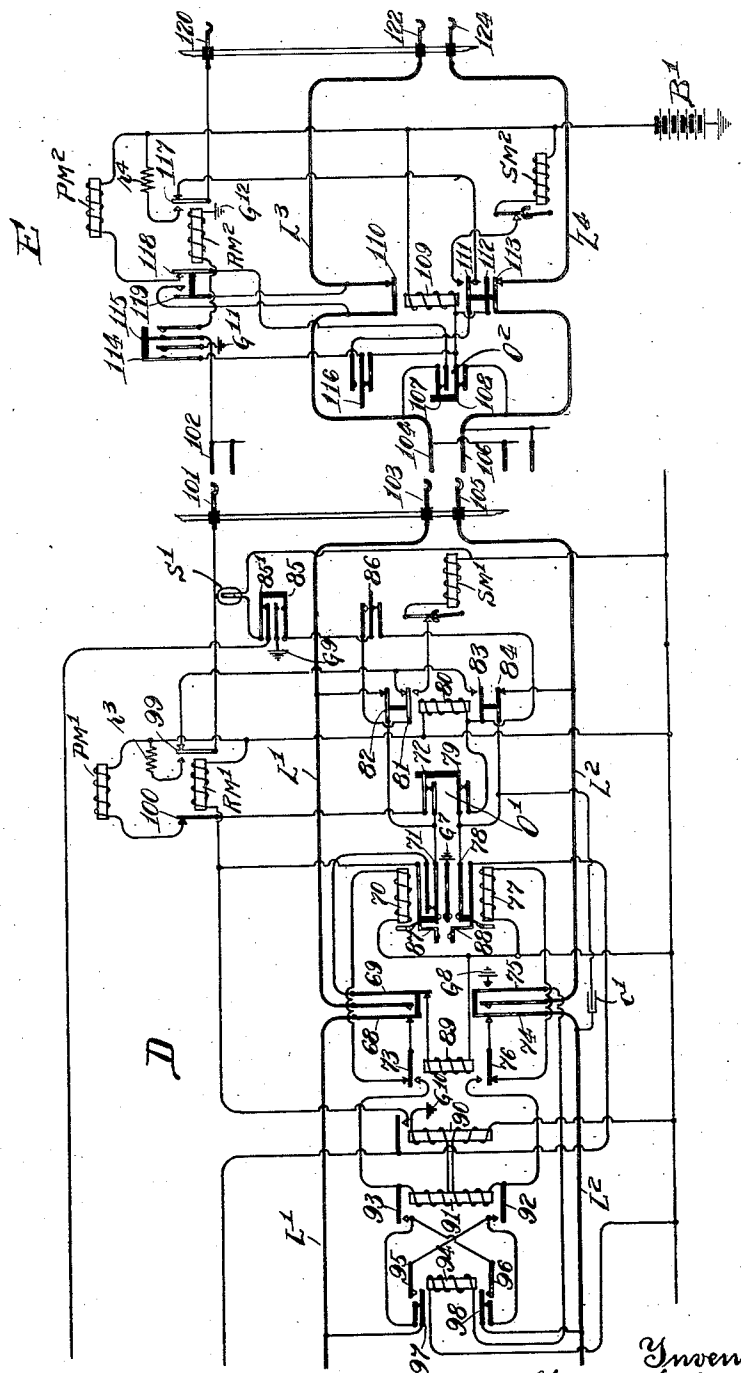

Fig. 1 sheet 2

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TELEPHONE SYSTEM

Filed June 4, 1906

9 Sheets-Sheet 3

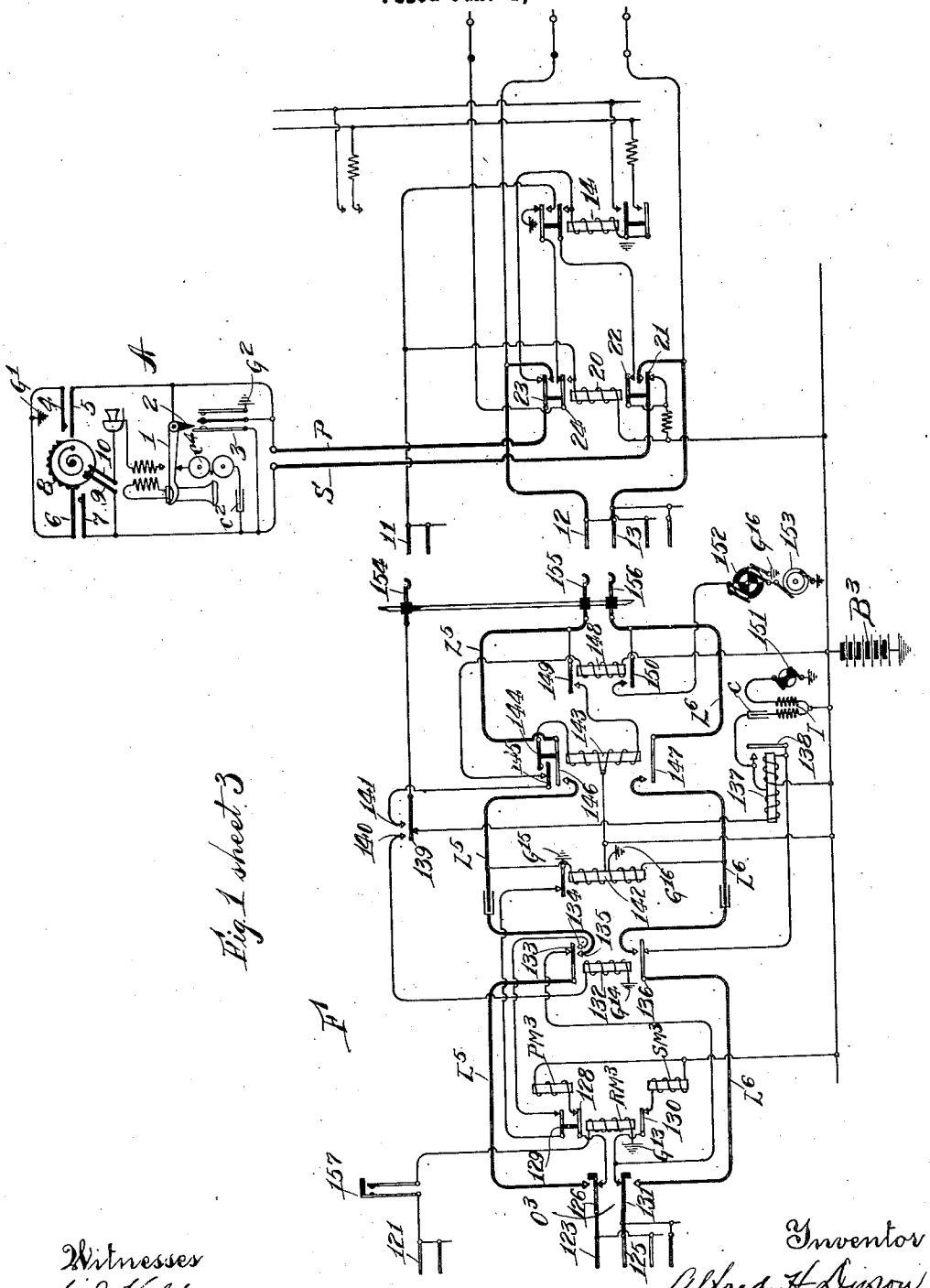

Fig. 1 sheet 3

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TELEPHONE SYSTEM

Filed June 4, 1906 9 Sheets-Sheet 4

Fig. 2

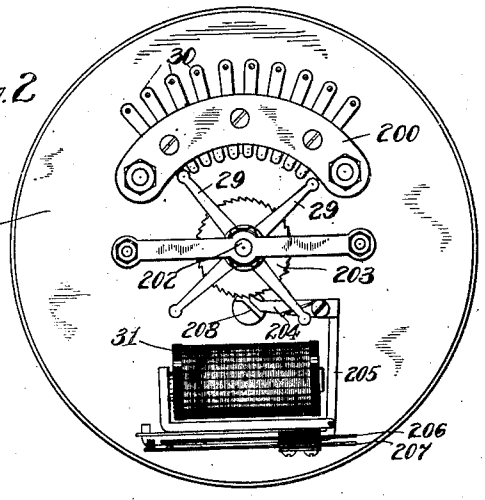


Fig. 3

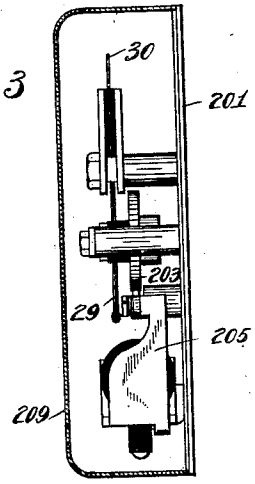


Fig. 4

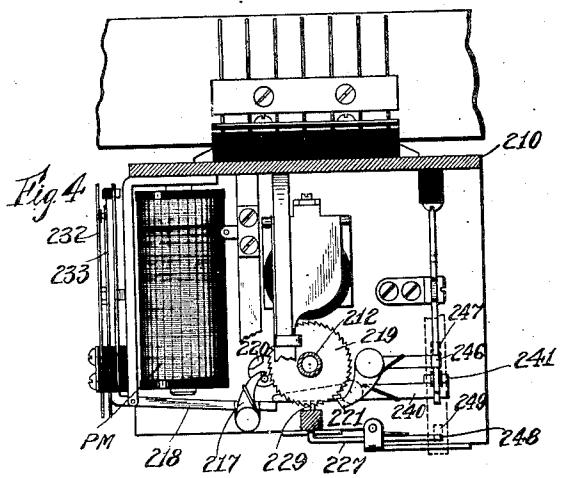


Fig. 5

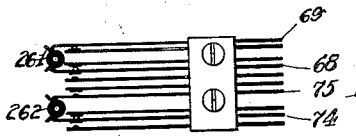


Fig. 6

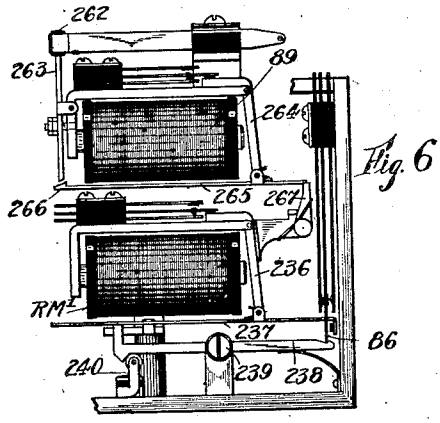
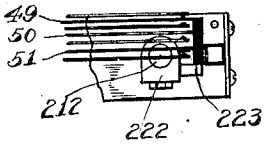


Fig. 7



Witnesses

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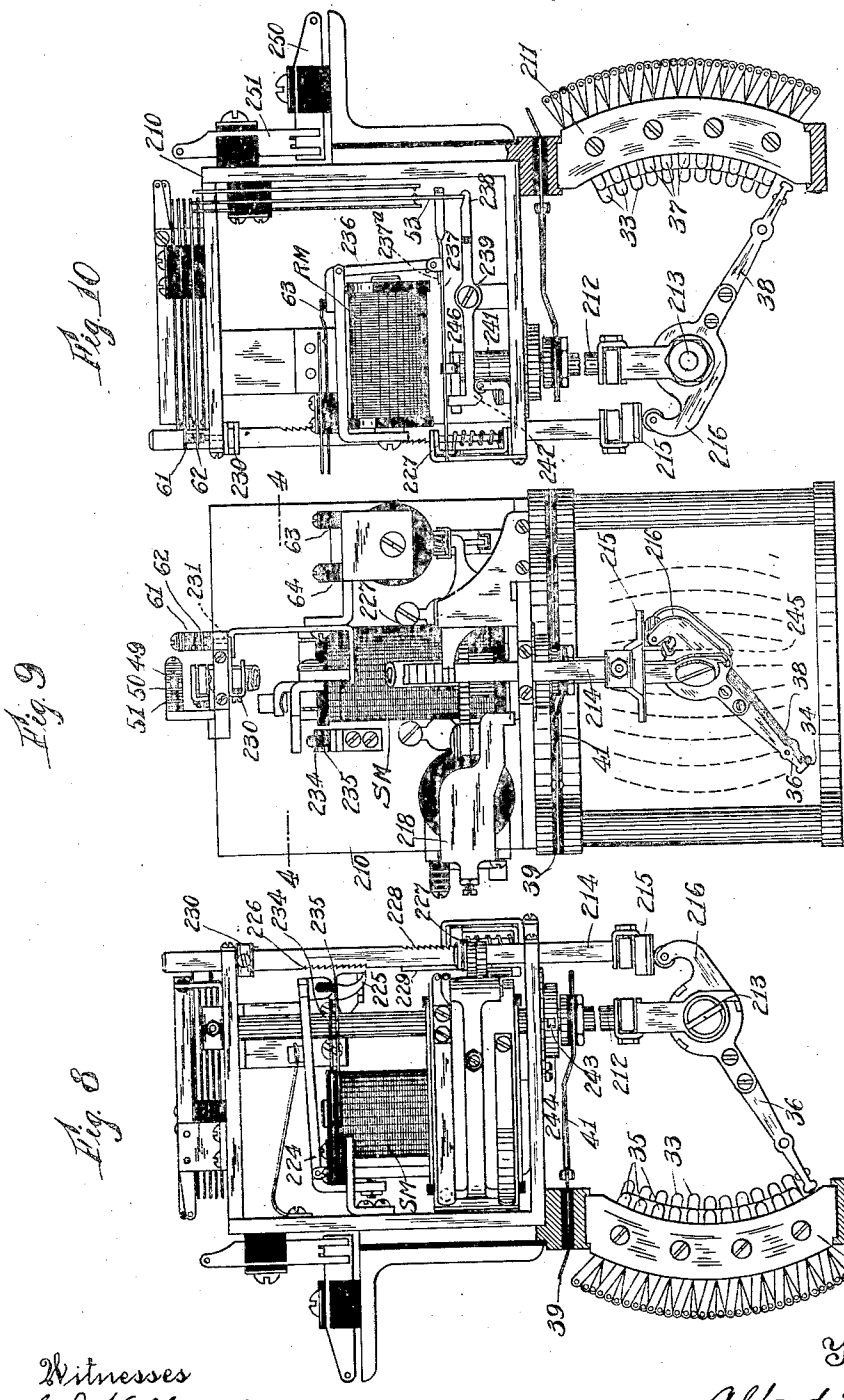
TELEPHONE SYSTEM

Filed June 4, 1906

9 Sheets-Sheet 5



Witnesses
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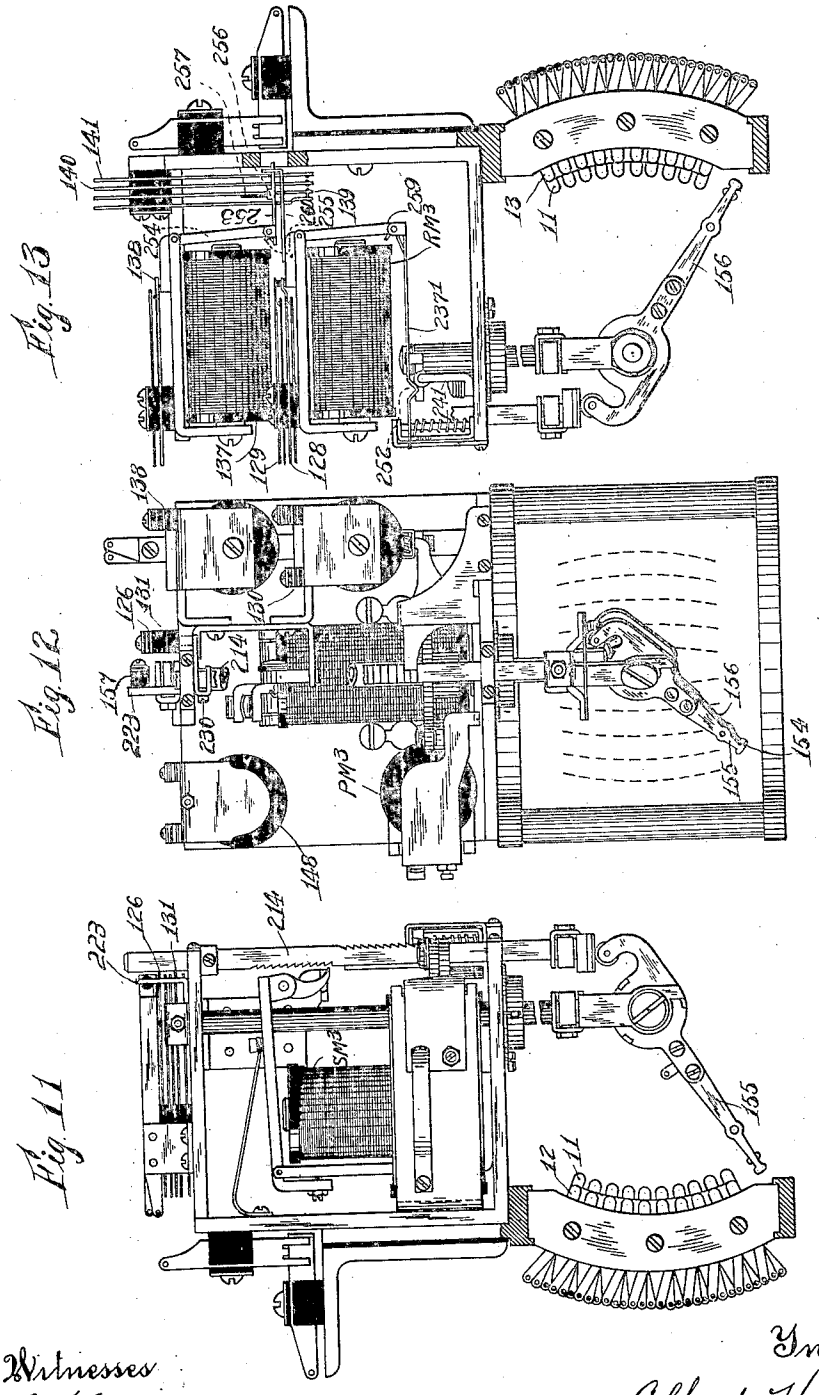
TELEPHONE SYSTEM

Filed June 4, 1906

9 Sheets-Sheet 6



Witnesses
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1,557,992

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TELEPHONE SYSTEM

Filed June 4, 1906

9 Sheets-Sheet 7

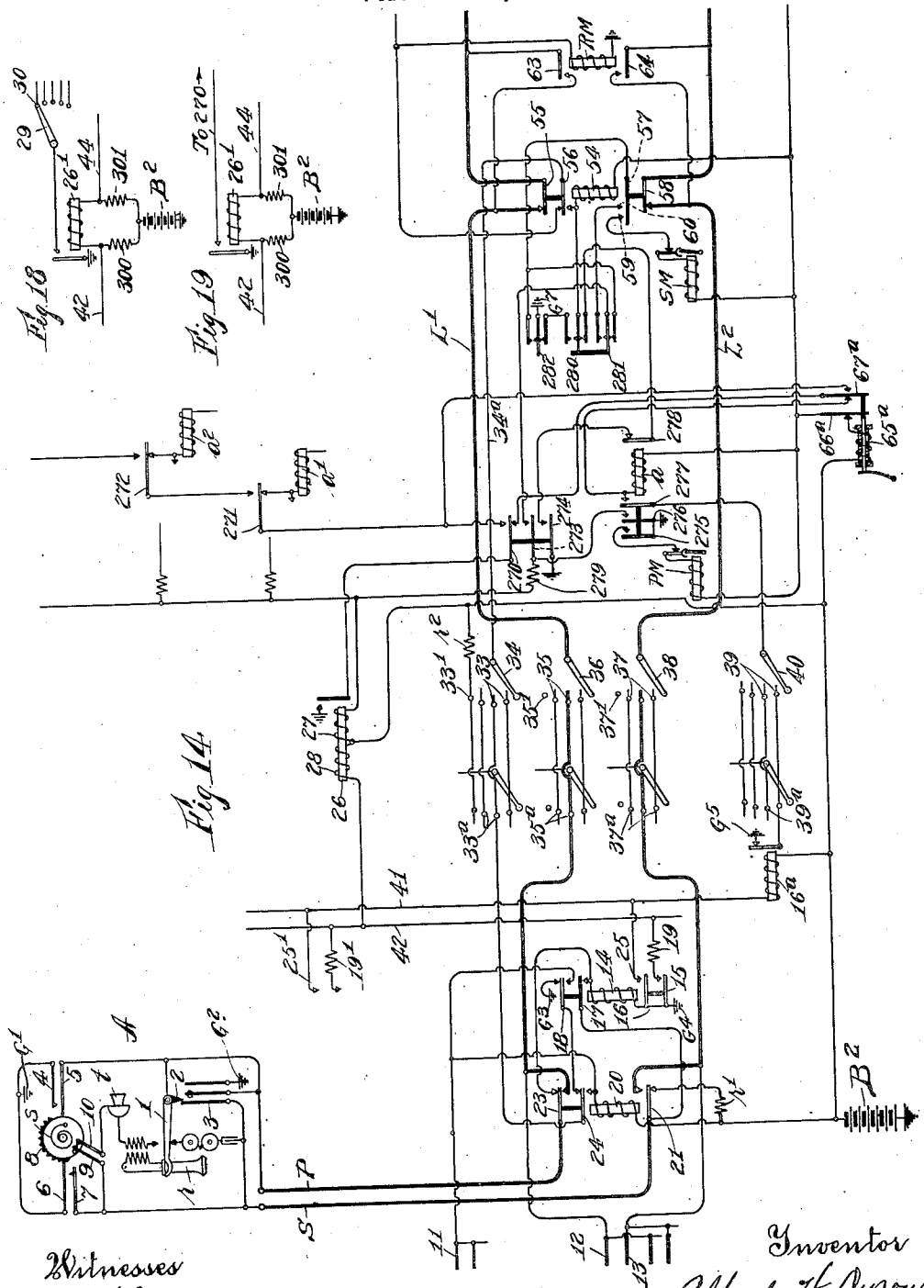

Fig. 14.

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TELEPHONE SYSTEM

Filed June 4, 1906

9 Sheets-Sheet 8

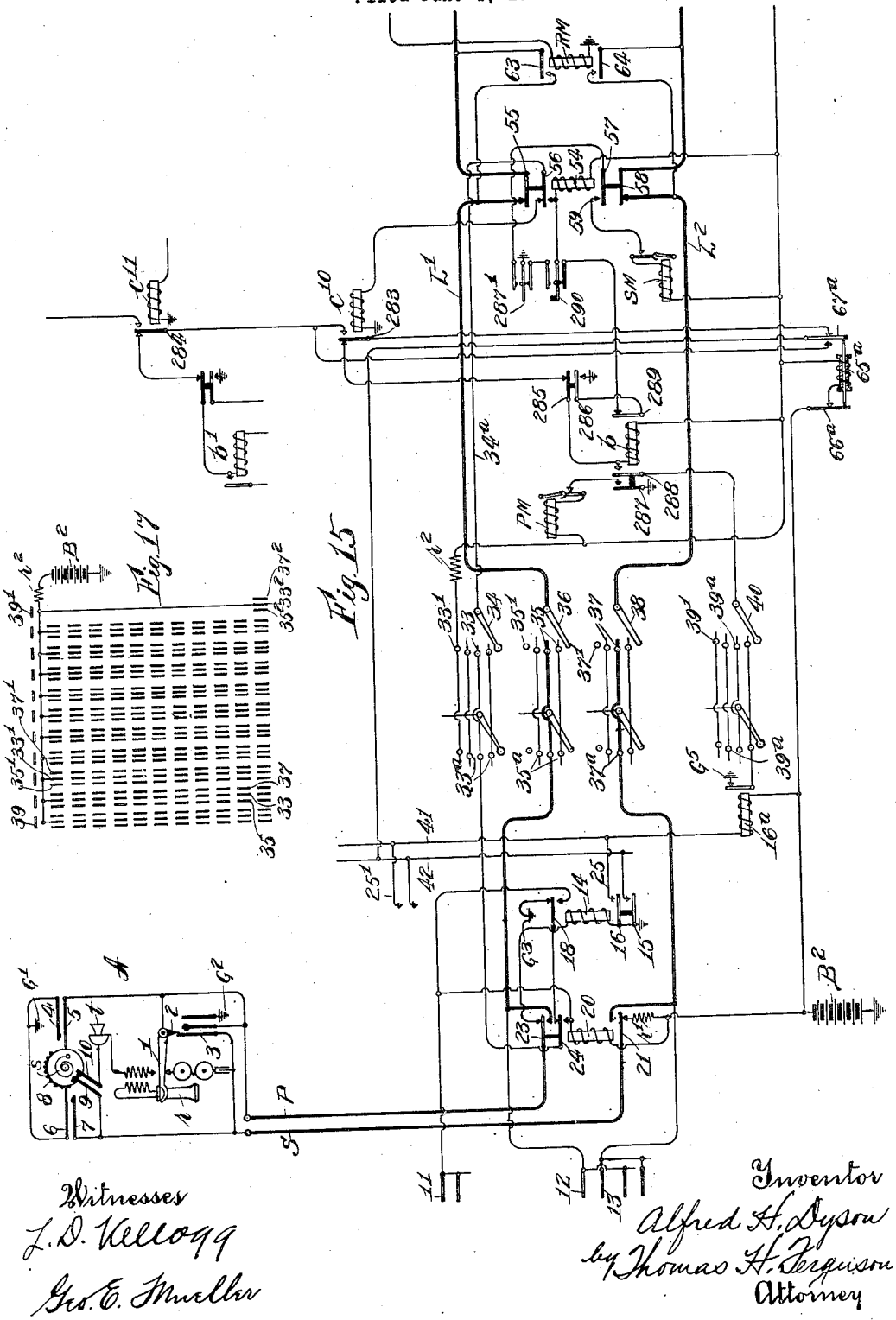

Fig. 15

Fig. 14

Witnesses

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Oct. 20, 1925. 1,557,992

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TELEPHONE SYSTEM

Filed June 4, 1906 9 Sheets-Sheet 9

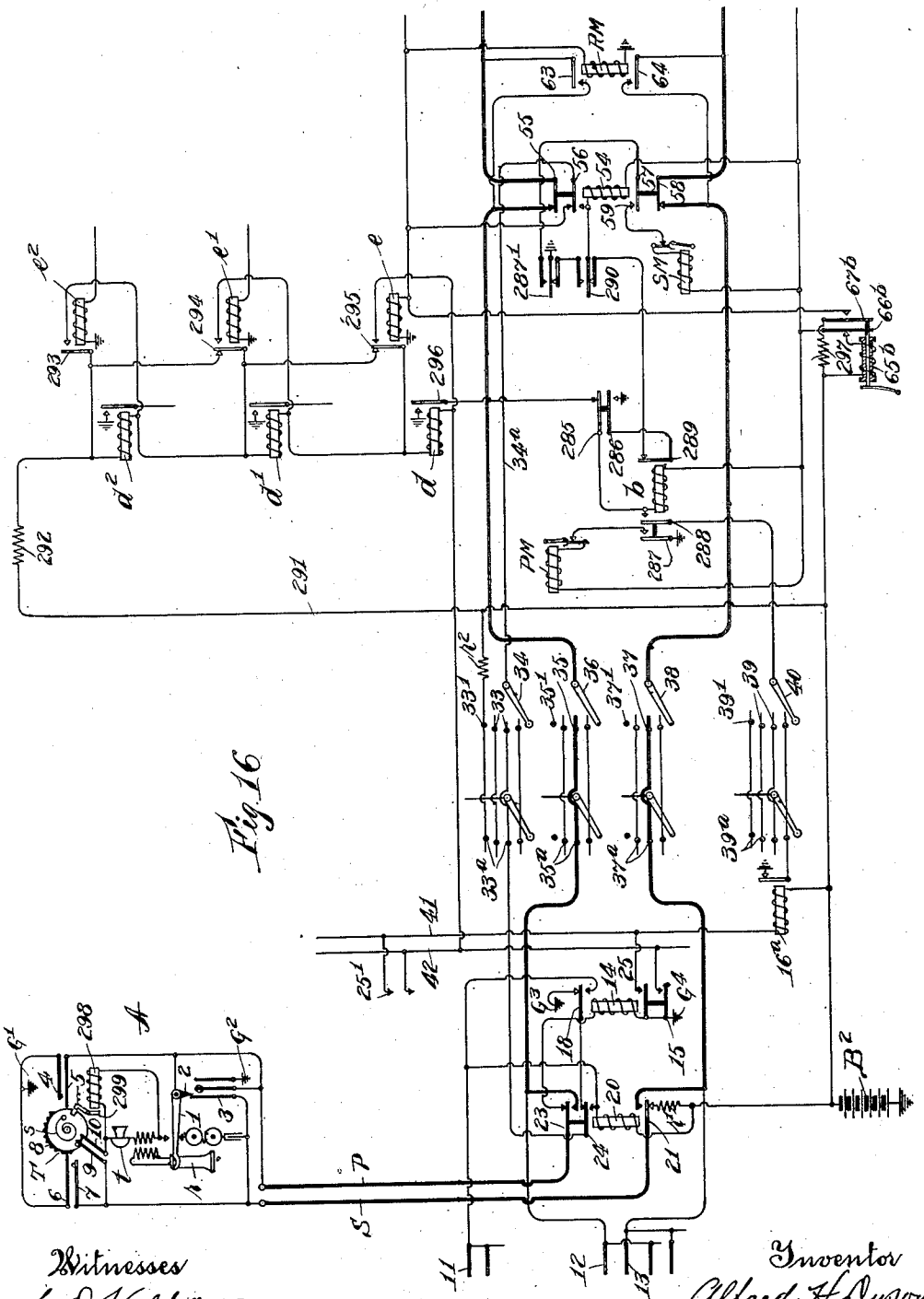

Fig. 16

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Patented Oct. 20, 1925. 1,557,992

UNITED STATES PATENT OFFICE.

ALFRED H. DYSON, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO KELLOGG SWITCHBOARD & SUPPLY COMPANY, A CORPORATION OF ILLINOIS.

TELEPHONE SYSTEM.

Application filed June 4, 1906. Serial No. 320,158.

To all whom it may concern:

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

The present invention relates generally to automatic telephone exchange systems and more particularly to that type in which electrically controlled switches are successively operated in response to current impulses transmitted over a calling line, to progressively connect a number of link-circuits so as to advance the circuit of the calling line to include a desired called line.

In systems of this class now in common use, each subscriber's line is provided with a switch of relatively complicated construction, called a "first selector," and these first selectors co-operate with similarly constructed "second selectors" and "connectors" in completing a connection between calling and called lines. On the basis of ten per cent trunking, which is that commonly employed, a ten thousand line exchange equipped in this manner requires ten thousand first selectors, one thousand second selectors and one thousand connectors. In order to reduce the cost of these systems, it has been proposed heretofore to replace the first selectors, which are individual to each line, by a simplified individual line switch in association with a reduced number of first selectors. Thus, on a ten per cent trunking basis, a ten thousand line exchange equipped in this manner would require ten thousand of these simplified individual switches, one thousand first selectors, one thousand second selectors and one thousand connectors.

The principal object of the present invention is to still further reduce the number and cost of the interconnecting switches employed. To this end, I have devised a system in which switches individual to each line are done away with; and in their stead, the subscribers' lines are arranged in groups and each group is provided with a plurality of switches which I term, "line selectors," fewer in number than the number of lines in the group, and each group of line selectors is controlled by a simple switch mechanism common to the group. On the basis of ten per cent trunking, and assuming ten line selectors per group of one hundred subscribers' lines, a system equipped in accordance with my invention requires one thousand line selectors, one hundred control or master switching mechanisms, one thousand first selectors, one thousand second selectors and one thousand connectors.

Another object of my invention is to provide a system having a minimum number of relays and other parts and one which shall be efficient in operation and economical to construct, install and maintain. It will, of course, be understood that in developing the invention along the lines indicated, I have provided features and circuit arrangements which are capable of use in other relations and that some of these are applicable to manual and so-called semi-automatic telephone systems, as well as to full automatic telephone systems.

The various features and aspects of the invention will be more fully understood upon reference to the following detiled description taken in connection with the accompanying drawings, and the scope of the invention will be particularly pointed out in the appended claims.

Referring to said drawing, Fig. 1, which includes sheets 1, 2 and 3, is a diagram of a system constructed in accordance with my invention; Fig. 2 is a front elevation of the preferred master switch mechanism for the control of the line selectors; Fig. 3 is a side elevation of the same, the enclosing cover being shown in section; Fig. 4 is a partial sectional view of a line selector switch, illustrating in plan the primary magnet together with its associated mechanism, the section being taken on a plane indicated by the line 4—4 of Fig. 9; Figs. 5 and 6 are detail views, illustrating the actuating magnets of certain switch mechanism associated with the first selectors; Fig. 7 is a detail of the off-normal switch associated with said line selector; Figs. 8, 9 and 10 are elevations of a line selector, each viewed from a different side; Figs. 11, 12 and 13 are similar views of a connector switch; Figs. 14, 15 and 16 illustrate modifications of that portion of the system shown in Sheet 1 of Fig. 1; Fig. 17 is a diagram of the line selector bank contacts; and Figs. 18 and 19 illustrate still other modifications.

Referring in detail to the drawing and more particularly to the diagram of Fig. 1, A designates the substation equipment of two lines which terminate at the exchange in multiple contacts of connector and line selector switches. Connection is obtained between a calling and a called line through the agency of the master switch mechanism B, line selectors C, first selectors D, second selectors E, and connectors F. In practice, on a basis of ten thousand subscribers' lines, ten per cent trunking, ten line selectors C per group of one hundred lines and one control switch B per ten line selectors C, as previously indicated, there would be one thousand line selectors C, one hundred control switches B, one thousand first selectors D, one thousand second selectors E and one thousand connectors F. With this apportionment, each line would be multiplied to ten connectors and to ten line selectors, each connector to one hundred second selectors, each second selector to one hundred first selectors, and each first selector would be connected to one line selector. It is, of course, to be understood that these values may be changed to suit any required conditions, and that where an ultimate capacity of only one thousand lines is desired under the assumptions of trunking made, one set of selector switches may be omitted. In operation, the calling party removes his receiver and thereby, through the agency of the control switch mechanism B, sets an idle line selector switch C into operation to automatically seek out and establish connection with the calling line, thus extending the line circuit to a first selector D. The calling party then transmits impulses corresponding to the digits of the number of the subscriber wanted. The first of these operates the connected first selector switch D to pick out an idle second selector switch associated with the thousand group to which the called line belongs. The second set of impulses operates the second selector to pick out a connector associated with the hundred group to which the called line belongs. The third set of impulses operates the connector to pick out that group of ten contacts to which the called line belongs, and the final set of impulses causes the connector to pick out the called line contacts in this group.

The control switch mechanism B comprises a differential relay 26 which controls the circuit of a relay 32, which in turn controls the circuit of electromagnet 31 which is instrumental in stepping around the wiper 29 over its contacts 30.

The line selector switch C comprises the bank contacts 33, 35 and 37 with which the wipers 34, 36 and 38 co-operate in making connection between the link-circuit strands L'—L^2 and the line limbs S—P. These wipers are given both a primary movement and a secondary movement in response to the energizations and de-energizations of the primary magnet PM and the secondary magnet SM respectively. By the primary movement, the wipers 34, 36 and 38 are stepped to a desired level or group of bank contacts; and by the secondary movement, they are moved over the contacts of the selected group until the desired contacts are encountered. The switch is also provided with a row of contacts 39, each of which corresponds to a level or group of bank contacts, and a wiper 41 co-operates with these in selecting the group in which the desired contacts are located. Normally, the contacts 33 and 39 are grounded; but as soon as a call is initiated, the contacts 33 corresponding to the calling line, and the contacts 39 corresponding to the group or level in which the contacts 33 of the calling line are located, have their normal grounds removed. Thus in the operation of the switch, all the wipers are stepped around until the wiper 41 engages an ungrounded contact 39; then the secondary movement of the wipers 34, 36 and 38 takes place and is continued until the wiper 34 engages the ungrounded contact 33 of the calling line. The bank contacts 33, 35, 37 and 39 are connected to corresponding bank contacts of other selectors, one set of which is represented at 33^a, 35^a, 37^a and 39^a.

The first and second selectors D and E and the connectors F are similar in construction and operation to the line selector, but are not provided with a wiper corresponding to the line selector wiper 41. In the operation of the first and second selectors, the impulses transmitted from the calling station step the wipers to the desired level or group and they are then automatically stepped over the contacts of said group until an idle link-circuit is encountered. In the operation of the connector, the first set of impulses step the wipers to the desired level or group of contacts, and the second set moves them into engagement with the contacts of the desired called line.

Considering this operation more in detail, it will be observed that the removal of the receiver r from its switch-hook 1 at the substation of the calling party completes a bridge between the two line limbs P—S, through the transmitter t and the normally closed contacts 9 and 10 of the calling device T. The completion of this bridge closes a circuit from the live pole of the battery B^2, through the protective resistance r', normal contact 21 of the relay 20, line limb S, contacts 9—10, transmitter t, switch-hook 1, line limb P, normal contact 23 of relay 20, winding of the relay 14 to ground at G^4. The closing of this circuit energizes the relay 14 sufficiently to attract its contacts 15, 16, 17 and 18. The move-

ment of the contact 16 to its alternate position completes a circuit from the live pole of the battery B^2, through the winding of the relay 16^a, conductor 25, alternate contact 16 to ground at G^4, thereby energizing the relay 16^a sufficiently to break the normal ground connection at G^5 of all the multiple contacts 39 associated with that group including the calling line, thereby establishing that condition which will stop the wiper 41 of any one of the selecting switches C, which may be started, at the row of contacts which includes the contacts 33, 35 and 37 of the calling line. The movement of the contact 18 of the relay 14 to its alternate position removes the normal ground from the private contacts 33 associated with the calling line. This normal ground connection extends from the contacts 33, through the normal contact 24 and normal contact 18 to ground at G^3. The removal of the ground from the contacts 33 of the calling line establishes that condition which will cause the wipers 34, 36 and 38 to stop on the contacts of the calling line when they are engaged upon the secondary movement of the switch. The movement of the contact 15 to its alternate position completes a circuit from the live pole of the battery B^2, through conductor 25^a, winding 28 of the differential relay 26 associated with the control switch B, through resistance 19, alternate contact 15 to ground at G^4. The closing of this circuit will energize the relay 26 sufficiently to attract its armature and thus ground the wiper 29 of the control switch B. If at this time the wiper 29 is in engagement with a contact 30 leading to a line selector switch C which is in use, said wiper will be moved over its contacts until one connected with an idle line selector switch is encountered. Upon the first movement of the line selector switch, its switch contacts 49, 50 and 51 are moved to their alternate positions. Consequently, if the wiper 29 engages a contact 30 leading to a busy line selector switch, a circuit will be completed from said grounded wiper, through the encountered contact 30 of said line selector, alternate contact 49, conductor 43, winding of relay 32 and conductor 25^a to the live pole of the battery B^2. The closing of this circuit will energize the relay 32 sufficiently to attract its armature and thereby complete a circuit through the winding of the actuating relay 31 which is included in a vibratory circuit and, as indicated in Figs. 2 and 3, is arranged to step around the wiper 29 over its fixed contacts. So long as the wiper 29 engages a contact 30 connected with a busy line selector, a circuit through the winding of the relay 32 will be maintained; but as soon as the wiper 29 engages a contact leading to an idle line selector, the circuit of said relay 32 will be broken at the contact 49, and instead of said circuit, a circuit will be completed for the relay 45 of the idle line selector switch. This circuit, which includes the winding of the heat coil 65 and its normally closed contacts, extends through the winding of the relay 45, normal contact 49, contact 30, wiper 29 to ground. The relay 45 is thereby sufficiently energized to move its contacts 46, 47 and 48 into their alternate positions. The movement of the contact 48 to its alternate position completes a vibratory circuit for the primary magnet PM which, by reason of its mechanical connections hereinafter referred to, steps the wipers 34, 36, 38 and 41 to that group or level in which the calling line contacts are located. During this movement the wiper 41 passes over the contacts 39. As indicated, the wiper 41 is normally out of engagement with the contacts 39, so that one primary step of the wipers is necessary to bring the wiper 41 into engagement with a contact 39. This same step, as previously indicated, causes the movement of the contacts 49, 50 and 51 to their alternate positions. The movement of the latter contacts interrupts the initial energizing circuit of the relay 45 at the contact 49; but so long as the wiper 41 engages a grounded contact, an energizing circuit is maintained for the relay 45 from the live pole of the battery B^2, the winding of relay 45, contact 46, wiper 41, contact 39 to ground at G^5. However, if the contacts of the calling line are in the first group, the first encountered contact 39 will be ungrounded and, therefore, there will be no energizing circuit for the relay 45 and the contacts of the latter will return to their normal position, thereby interrupting the vibratory circuit of the primary magnet PM at contact 48 and stopping the further primary movement of the switch. If the contacts of the calling line are in other groups than the first, the wiper 41 will continue its movement over the contacts 39 until the ungrounded contact of the desired group is encountered, at which time the relay 45 will be de-energized and the primary movement of the switch discontinued, as just described.

The construction of the line selectors is such that, upon the first movement of the switch, not only are the contacts 49, 50 and 51 moved to their alternate positions, but the contact 53 is also moved to its alternate position. Thus, as soon as the relay 45 is de-energized after the selection of the group or level of contacts, an energizing circuit for the relay 54 is completed from the live pole of the battery B^2, through the winding of said relay, normal contact 61, normal contact 47 and alternate contact 51 to ground at G^6. The completion of this circuit suf-

ficiently energizes the relay 54 to move its contacts 55, 56, 57 and 58 to their alternate positions. The movement of the contact 57 to its alternate position completes a circuit from the live pole of the battery B^2, through the winding of the secondary magnet SM, contacts 57, 59, 60, and alternate contact 53 to ground at G^7. The magnet SM is included in a vibratory circuit and, by means of its mechanical connection hereinafter referred to, steps the wipers 34, 36 and 38 over the contacts 33, 35 and 37 respectively, while leaving the wiper 41 unmoved.

By the movement of the contacts 55 and 58 to their alternate positions, all battery and ground connections with the wipers 36 and 38 are removed, so that, as they pass over the contacts 35 and 37 of lines which may be in use, there will be no interference with conversation over said lines. Upon the first secondary movement of the switch parts, the construction is such that the switch contacts 61 and 62 are moved to their alternate positions. By this time, however, the wiper 34 will be in engagement with one of its contacts 33; and so long as it remains in engagement with a grounded contact, a maintaining circuit for the relay 54 will exist. This circuit extends from the live pole of the battery B^2, through the winding of said relay, alternate contact 56, wiper 34 to grounded contact 33. The connections between these contacts 33 and ground will depend upon the operative conditions of the subscribers' lines to which they correspond. The contacts 33 of a called line will be grounded by way of alternate contact 24 and the contact 11 of the connector with which the called line is in connection. The contacts 33 of an idle line will be completed, as previously traced, through the normal contact 24 and normal contact 18 to ground at G^3. The contacts 33 of a line, which is in use as a calling line, will be completed through the wiper 34 of the connected line selector C, conductor 34^a, normal contact 56 and winding of the release magnet RM to ground. As soon, however, as wiper 34 engages an ungrounded contact 33, which will be that of the calling line over which connection is desired, the circuit of the relay 54 will be interrupted and, by the return of the contact 57 to its normal position, the circuit of the secondary magnet SM will also be broken and the further secondary movement of the switch prevented. The wipers 34, 36 and 38 will thus be left in engagement with the contacts 33, 35 and 37 of the calling line, and the normal connection of the link-circuit strands L′ and L^2 will be restored at the contacts 55 and 58. The engagement of the wiper 34 with an ungrounded contact 33 renders busy the private contacts 11 of the connectors associated with the calling line, energizes the relay 20 and de-energizes the relay 54. The private contacts 11 are normally supplied with current from the live pole of the battery B^2, through the winding of the relay 20; but upon the engagement of the wiper 34 with the contact 33 associated with the calling line, these contacts 11 are connected to ground over a circuit including the alternate contact 18 of the relay 14, normal contact 24 of the relay 20, contact 33, wiper 34, conductor 34^a, normal contact 56 of relay 54, and winding of release magnet RM to ground. This sufficiently reduces the normal potential upon the contacts 11 to render them busy. By this grounded connection, a circuit is also completed through the winding of the relay 20, and the latter is energized sufficiently to move its contacts 21, 22, 23 and 24 to their alternate positions, while the contacts of the release magnet RM remain unmoved, since said magnet will not operate through the resistance of the relay 20. By the movement of the contacts 21 and 23 to their alternate positions, the circuit of the line limbs S and P is continued so as to include the link-circuit strands L′ and L^2. The movement of the contact 24 to its alternate position maintains a circuit for the relay 20 through the alternate contact 24, contact 33, wiper 34, conductor 34^a, normal contact 56 and the winding of the release magnet RM to ground. In this operation, the alternate contact 24 is made before normal contact 21 is interrupted. The movement of the contact 23 to its alternate position interrupts the circuit of the relay 14 and allows the contacts of the latter to return to their normal positions. The movement of the contact 21 to its alternate position, in addition to continuing the line limb S, breaks the normal connection between the battery B^2 and said limb. The interruption of the circuit of the relay 54 allows its contacts to return to normal, thereby extending the link-circuit strands L′ and L^2, interrupting the circuit of the secondary magnet SM and thereby preventing further movement of the switch contacts while completing connection between conductor 34^a and the winding of the release magnet RM. From this, it follows that the de-energization of the relay 54 must precede the energization of the relay 20 and the consequent de-energization of the relay 14.

In the operation above explained, it will be observed that as soon as the relay 14 is energized in response to the removal of the receiver from its hook at the calling station, a circuit will be completed through the winding 28 of the differential relay 26 and this will be sufficient to maintain the armature of said relay attracted until neutralized by a current flow through the other winding

27 of said relay. It will be observed that the latter flow, however, will not occur until after an idle line selector switch C has been selected and its wipers given their first step in a primary direction. As soon as this occurs, a circuit will be completed through the winding 27 of the relay 26, through conductor 44, alternate contact 50, resistance 52, normal contact 62, alternate contact 53 to ground at G^7. By a proper proportioning of the resistances 19 and 52, the current in the windings 27 and 28 at this time neutralize each other, and the armature of said relay returns to its normal position. Thus the control switch B is free to continue its work of selecting other idle line selector switches for other calling lines without waiting for the complete connection of the first calling line with the desired called line. The winding 28 is common to the one hundred subscribers' lines constituting the group to which the line selectors have access, and the winding 27 is common to such line selectors. Therefore, if an additional call comes in before the contacts of the relay 26 have returned to normal, the current in the winding 28 will predominate over that in the winding 27 even after the resistance 52 has been included in circuit with the latter, by reason of the parallel paths to ground through the resistances 19 and 19′ of the calling lines. Thus the armature of the relay 26 will be maintained attracted and, after setting one line selector switch in operation, the control switch B will be free to move its wiper into engagement with a contact leading to a second idle selector for the purpose of setting it in operation. However, as soon as connection has been completed by a line selector between the line limbs S and P and link-circuit strands L′ and L^2, as previously noted, the relays 54 and 14 will be successively de-energized, thereby interrupting the paths through the winding 28 of the relay 26 and the resistance 19 on the one hand, and the winding 27 of said relay and the resistance 52 on the other. At this point it may be noted that after the first secondary movement of the line selector by which the switch contacts 61 and 62 are moved to their alternate positions, the circuit through the winding 27 of the relay 26 and the resistance 52 is continued to ground at G^7, through the contacts 57 and 60 of the relay 54, so that this branch is directly under the control of the relay 54 after the first secondary movement of the switch contacts. It should also be observed that upon the de-energization of the relay 14, the circuit through the winding of the relay 16^a is interrupted and, by its contacts, ground at G^5 is again placed upon the contact 39 of the group or level in which the contacts of the calling line are located, thereby leaving the switches free to select other contacts in the same group, should a call be made over a line terminating in such contacts.

At this point, it may be observed that if the relay 14 were energized only long enough to permit the circuit through the winding 27 of the relay 26 to be closed and were then de-energized so as to interrupt the circuit of the winding 28 of said relay 26, then the winding 27 would sufficiently energize the relay 26 to maintain its contacts closed, and other line selector switches would be thereby set in operation. Although this would not occur in the ordinary operation of the system by reason of the retarded return movement of the switch-hook 1, yet it might possibly be occasioned by the accidental crossing of the line limbs S—P by a workman engaged in repairing the line, or otherwise. In order to prevent this operation of a number of line selectors, due to the momentary crossing of the line limbs, I provide a locking circuit for the relay 14, which is maintained during the time required by the line selector to pick out the calling line. This circuit is completed upon the energization of the relay 14 and extends from the live pole of the battery B^2, through the resistance r', normal contact 22 of the relay 20, alternate contact 17 of the relay 14, the winding of said relay, to ground at G^4. This circuit is maintained as long as the relay 20 remains de-energized. As soon as said relay is energized, however, to complete the line limbs to the contacts of the line selector, the locking circuit is interrupted at contact 22.

From the above description, it will be apparent that the terminals of any of the one hundred subscribers in the group to which a given line selector switch has access will be connected with a maximum number of twenty steps of the wipers, while the average number of steps will be more nearly in the neighborhood of ten. As a speed of fifteen steps per second is very moderate for switches of the character I employ, and as a speed of thirty or more steps a second may readily be obtained, it will be obvious that there will be time for the desired operation of the master switch and line selector before the calling party begins to operate the disk 8 of his calling device T. If it is desired to employ slower switches, the subscribers may be instructed to pause an instant after removing their receivers before beginning to operate their calling apparatus, or any suitable means may be employed for giving the required time interval.

The next step in the calling operation consists in the manipulation of the disk 8 of the calling device T in accordance with the number of the telephone with which connection is desired. Thus, assuming that conversation is desired with the substation at the right in Fig. 1, and that the number of the

latter's telephone is 3456, then the dial 8 will be manually rotated against the tension of its spring *s* four times, the first time bringing three of the teeth of the dial below the contact spring 5, the second time four, the third time five, and the fourth time six. Upon the return of the dial after its first movement, contact springs 4 and 5 will be engaged three times and this will be followed by a single engagement of the contact springs 6 and 7, since, in the normal position of the disk, one tooth lies below the spring 6. The three engagements of the springs 4 and 5 send three impulses of current over the line limb P, while the single engagement of the springs 6 and 7 sends a single impulse over the line limb S. At the time these impulses are being transmitted, the bridge through the transmitter *t* is interrupted at the contacts 9—10 which separate when the dial is moved from its normal position. Three impulses transmitted over the line limb P energize and deenergize the primary relay 70, associated with the first selector switch D, three times, while the following single impulse over the line limb S energizes the secondary relay 77 once. A circuit for the primary relay extends from the live pole of the battery B^2, through the winding of said relay, normal contact 73, normal contact 68, link-circuit strand L′, wiper 36, contact 35, alternate contact 23, line limb P, springs 4—5, to ground at G′. The corresponding circuit for the secondary relay 77 extends from the live pole of the battery B^2, through the winding of said relay, the normal contact 76, normal contact 74, link-circuit strand L^2, wiper 38, contact 37, alternate contact 21, line limb S, springs 6—7 to ground at G′. Each impulse transmitted through the primary relay 70 transmits corresponding impulses through the winding of the primary magnet PM′ of the first selector switch D. This circuit may be traced from the live pole of the battery B^2, through the winding of the magnet PM′, normal contact 100 of the release magnet RM′ of said selector, normal contact 72 of the secondary off-normal switch O′ associated with the first selector D, and alternate contact 71 of the primary relay 70 to ground at G^7. The selector switch is so constructed that its wipers 101, 103 and 105 are given a primary movement in one direction, followed by a secondary movement at an angle thereto, as previously stated. By the primary movement, the wipers are brought opposite a level or group of bank contacts connected to corresponding second selector switches and, by its secondary movement, an idle second selector switch is selected. Thus in response to the three impulses transmitted from the primary relay 70, the primary magnet PM′, through the agency of its associated mechanism hereinafter described, causes the wipers 101, 103 and 105 to be stepped to the third level or group of bank contacts, which are those assigned for connection to the third thousand group of subscribers' lines. The following impulse transmitted over the line limb S, which energizes the secondary relay 77, closes a momentary circuit from ground at G^7, through alternate contact 78 of said relay, normal contact 79 of the off-normal switch O′, the winding of the private relay 80 to the live pole of the battery B^2, thereby energizing said relay to move its contacts 81, 82, 83 and 84 to their alternate positions. By the first primary movement of the selector switch D, the contacts 85 and 86 are moved to their alternate positions. Consequently, as soon as the private magnet 80 is energized, current will flow over the vibratory circuit including the winding of the secondary magnet SM′, alternate contact 81, alternate contact 86 and alternate contact 85 to ground at G^9. The magnet SM′, by reason of its vibratory circuit and its mechanical connection with the wipers 101, 103 and 105, steps them over the co-operating bank contacts 102, 104 and 106. As soon as the circuit of the private relay 80 is interrupted, its contacts will return to their normal positions and consequently the circuit of the secondary magnet SM′ is interrupted and the stepping of the switch ceases. Therefore, while the wipers are passing over busy contacts, an energizing circuit for the magnet 80 is maintained. If an encountered contact 102 is that of a busy link-circuit, it will be connected to ground through one of its multiple contacts, through wiper 101 of another selector switch and over a circuit of said switch to ground as follows: through the normal contact 99, normal contact 81, alternate contact 86 and alternate contact 85 to ground at G^9. Therefore, as long as the wiper 101 of the selecting switch engages a grounded contact 102, the private relay 80 will be energized over a circuit from the live pole of the battery B^2, through the winding of said relay, alternate contact 83, normal contact 99, wiper 101 and contact 102 to ground. As soon, however, as an idle link-circuit is encountered, this circuit will be interrupted and the further progress of the switch stayed, thus connecting the wipers 103—105 of the link-circuit strands L′—L^2 to the contacts 104—106 of the link-circuit including the strands L^3—L^4, connecting with an idle second selector switch E. At this point, it may be noted that the link-circuit strands L′—L^2 are interrupted at the switch contacts 68—74; and that at the time the wipers 103—105 are passing over the contacts 104—106, the relay 80 is also energized and consequently all ground or battery connections with the wipers 103—105 are

removed. This prevents interference with conversation through other selector switches over multiple contacts 104 and 106, over which the wipers 103 and 105 may pass.

The next step in the calling operation consists in moving the dial 8 far enough to bring four teeth (corresponding to the hundreds digit in the number 3456) below the contact spring 5 and then allowing it to return to normal, thereby transmitting four impulses over the line limb P to actuate the primary relay 70 four times. This, as before, will be followed by a single impulse over the line limb S and will actuate the secondary relay 77. These impulses will cause the second selector switch E to move its wipers 120, 122 and 124 to the fourth level or group of subscribers' lines, and thence into engagement with an idle link-circuit connecting with an idle connector switch F having access to the called subscriber's line. The four energizations of the primary relay 70 cause four closures of the circuit from ground at G^7, through alternate contact 71 of said relay, the normal contact 82, wiper 103, contact 104, normal contact 107 of the secondary off-normal switch O^2 associated with the second selector switch E, normal contact 118 of the release magnet RM^2 associated with said selector, the winding of the primary magnet PM^2 to the live pole of the battery B'. The impulses transmitted through the magnet PM^2 are instrumental in producing the primary movements of the wipers 120, 122 and 124. The first movement from normal will move the contacts 114—115—116 to their alternate positions. The impulse transmitted by the secondary relay 77 will close a circuit from ground at G^7, through alternate contact 78, normal contact 84, wiper 105, contact 106, normal contact 108 of the secondary off-normal switch O^2, winding of the private relay 109 of the second selector switch E to the live pole of the battery B', thereby energizing said relay and causing it to disconnect wipers 122—124 from circuit by moving the contacts 110—113 to their alternate positions, while at the same time moving contacts 111—112 to their alternate positions. The energization of the private relay 109 thus completes a circuit for the secondary magnet SM^2 by which the wipers 120, 122 and 124 are given their secondary movement. This circuit extends from the live pole of the battery B', through the winding of said secondary magnet SM^2, alternate contact 111, alternate contact 116, and alternate contact 114 to ground at G^{11}. By reason of the vibratory character of this circuit and its mechanical relations to the switch parts as hereinafter indicated, the secondary magnet SM^2 will step the wipers over their associated bank contacts until its circuit is interrupted. This occurs, as previously indicated in connection with the description of the first selector switch D, when an idle link-circuit is encountered. At this time, as previously indicated, wipers 122—124 are again included in circuit upon the return of the contacts 110—113 to normal, thus projecting the circuit of the calling line through the line selector switch C of said line and the selector switches D and E. It will be noted that as the wipers 122—124 are passing over the contacts 123—125, they are disconnected from battery or ground, thus preventing interference with possible conversation being held through other selector switches, over whose multiple contacts these wipers pass.

The next step in the calling operation consists in moving the dial 8 into a position to transmit five impulses over the line limb P, through the primary relay 70, followed by a single impulse over the line limb S, through the secondary relay 77. The primary impulses are extended from the primary relay over a circuit extending from ground G^7 at said relay, through wiper 103 of the first selector switch D as previously traced, thence through contact 104, normal contact 110, wiper 122, contact 123, normal contact 126 of the secondary off-normal switch O^3 of the connector F, normal contact 128 of the release magnet RM^3 of said connector, through the winding of the primary magnet PM^3 to the live pole of the battery B^3. In this instance, the five impulses of current transmitted through the primary magnet will step the wipers 154, 155 and 156 to the fifth level or group of contacts to which the subscribers' lines, having numbers from 3450 to 3459 inclusive, are connected. At the first movement of the switch in response to these primary impulses, the switch contact 157 is moved to its alternate position, thereby grounding the associated bank contacts 121 through the winding of the release magnet RM^3. The secondary impulse following these primary impulses closes a circuit from ground G^7 at the secondary relay 77 to the wiper 105 of the first selector switch D as previously traced, thence through contact 106, normal contact 113, wiper 124, contact 125, normal contact 131, normal contact 130, winding of the secondary magnet SM^3 to the live pole of the battery B^3. This causes a momentary energization of the secondary magnet SM^3 which is instrumental in giving the wipers one step in their secondary direction. As indicated in Figs. 11, 12 and 13, the wipers of the connector are normally two steps distant from the first set of bank contacts and consequently this single step does not bring them into engagement, but is occasioned for the purpose of actuating the secondary off-normal switch contacts 126—131. At this time, the contact 126 is moved to its alternate position; and at the same time, the con-

tact 131 is moved far enough to break its normal contact, but not far enough to close its alternate contact. The movement of the contact 131, far enough to make its alternate contact, does not occur until the next step of the switch. The purpose of this operation is to prevent the above secondary impulse from hanging over and being transmitted through the right-hand winding of the busy relay 137 by way of the normal contact 136, which might occur if the contact 131 were thrown at once to its alternate position.

The next step in the calling operation consists in moving the dial 8 so as to transmit six primary impulses, again followed by a single secondary impulse. In this case the circuit under control of the primary relay 70 is the same as that heretofore traced as far as contact 123. From this point, it extends through alternate contact 126 of the secondary off-normal switch O^3, normal contact 133, normal contact 130 of the release magnet RM^3, through the winding of the secondary magnet SM^3 to the live pole of the battery B^3. Thus the secondary magnet is energized and de-energized six times, thereby stepping the wipers 154, 155 and 156 into engagement with the sixth set of contacts 11, 12 and 13 in the fifth level or group, thus establishing connection with the contacts of the desired called line which, we have assumed, is that extending to the substation A shown in Sheet 3 of Fig. 1. At this point, it may be noted that as the wipers 155 and 156 pass over the contacts 12 and 13 associated with other lines than the desired line, they are free from battery or ground connections, thus preventing interference with conversation over said lines. The secondary impulse, which follows the six primary impulses, is extended by the secondary relay 77 to the contact 125 of the second selector switch E, over a path the same as that heretofore traced. From this point, its circuit is continued through alternate contact 131 of the secondary off-normal switch O^3, normal contact 136 of the control relay 132, the right-hand winding of the relay 137 which controls the application of the busy signal, to the live pole of the battery B^3. The completion of this circuit momentarily energizes the relay 137 to cause it to move its contact 138 to its alternate position. In case the desired line is in use, we have seen that its private contacts 11 will be connected to ground through the winding of the release magnet RM of the line selector switch with which connection has been established, if the desired line has been operated as a calling line. On the other hand, if connection has been established with the desired line as a called line, the private contacts 11 will be grounded through the wiper 154 of another connector switch F, contacts 139—140, which will be in engagement at this time, through the winding of relay 132 to ground at G^{14}. Consequently, if the called line is busy, a path for current will be completed so as to lock the relay 137 and thereby apply busy current to the line to signal the calling party. This circuit may be traced from the live pole of the battery B^3, through the right-hand winding of the relay 137, normal contact 139, wiper 154 and contact 11 to ground over either of the paths previously traced. The windings of the relay 137 are so arranged that at this time their effects will be cumulative and consequently the contact 138 of the relay will be held closed. The busy signal may be applied to the line in any preferred manner; and in the present instance, I have illustrated for this purpose an interrupter 151, included in a primary circuit with one winding of an induction coil I, and battery and by the other winding of said coil inductively with condenser *c*, relay contact 138, normal contact 136 of the control relay 132, the alternate contact 131 of the secondary off-normal switch, second selector switch contacts 124—125, normal contact 113, first selector switch contacts 105—106, normal contact 84, condenser *c'*, normal contact 58, line selector switch contacts 37—38, alternate contact 21 of the relay 20, line limb S, contacts 9—10 of the calling device T, transmitter *t*, switch-hook 1, line limb P, alternate contact 23 of relay 20, line selector switch contacts 35—36, normal contact 55 of the relay 54, normal contact 68, normal contact 73, winding of the primary relay 70, and battery B^2 to ground. The current induced in this secondary circuit will produce the customary "buzzing" sound in the receiver of the calling party, as an indication to him that the called line is busy.

In case the called line is not busy, the final secondary impulse transmitted from the calling station will only momentarily energize the relay 137 and will, therefore, not apply the busy signal. Upon the de-energization of this relay, its mechanical construction is such, as will hereinafter more fully appear, as to cause a movement of the contact 139 to its alternate position, thereby placing ground on the multiple contacts 11 of the called line over the previously traced path from the wiper 154, through contacts 139—140, winding of the control relay 132 to ground at G^{14}. The placing of ground upon the contacts 11 over this path completes an energizing circuit for the relay 20 associated with the called line. This circuit extends from the live pole of the battery B^3, through the winding of said relay to the contact 11 and thence to ground through the winding of the control relay 132. The completion of this circuit energizes both relays 20 and 132. By the energization of the

former, the contacts 21 and 23 are moved to their alternate positions to complete the connection between the line limbs S and P and the contacts 12 and 13, while at the same time interrupting the circuit through the relay 14 so as to prevent the initiation of a call over said line. The energization of the relay 132 interrupts the circuit of the secondary magnet SM^3 at the contact 133 and completes the strands L^5 and L^6 of the link-circuit at this point. At the same time, the engagement of the contacts 133—134 completes a circuit from ground G^{15}, through the normal contact of relay 142, normal contact 129, contacts 134—133, link-circuit strand L^5, alternate contact 126 of the secondary off-normal switch O^3, second selector switch contacts 123—122, normal contact 110, first selector switch contacts 104—103, normal contact 82, normal contact 71 of the private relay 70, normal contact 69, winding of relay 89 to the live pole of the battery B^2. The completion of this circuit energizes relay 89 sufficiently to move its contacts 73—76 to their alternate positions and thereby complete a circuit for transmission current to the calling substation from the live pole of said battery, through the lower windings of the relays 90—91, alternate contact 76, normal contact 74, link-circuit strand L^2, line selector contacts 37—38, line limb S, through the transmitter at the substation, line limb P, line selector contacts 35—36, link-circuit strand L', normal contact 68, alternate contact 73, upper windings of the relays 91—90 to ground at G^{10}. The arrangement of the windings of the relay 91 is such that at this time their effects are cumulative and consequently the relay is energized to attract its contacts 92—93 and thereby complete an additional path to the link-circuit strands L' and L^2 from the live pole of the battery B^2, through the lower windings of the relays 90—91, closed contact 92, normal contact 98, to the link-circuit strand L^2; and from the link-circuit strand L', through normal contact 97, closed contact 93, the upper windings of the relays 91 and 90 to ground at G^{10}. The arrangement of the windings on the relay 90 is such that their effects are differential and consequently the contact of this relay is not closed at this time. At the same time that the control relay 132, associated with the connector F, is energized, a circuit is completed through the winding of the ringing relay 148. This circuit extends from the live pole of the battery B^3, through the winding of said relay, normal contact 145, contacts 141, 139 and 140, through the winding of the relay 132 to ground at G^{14}. The ringing relay 148 is thereby energized closing its contacts 149—150 and thereby completing a circuit over which ringing current is supplied to the called line. The path for the latter extends from the generator 153, through the interrupter 152, closed contact 150, wiper 156, contact 13, alternate contact 21, line limb S, condenser c^2 at the substation, call-bell c^4, switchhook 1, line limb P, alternate contact 23, contact 12, wiper 155, closed contact 149, the lower winding of the relay 143 and through the battery B^3 to ground, thereby actuating the call-bell as a signal to the called party. By means of the interrupter 152, ringing current is intermittently transmitted from the generator 153 and, during the non-transmitting intervals, the circuit is grounded at G^{16}. The relay 143 is so constructed that the passage of ringing current through its winding in circuit with the condenser c^2 will not move its contacts from their normal positions. As soon as the called party removes his receiver from its hook, thereby completing a conductive bridge between the line limbs S and P through his transmitter, battery current is transmitted over the ringing circuit just traced, except that through the substation it finds a path through the closed bridge including the transmitter. The battery current over this circuit now energizes the relay 143 to cause the movement of its contacts 144, 146 and 147 to their alternate positions, thereby completing the adjacent portions of the link-circuit strands L^5 and L^6 at the contacts 146—147, interrupting the circuit through the ringing relay 148 at contact 145 and closing a locking circuit through the upper winding of the relay 143 at the contacts 144—145. This locking circuit extends from the live pole of the battery B^3, through the upper winding of the relay 143, contacts 144—145, contacts 141, 139 and 140, and winding of relay 132 to ground at G^{14}. The breaking of the ringing relay circuit discontinues the application of ringing current to the called line, and the closing of the contacts 146—147 completes a new path for transmission current from the live pole of the battery B^3, through the upper winding of the relay 142, link-circuit strand L^5, wiper 155, contact 12, line limb P, through the transmitter at the substation, line limb S, contact 13, wiper 156, link-circuit strand L^6, and the lower winding of the relay 142 to ground at G^{16}. The closing of this circuit energizes the relay 142 to open its contacts and thereby open the circuit of the relay 89 associated with the first selector switch D, thereby deenergizing said relay. The mechanical associations of the relay 89 are such that upon its de-energization the switch contacts 68—69 and 74—75 are thrown to their alternate positions, thereby making the last connection necessary to the completion of the talking circuit between the calling and called stations. At the same time, the contact 75 is grounded at G^8 and a circuit is thereby completed through the

winding of the relay 94, which is energized sufficiently to move its contacts 95—96 into engagement with the contacts 97—98 respectively, and at the same time causing the latter to break their normal contacts. By this means, the direction of current flow to the calling station is reversed. This is occasioned for the purpose of operating pay-station and other devices which may be used in the system.

In order to restore the parts to normal position at the end of conversation, it is only necessary for either or both parties to hang up their receivers. Associated with each switch-hook, is a contact 3, over which a projection 2 on the switch-hook passes when the receiver is taken down. Upon the return of the receiver, the projection 2 moves the spring to its alternate contacting position to ground both sides of the line. By the time the switch-hook reaches its normal position, the projection 2 has passed over the spring 3 and the parts are left in their normal positions. If the calling party first restores his receiver to the switch-hook and thereby grounds both line limbs, the normal balance of the relay 90 is destroyed, since a circuit is now completed through the lower winding of said relay over one line limb to ground at the substation. The relay thereupon closes its contacts and a circuit is completed from the live pole of the battery B^2 through the release magnet RM′ of the first selector switch D and the release magnet RM of the line selector switch C. This circuit may be traced from the live pole of the battery B^2, through the winding of the release magnet RM′, closed contacts of the relay 90 and winding of the release magnet RM to ground. The energization of release magnet RM′ closes a second circuit through the release magnet RM^2 of the second selector switch. This circuit extends from the live pole of the battery B^2, through the resistance r^3, alternate contact 99, wiper 101, contact 102, alternate contact 115, winding of the release magnet RM^2 to ground at G^{12}. The energization of release magnet RM^2 in turn closes a circuit through the release magnet RM^3 of the connector switch F. The circuit of this latter magnet extends from the live pole of the battery B′, through the resistance r^4, alternate contact 117, wiper 120, contact 121, alternate contact 157 and winding of the release magnet RM^3 to ground at G^{13}. The construction of the substation equipment is such that the ground on the line limbs will remain long enough to permit these release relays to be energized. Upon the deenergization of each of these relays, the associated switch parts are returned to normal. This is due to the mechanical construction and arrangement of the parts, as will be hereinafter more fully pointed out.

If the called party first hangs up his receiver, he will similarly ground both line limbs, but this will not be instrumental in releasing the switch mechanism, since at this time a circuit will be completed through the upper winding of relay 142, over the line limb P to the ground at the substation. This circuit will maintain the relay 142 energized to hold its contacts open the same as during conversation. However, as soon as the switch-hook reaches its normal position and the ground is removed, and the bridge for battery current between the line limbs S and P interrupted, the relay 142 will be de-energized and will thereupon, by the closing of its contacts, complete a circuit from ground at G^{15}, through normal contact 129, contacts 134—133, link-circuit strand L^5, alternate contact 126, contacts 123—122, contact 110, contacts 104—103, alternate contact 68, contacts 97—95, closed contact 92, the lower windings of the relays 91—90 to the live pole of the battery B^2. The closing of this circuit will destroy the normal balance of the windings of the relay 90 and will energize it sufficiently to close its contacts with the consequent releasing of the different switching mechanisms, as previously pointed out.

The energization of the release magnet RM associated with the line selector switch causes the return of the switch contact 53 to its normal position, thereby completing a circuit from the live pole of the battery B^2, through the winding of the relay 54, alternate contact 61 and normal contact 53 to ground at G^7. The completion of this circuit energizes the relay 54 to interrupt the link-circuit strands L′ and L^2 at the contacts 55—58, thereby removing all ground or battery connections from the wipers 36 and 38. The energization of the release magnet RM, by closing its contacts 63 and 64, shunts the open contacts 55 and 58 and thereby maintains the unbalancing circuit of the differential relay 90. Upon the de-energization of the release magnet RM, the wipers 34, 36, 38 and 41 return to normal. During this movement, the contacts 49, 50, 51, 61 and 62 are also returned to normal. It should be noted that during this return movement of the wipers, interference with conversation over other link-circuits is prevented, since at this time the wipers 36 and 38 are free from battery and ground connections, the contacts 63 and 64 of the release magnet having returned to normal, and the contacts 55 and 58 of the private magnet 54 being attracted until the return of the contact 61 to normal, which occurs at the instant of the movement of the line selector switch wipers 34, 36 and 38 out of engagement with the last bank contacts 33, 35 and 37.

Similarly, upon the energization of the

release magnet RM′ associated with the first selector D, the switch contact 86 is returned to normal, thereby completing a circuit through the private magnet 80 which is energized to move its contacts 82—84 out of connection with the link-circuit strands L′—L². This circuit is maintained until the contact 85 is returned to its normal position, which occurs only when all the parts have reached their normal positions. Upon the de-energization of the release magnet RM′, its mechanical connections are such that the wipers return to normal, and upon such de-energization, the contacts 68, 69, 74 and 75 also return to normal. From this it will be seen that as the wipers 103 and 105 pass over the contacts 104 and 106 of busy selector switches, there will be no interference with conversation.

Similarly, upon the energization of the release magnet RM² of the second selector switch E, the switch contact 116 will be returned to normal, thereby completing a circuit through the private relay 109 from the live pole of the battery B′, through the winding of said relay, normal contact 116 and alternate contact 114 to ground at G¹¹. This circuit is maintained until the wipers reach their normal positions, at which time the contact 114 returns to normal, thereby interrupting the circuit. As soon as the circuit is completed, the relay 109 is energized and the link-circuit strands L³ and L⁴ are interrupted at contacts 110—113. In order to maintain the circuit for the magnet 90 from the called station, the contact 110 is bridged by the contact 119 which is closed upon the energization of the release magnet RM². Upon the de-energization of the release magnet, the contact 119 is opened and the wipers 122—124, which are then free to return to normal, are free from ground and battery connections and, therefore, there will be no interference with conversation through other selector switches.

Upon the energization of release magnet RM³ associated with the connector switch F, the circuit from ground G¹⁵, through the lower winding of the differential magnet 90, is interrupted at contact 129. At this time, all the release magnets RM, RM′, RM² and RM³ are caused to be de-energized. The de-energization of the release magnet RM³, as in the other cases, is instrumental in returning the parts of the connector switch F to normal. This magnet is also related to the contact 139 so that, upon the energization of the magnet, said contact is returned to its normal position, thereby breaking the locking circuit through the relay 143, as well as the circuits through the control relay 132 and relay 20. The de-energization of relay 143 breaks all ground and battery connections to the wipers 155—156 so that, as they pass over the contacts 11—12 of other lines, there will be no interference with possible conversation thereover. The de-energization of the relay 20 restores the normal connections of the line limbs S—P of the called line, while the de-energization of the control relay 132 breaks the link-circuit strands L⁵ and L⁶ at contacts 133 and 136 and also interrupts the circuit from ground G¹⁵, through the differential relay 90 by which the operation of the release magnets of the several switches is controlled.

If the calling party's line has been projected beyond the line selector, and the calling party hangs up his receiver before obtaining connection with the called line, he will simultaneously energize both the primary and secondary relays 70 and 77 over circuits to the substations such as have been previously traced, except that at the substation the ground connection will occur at G² instead of G′. When both the primary relay 70 and the secondary relay 77 are simultaneously energized, a circuit is completed from the live pole of the battery B², through the winding of the release magnet RM′ of the first selector switch D, thence through the contacts 87 and 88 of the primary and secondary relays and winding of the release magnet RM to ground, thereby momentarily energizing both release magnets RM′ and RM and causing them to release their switches and allow them to return to normal, as before described. In the event of either the second selector or the second selector and the connector being partially operated, the release magnets RM² and RM³ will be energized and de-energized as before described. In order that an impulse may not be improperly sent through the primary magnet PM′ of the first selector switch D, if the calling party should take off his receiver and immediately return the same, allowing only sufficient time for the contacts 87 and 88 to come into engagement, the contact 100 controlled by the release magnet RM′ is provided. Upon the engagement of the contacts 87 and 88, both contacts 71 and 78 are grounded at G⁷; and since the contacts 72 and 79 of the secondary off-normal switch O′ are moved to the alternate position only upon the first secondary movement of the switch, a circuit would thus be completed through the primary magnet PM′, if it were not for the contact 100 which is opened by the energization of the release magnet RM′ upon the engagement of the contacts 87 and 88.

In the system, I have shown a protective device in association with the line selector and have arranged its contacts so that, when the device is operated, the conductor 43 and the conductor running to the contact 30 of the master switch B are connected, as clearly illustrated in Fig. 1. As will be apparent from the previous description, this will ren-

der the particular line selector in question busy, and the wiper 29 of the master switch will fail to stop on the contact 30 associated with such switch. In the present instance, a heat coil 65, having its winding included in circuit with the battery B^2, is employed and its contacts 66—67, upon the operation of the device, complete the connection between the conductor 43 and the associated contact 30; while its normally closed contacts interrupt the supply of current to the line selector. Similar protective devices are also preferably employed in connection with the first and second selector switches and the connector switches.

In connection with the line selectors C and the first selectors D, I also preferably employ a signal which may be located at any suitable point for the purpose of indicating to a switchboard attendant or other person the failure of proper operation of the associated switches. This is accomplished by associating with the contact 85 of each first selector D a second contact 85′, and by providing a contact for the alternate position of the contact 53 associated with the connected line selector C. A suitable signal, such as the lamp s', is included in circuit with these contacts. In the normal position of the parts, this circuit is broken at the contact 53. As soon, however, as the line selector makes its first movement, the contact 53 is moved to its alternate position, and the circuit of the signal lamp s' is closed, thereby displaying said signal. This circuit is maintained until the contact 85′ is moved to its alternate position, which occurs when the first selector makes its initial movement. From this it will be seen that the operation of the line selector and the failure of the subsequent operation of the associated first selector switch will be indicated by the lamp s' remaining lighted, and proper attention can at once be given to locating and removing the trouble.

Obviously in the practice of the system above described, any preferred mechanical construction may be employed for performing the switching functions therein indicated. However, I preferably employ the switching mechanism illustrated in Figs. 2 to 13 inclusive.

Referring first to the master switch mechanism B, which is illustrated in Figs. 2 and 3, the contacts 30 are arranged in a suitable bank 200, mounted on a base 201, and arranged in the arc of a circle. Ten of these contacts are shown, although obviously a greater or less number might be employed. Co-operating with these contacts are the movable wipers 29, of which four are shown mounted upon a shaft 202 and so positioned with reference to the contacts 30 that, as soon as one wiper passes beyond the last contact, another wiper will pass into engagement with the first contact. The shaft 202 is provided with a ratchet wheel 203 which is adapted to be actuated by a pawl 204, carried by the armature 205 of the actuating magnet 31 which, as previously described, is included in a vibratory circuit. This circuit is made and broken by the contacts 206—207 in response to the movements of the armature 205. The beveled stop 208 co-operates with the end of pawl 204 to limit its movement so that the wipers 29 are moved but a single step upon each energization and de-energization of the magnet 31. The moving parts of the switch are suitably encased by a cover 209, fitted upon the base 201.

Referring now to the line selector switch C, which is illustrated in Figs. 4, 7, 8, 9 and 10, 210 designates a suitable supporting frame for the switch mechanism, which includes the primary magnet PM, secondary magnet SM and the release magnet RM. The frame also carries the fixed contacts 33, 35, 37, which are arranged in a bank 211 with their free ends adapted for the attachment of suitable conductors and having their contacting inner ends terminating in a spherical surface. These contacts are suitably insulated from each other and co-operate with the wipers 34, 36 and 38, which are pivoted at the center of rotation of the spherical surface to the lower end of a rotary shaft 212, carried by the frame 210. The wipers are rotatable with the shaft 212 in a horizontal direction and, in addition, may be rotated vertically about their pivot 213, through the agency of an additional longitudinally movable shaft 214 having a broad foot 215 which engages a rearward projection 216 on the wipers. Thus, by rotating the shaft 212, the wipers may be given their primary movement to the desired level or group of bank contacts; and by subsequently giving the shaft 214 a longitudinal movement, the wipers may be moved to the desired bank contact in the selected level. The foot 215 on the shaft 214 is made sufficiently large to engage the projection 216, no matter what the position of the wipers may be. In addition to the wipers and bank contacts thus provided, a horizontal row of fixed contacts 39 is carried at the upper side of the bank contacts 33, 35 and 37 and these contacts are arranged in the arc of a circle in a position to have their inner ends engaged by the wiper 41, carried by and insulated from the shaft 212. As will be apparent, the wiper 41 is capable of a horizontal movement only and, therefore, does not partake of the secondary movement of the wipers 34, 36 and 38. The mechanism associated with the primary magnet PM, by which the shaft 212 is given its primary or rotary movement, comprises an actuating pawl 217, car-

ried by the armature 218, adapted to engage the teeth of the ratchet wheel 219 to step the shaft around. The movements of the pawl 217 are limited by the beveled stop 220. The shaft 212 is retained in its various positions by the retaining pawl 221 which is adapted to engage the teeth of the ratchet wheel. The upper end of the shaft 212 carries a member 222, as illustrated in Fig. 7, having a projection 223 which normally maintains the spring contacts 49, 50 and 51 in their normal positions; but upon the first movement of the shaft, allows them to return, under their inherent tension, to their alternate positions. The secondary magnet SM, through the agency of its armature 224, actuating pawl 225, and the ratchet teeth 226 on the shaft 214, steps the latter downward to carry the contacting ends of the wipers 34, 36 and 38 into their desired positions. A suitable retaining pawl 227 engages the teeth 228 upon the shaft 214 to hold it in its different operating positions. The shaft 214 is also provided with a suitable spline 229 which, after the first movement of the shaft, engages the teeth of the ratchet wheel 219 to lock the shaft 212 against rotation. The contact springs 61 and 62 are normally held against their spring tension in the position illustrated in Fig. 1, through the agency of a projection 230 carried at the upper end of the shaft 214. The outer end of this projection normally engages a pin 231 to hold the contacts in this position. The vibratory circuit of the primary magnet PM is completed through the contacts 232 and 233, which are actuated by the armature 218 of said magnet. The vibratory circuit of the secondary magnet SM is completed through the contacts 234 and 235 which co-operate with the armature 224 in making and breaking the circuit. Upon the energization of the release magnet, as previously pointed out, the contacts 63 and 64 are moved to their alternate positions; and the contact spring 53, carried by the frame 210, is restored to its normal position. The armature 236 of the release magnet directly engages the contact springs 63 and 64 to give them the desired movement and is provided at its lower end with a member 237 which extends beyond the contact spring 53 into a position to draw it to its normal position upon the attraction of the armature 236. This spring has a tendency to move it to its alternate position, but is normally restrained against such movement by the catch 238, pivoted at 239 to a post projecting from the frame 210. The catch 238 is removed from its retaining position so as to allow the spring 53 to move to its alternate position upon the first energization of the primary magnet PM. This is brought about through the agency of a lever 240, pivotally supported near its center upon the frame 210 and having one end lying in the path of movement of the armature 218 of the primary magnet. Its opposite end is provided with an upturned projection 241 which bears against the under side of the catch lever 238. Upon the first movement of the armature 218, the lever 240 is rocked about its pivot and its upturned end rides over the inclined surface 242 on the under side of the catch lever 238 so as to rock the latter about its pivot 239 and thereby release the spring 53 and allow it to move to its alternate position.

As previously indicated, after the wipers have been given their primary and secondary movements, they are retained in their connected position by means of the primary retaining pawl 221 and the secondary retaining pawl 227. In giving the wipers their primary movement, the shaft 212 is rotated against the tension of the spiral spring 243 contained in a suitable casing 244, carried by the frame 210. Similarly, in giving the wipers their secondary movement, they are rotated against the tension of a spiral spring 245 located about the pivot 213 and co-operating between the lower end of the shaft and said wipers. In view of this, it is therefore only necessary, in order to return the wipers and other switch parts to their normal positions, to disengage the retaining pawls 221 and 227. As previously indicated, this is brought about upon the de-energization of the release magnet RM. Upon such release, the retraction of the armature 236 draws the member 237 with it and this member is arranged to engage the retaining pawls at this time and therefore moves them out of operative position. This will be more apparent from an inspection of Figs. 4, 9 and 10, in which it will be seen that the primary retaining pawl 221 is provided with a tail having an upturned end 246 which is adapted to pass through a co-operating opening 247 in the member 237. Similarly, the secondary retaining pawl 227 is provided with a tail having a similar upturned end 248, similarly adapted to pass into an opening 249 in the member 237. Upon the attraction of the release magnet armature 236, the member 237 passes over the upturned ends 246 and 248 until the openings 247 and 249 come into registration therewith. The member 237 then, by the action of its spring 237^a, moves downward far enough to engage the projecting ends of the pawls. Then, upon the retraction of the armature 236, these pawls are moved out of engaging position and, through the agency of the springs 243 and 245, the wipers are returned to their normal positions. For convenience in establishing connection, connecting strips 250 and 251 are carried by and

suitably insulated from the frame 210 of the switch.

The selector switches D and E and the connector switch F partake of the general character of the line selector switch C just described. In each of these, the customary bank contacts 39 and the co-operating wiper 41 of the line selector are omitted. Referring to Figs. 11, 12 and 13, which illustrate the connector switch F, it will be seen that the bank contacts 11, 12 and 13 and co-operating wipers 154, 155 and 156, are similarly arranged and are given their primary and secondary movements in the same manner as previously described, the primary movement being given by the primary magnet PM^3, and the secondary movement by the secondary magnet SM^3. In this instance, no contacts, similar to the contacts 234 and 235 of the line selector, are provided, since the secondary magnet is not included in a vibratory circuit. In this instance also, the release magnet RM^3 operates through the agency of a member 237' to release the primary and secondary retaining pawls in a manner similar to that heretofore described; but in this instance, the catch lever 238 of the line selector is omitted; and the upturned end 241 of the lever 240, co-operating with the primary magnet armature 218, engages directly with the inclined surface 252, formed on the member 237'. In the case of the connector, the projection 223 at the upper end of the primary shaft 212 controls the movement of the single contact 157, while the projection 230 at the upper end of the secondary shaft 214 controls the movement of the contacts 126—131. As previously indicated, the contact 126 moves to its alternate position upon the first downward step of the shaft 214, while the contact 131 moves from its normal position upon the first downward step of said shaft, but does not move to its alternate position until the shaft has taken a second step. This is brought about by properly spacing the springs 126 and 131 and their co-operating springs, as illustrated in Fig. 11. In the connector also, the contact springs 139, 140 and 141 are under the joint control of the release magnet RM^3 and the magnet 137. As previously indicated, contact 139, which is normally in the position illustrated in Fig. 13, is moved against the contact 140 so as to press it into engagement with the contact 141 upon the de-energization of the magnet 137, and is restored to normal upon the energization of the release magnet RM^3. This is brought about through the agency of an arm 253, carried at the lower end of the armature 254 of the magnet 137 and having its outer end forced upward by a spring 255. Upon the attraction of the armature 254, a projection 256 on the arm 253 passes to the left of an insulating block 257, carried by the spring contact 139; and upon the retraction of the armature 254, the right-hand shoulder of the projection 256, by engaging the left face of the block 257, forces the spring 139 to its alternate position. In order to release the parts, the armature 259 of the release magnet RM^3 is provided with an arm 260, whose outer end overhangs the outer end of the arm 253, so that upon the attraction of the armature 259, the outer end of the arm 253 is drawn downward so as to free the projection 256 from the block 257 to allow the return of the spring 139 to its normal position. The electromagnet 137 has associated with it suitable contact springs arranged so that when the armature 254 is attracted, the contact spring 138 is moved to its closing position. Similarly, the release magnet RM^3 has associated with it suitable spring contacts, co-operating with the armature 259 so that, upon its attraction, contacts 128, 129 and 130 are moved to their alternate positions. Obviously, the frame may carry any of the other relays associated with the connector, such, for example, as ringing relay 103. As previously indicated, the wipers of the connector are placed two steps distant from the first set of bank contacts, while in the line selector and the other selector switches, the wipers are only distant one step. The first and second selectors are similar to the line selector previously described, but the number of spring contacts controlled by the primary and secondary movements of the switch are different. This merely necessitates a different number of springs to take the place of the line selector springs 49—50—51 and 61—62. However, the first selector switch D has its release magnet RM' so related to the parts of the relay 89 and the contacts 68, 69, 74 and 75, that, as previously indicated, upon the de-energization of the relay 89, said contacts will be moved to their alternate positions; and upon the de-energization of the release magnet RM', they will be restored to their normal positions. The mechanical arrangement of the parts, by which this is accomplished, is illustrated in Figs. 5 and 6, wherein the spring contact 86 is controlled by the release magnet armature 236 and the member 237 in the manner previously described in connection with the control of contact 53 of the line selector switch. The arrangement of the contacts 68, 69, 74 and 75 is illustrated in Fig. 5, wherein the insulating spacers 261 and 262, carried at the upper end of the lever 263, supported on the frame of the relay 89, are adapted to move the contacts to their alternate positions. In operation, as soon as the force by which the lever 263 is actuated is withdrawn, the tension of the springs and the shape of the

spacers is such that the parts return to the position illustrated. The armature 264 of the magnet 89 carries a spring-pressed arm 265 which is provided with a catch 266 at its outer end, adapted to engage the lower end of the lever 263. Normally the catch is in non-engaging position, but upon the attraction of the armature 264, the arm 265 is moved far enough to allow the catch 266 to engage the lever 263; and upon the retraction of the armature, the lever is rocked about its pivot so as to force the spacers 261 and 262 and the associated contact springs to their alternate positions. Co-operating with the arm 265 is a spring-pressed member 267, carried by the armature 236 of the release magnet RM'. With the spring contacts in their alternate positions, the end of the arm 265, adjacent to the armature 264, will engage the side of the member 267. With the parts in this position, upon the attraction of the armature 236 of the release magnet, the member 267 will be drawn downward past the end of the arm 265 so as to engage the under side of its adjacent end. Then, upon the retraction of the armature 236, the member 267 will rock the arm 265 about its pivot and thereby release the lever 263 which will thereupon return to its normal position, thereby permitting the springs also to return to their normal positions.

It will, of course, be apparent to those skilled in the art that many alterations and modifications may be made in the mechanical construction of the switching mechanisms herein described without departing from the spirit and scope of my invention.

In the system heretofore referred to, the line selectors of each group are controlled by a single master switch mechanism B which is instrumental in starting an idle line selector to pick out the bank contacts of the calling line. The control of the line selectors may be obtained in various other ways. Certain of these are illustrated in Figs. 14, 15 and 16.

Referring to Fig. 14, it will be observed that the extensions of the line limbs S and P to the contacts of the line selector and the associated relays and contacts are substantially the same as those disclosed in Fig. 1, but that the circuits and relays for the control of the line selector switch are different.

In operation, the removal of the receiver r from its switch-hook 1 causes the energization of the relay 14 and the consequent movement of its contacts 15, 16, 17 and 18 to their alternate positions, the same as heretofore described. The movement of the contact 16 similarly energizes the relay 16^a to remove the normal ground connection at G^5 of all of the multiple contacts 39 associated with the group including the calling line. The movement of the contact 18 similarly removes the normal ground from the private contacts 33 associated with the calling line. The movement of the contact 17 closes a locking circuit for the relay 14 for the purpose heretofore pointed out, and the movement of the contact 15 completes a circuit through the winding 28 of the differential relay 26 to cause the latter to close its contacts. Thus the operation up to this point is substantially the same as that heretofore described in connection with Fig. 1. The closing of the contacts of relay 26 completes a circuit for one of the relays a, a', a^2, etc., according to the position of the contacts 270, 271 or 272, etc. If the line selector associated with the relay a is in use, the contact 270 will be in its alternate position, since the contacts 270, 273 and 274 are thrown to their alternate positions upon the first primary movement of the line selector. Under such conditions, the circuit of the contacts of the relay 26 would be continued through the contacts 270 and 271 to the relay a' associated with a second line selector. Similarly, in case the second line selector be in use, the circuit of the contacts of the relay 26 is continued to the third line selector, and so on. Assuming that the selector associated with the relay a is idle, a circuit will be completed through said relay over the following path: from the live pole of the battery B^2, through the winding of heat coil 65^a, normal contact 66^a, winding of the relay a, normal contact 67^a, normal contact 270 and contacts of the relay 26 to ground. The closing of this circuit will sufficiently energize the relay a to move its contacts 275, 276, 277 and 278 to their alternate positions. The movement of the contact 275 completes a vibratory circuit for the primary magnet PM, which is instrumental in stepping the wipers 34, 36, 38 and 40 in a primary direction. As before indicated, upon the first primary movement, the contacts 270, 273 and 274 are moved to their alternate positions. At the same time, the wiper 40 engages a contact 39. If this contact be grounded, a circuit for the relay a will be maintained through the alternate contact 277, wiper 40, contact 39 to ground at G^5. This circuit will be maintained as long as the wiper 40 engages grounded contacts 39. As soon as an ungrounded contact is encountered, however, the circuit of the relay a will be interrupted and the said relay will be de-energized, thereby interrupting the circuit of the relay PM and stopping the further movement of the wipers in a primary direction. The movement of the contact 276 to its alternate position upon the energization of the relay a completes a circuit through the winding 27 of the differential relay 26, which may be traced from the live pole of the battery B^2, through said winding, a resistance 279, alternate contact 276 to ground. Thus, as soon as an idle line

selector is found and set in operation, current is supplied to the windings 27 and 28 of the relay 26 in parallel, and the resistances 19 and 279 in these parallel branches are so proportioned that the windings 27—28 substantially neutralize each other and allow the contacts of the relay 26 to open. Thus, after the first movement of the line selector, conditions are established for the selection of a second line selector upon the occurrence of a suitable inequality in the magnetizing effects of the windings 27—28. This, as previously pointed out, may be brought about by a second calling party connecting resistance 19′ to ground.

As soon as the relay *a* becomes de-energized, following the movement of the wipers to the desired level or group of bank contacts, an energizing circuit is completed for the private relay 54, which may be traced from the live pole of the battery B^2, through the heat coil, the winding of said relay, normal contact 280, normal contact 278, alternate contact 274 to ground. The completion of this circuit sufficiently energizes the relay 54 to cause a movement of its contacts 55, 56, 57 and 58 to their alternate positions. Upon the first primary movement of the line selector, not only are the contacts 270, 273 and 274 moved to their alternate positions, but the contact 282 is also moved to its alternate position. Consequently, as soon as the contact 57 of the relay 54 engages contact 59, a circuit is completed for the secondary magnet SM from the live pole of the battery B^2, through the heat coil 65^a, winding of said magnet, contacts 59—57, alternate contact 282 to ground at G^7. This secondary magnet is included in a vibratory circuit and causes the wipers 34, 36 and 38 to move over the bank contacts of the selected level or group. Upon the first secondary movement of these wipers, the switch contacts 280 and 281 are moved to their alternate positions. Consequently, from this time on, the relay 54 is maintained energized over a circuit extending from the live pole of the battery B^2, through the heat coil 65^a, winding of the relay 54, alternate contact 56, wiper 34, and contact 33 to ground. This circuit is maintained as long as the wiper 34 passes over grounded contacts. While the wipers are thus being moved, it will be observed that all battery and ground connections are removed from the wipers 36 and 38 by the contacts 55 and 58 of the relay 54. As soon as the wiper 34 engages an ungrounded contact, the circuit of the relay 54 is interrupted and its contacts return to their normal positions, thereby interrupting the circuit of the secondary magnet SM and stopping the wipers on the contacts of the desired line, as heretofore described. As before, also, as soon as the wiper 34 engages an ungrounded contact 33, and the contacts of the relay 54 are returned to normal, a circuit is completed for the relay 20 and the latter is energized sufficiently to move its contacts 21, 23, 24 to their alternate positions. By this movement of the contacts 21 and 23, the circuit of the line limbs S and P is continued so as to include the link-circuit strands L'—L^2. The movement of the contact 24 to its alternate position maintains a circuit for the relay 20. The initial energizing circuit for the relay 20 extends from the live pole of the battery B^2, through the winding of said relay, alternate contact 18, normal contact 24, private contact 33, wiper 34, conductor 34^a, normal contact 56, winding of the release magnet RM to ground. The operation in these respects is the same as that heretofore described in connection with Fig. 1. With the line limbs thus projected through the line selector to the first selector connected therewith, the operation of completing the connection with the called line is the same as that heretofore described.

As previously pointed out, as soon as the relay *a* is energized and its contact 276 removed to its alternate position, a path for current is provided through the winding 27 of the relay 26 which includes the resistance 279. As soon as the relay *a* is de-energized, this original path is interrupted at the contact 276, but prior to such interruption, the contact 273 was moved to its alternate position, thereby completing an alternate path from said contact, through the normal contact 281 and alternate contact 282 to ground at G^7. Upon the first secondary movement of the line selector, however, the contact 281 is moved to its alternate position and the path to ground from that time on is completed through the alternate contact 281, contacts 60—57 and alternate contact 282 to ground at G^7. Thus parallel paths are provided which include winding 28 and resistance 19 on the one hand, and the winding 27 and resistance 279 on the other, and these paths are maintained until the relays 14 and 54 are de-energized. These de-energizations occur at substantially the same time and the parallel paths are thereby simultaneously interrupted and the branches left in their normal condition.

In the releasing operation, the relay 54 and the release magnet RM perform the functions heretofore described in connection with Fig. 1, the contact 282 being moved to its normal position upon the energization of the release magnet RM, the contacts 270, 273, 274, 280 and 281 being returned to normal as heretofore. It may be here noted that upon the operation of the heat coil 65^a, the normal battery supply to the primary magnet PM and the relay *a* will be interrupted at the contact 66^a; and further, that the normal connection between the winding

of the relay a and the contacts of the differential relay 26 will be interrupted and connection established between said differential relay contacts and the control relay a' of the second line selector by way of the alternate contact 67^a and the normal contact 271.

In Fig. 15, I have illustrated a still further modification of the line selector and its associated control mechanism, in which the differential relay 26 of the previous figures is omitted. In this figure, the extensions of the line limbs S—P to the contacts of the line selector, and the associated relays 14 and 20, are substantially the same as those described heretofore, except that a locking circuit for the relay 14 has been omitted. The operation up to the point of removing the grounds from the contacts 33 and 39 associated with the calling line and grounding the conductor 42 at contact 15 are the same as heretofore described. The placing of the ground upon the conductor 42 completes a circuit for one of the relays b, b', etc., according to the position of the contacts 283, 284, etc., of the control relays c^{10}, c^{11}, etc. If the line selector associated with the relay b is in use, the contact 283 will be in its alternate position, as will hereinafter more fully appear, and the conductor 42 will be thereby connected in circuit with the relay b' through the alternate contact 283 and normal contact 284. Similarly, in case the second line selector is in use, said conductor will be connected to the corresponding relay of the third line selector, and so on. Assuming that the selector associated with the relay b is idle, then a circuit will be completed from ground at contact 15 of relay 14, through conductor 42, normal contact 67^a of the heat coil 65^a, normal contact 283, normal contact 285, winding of the relay b, winding of the heat coil 65^a, normal contact 66^a of said coil to the live pole of the battery B^2. The closing of this circuit will sufficiently energize the relay b to move its contacts 287, 288 and 289 to their alternate positions. The movement of the contact 287 completes a vibratory circuit for the primary magnet PM, which is instrumental in stepping the wipers 34, 36, 38 and 40 in a primary direction. Upon the first primary movement of the selector, contacts 285, 286 and 287′ are moved to their alternate positions. At the same time, the wiper 40 engages a contact 39. If this contact be grounded, a circuit for the relay b will be maintained through the alternate contact 288, wiper 40, contact 39 to ground at G^5. This circuit will be maintained as long as the wiper 40 engages the grounded contact 39. However, as soon as an ungrounded contact is encountered, the circuit of said relay will be interrupted, thereby interrupting the circuit of the primary magnet PM and stopping the further movement of the wipers in a primary direction. Upon the return of the contact 289 to its normal position as a result of the de-energization of the relay b, a circuit is completed for the private magnet 54 from the live pole of the battery B^2, through the heat coil 65^a, winding of the relay 54, normal contact 290, normal contact 289 and alternate contact 286 to ground. As before, the energization of this relay causes the movement of its contacts 55, 56, 57, 58 to their alternate positions. By the movement of the contact 57 into engagement with the contact 59, a circuit is completed from the live pole of the battery B^2, through the winding of the secondary magnet SM, through the contacts 59—57 and the alternate contact 287′ to ground. This secondary magnet, being included in a vibratory circuit, causes the wipers 34, 36 and 38 to move over the bank contacts of the selected level or group. Upon the first secondary movement of these wipers, the contact 290 is moved to its alternate position. This interrupts the initial energizing circuit of the relay 54 and said relay is maintained energized over a circuit extending from the live pole of the battery B^2, through the heat coil 65^a, winding of the relay 54, alternate contact 56, wiper 34 and contact 33 to ground, so long as grounded contacts 33 are encountered. As before, during this movement, the wipers 36 and 38 are disconnected from battery or ground; and as soon as the wiper 34 engages an ungrounded contact, the relay 54 is de-energized and its contacts return to normal, thereby discontinuing the further secondary movement of the wipers and connecting the parts of the link-circuit strands L′—L^2. At the same time, a circuit is completed through the relays 20 and c^{10}. This circuit extends at first from the live pole of the battery B^2, through the winding of the relay 20, alternate contact 18, normal contact 24, contact 33, wiper 34, normal contact 56, winding of relay c^{10} to ground. The closing of this circuit energizes both relays 20 and c^{10} to move their contacts to their alternate positions. As soon as the contact 24 reaches its alternate position, the circuit from the winding of the relay 20 to the contact 33 extends through the said alternate contact 24. The movement of the contacts of the relay 20 performs the functions heretofore described, while the movement of the contact 283 of the relay c^{10} to its alternate position breaks the connection between the conductor 42 and the relay b and extends the connection from said conductor to the relay b' of a second line selector, as previously indicated. From this it will be seen that in this form of the invention, a call initiated over a second line will not be instrumental in starting a second line selector until the previous line selector has completed its work of establishing connection. Under certain

circumstances, this may be very desirable; and in this respect, this form of the invention differs from the forms previously described. With the line limbs S and P thus projected through the line selector to the first selector connected therewith, the operation of completing a connection with a called line is the same as that heretofore described. The releasing operation is the same as that heretofore described; and upon the de-energization of the release magnet, the various switch parts are returned to their normal positions. At this point it may be observed that if the heat coil 65^a operates, the normal connection of the conductor 42 with the relay b will be interrupted and connection established with the relay b' of a second line selector, while the normal battery supply will be broken at the contact 66^a.

In Fig. 16, I have illustrated a still further modification which differs from that illustrated in Fig. 15 only in the manner of controlling the circuit through the relay b associated with the line selector. In the present instance, as soon as a ground connection is established at the contact 15 of the relay 14, a circuit is completed from the live pole of the battery B^2, through conductor 291, protective resistance 292, normal contact 294, normal contact 295, winding of relay d, conductor 42, alternate contact 15 to ground at G^4. It will be noted that the path through the contacts 294 and 295 is in shunt to a path through the windings of the relays d^2—d'. The effect of closing this circuit is to energize the relay d sufficiently to move its contact 296 to its alternate position. By so doing, a circuit is completed from the live pole of the battery B^2, through the heat coil 65^b, winding of the relay b, normal contact 285 and alternate contact 296 to ground. During the operation of the line selector in establishing connection with a calling line, the relay d remains energized until the de-energization of the relays 54 and 14 which, it will be remembered from the previous descriptions of operation, occur practically simultaneously. Thus, after the line selector has made its secondary movement and the relay 54 has been de-energized, a circuit is completed through the winding of the relay 20 and, through the agency of the latter, the circuit through the relay 14 is interrupted and, by the return of its contact 15 to normal, the ground upon the conductor 42 is removed. If, during the energization of the relay d, a second calling line establishes a ground connection at another point on the conductor 42, the flow of current through the relay d is practically unaffected and its contact 296 is still maintained in its alternate position; while at the same time, no path is provided which will cause the energization of the relay d' associated with the next line selector. The circuit through the relay 20, which is completed upon the de-energization of the relay 54, includes in parallel paths the control relay e and the release magnet RM. This circuit may be traced from the live pole of the battery B^2, through the winding of the relay 20, at first through alternate contact 18 of relay 14 and normal contact 24 of relay 20, and later through alternate contact 24, thence through contact 33, wiper 34, conductor 34^a normal contact 56, and thence by one path through the winding of the relay e to ground, and by another path through the winding of the release magnet RM to ground. As in the case of the system illustrated in Fig. 1, the closing of this circuit is insufficient to cause the release magnet to attract its contacts 63—64. However, the flow of current through the relay e is sufficient to move its contact 295 to its alternate position and thereby close a path in shunt to the winding of the relay d so that, upon the existence of grounds upon the conductor 42, due to other calls, a path for current will be provided through the relay d' associated with the next line selector. This circuit would extend from the live pole of the battery B^2, through conductor 291, resistance 292, normal contact 294, winding of relay d', alternate contact 295, conductor 42, alternate contact 15 to ground. In like manner, the winding of the relay d' may be shunted upon the energization of the relay e' to cause the operation of the relay d^2 associated with a third line selector, and so on throughout the line selectors of the group. Thus it will be seen that in this form also, it is impossible for a second line selector to be set in operation until a line selector already in operation has completed its work of establishing connection with its calling line.

In this form of the invention, the operation of the heat coil 65^b interrupts the supply of current at the contact 66^b and provides a supply of current to the windings of the relay e and the release magnet RM, through the protective resistance 297 and the alternate contact 67^b of the heat coil. This supply is sufficient to cause the contact 295 of the relay e to be moved to its alternate position and to thereby complete a shunt about the winding of the relay d to establish conditions to permit of the operation of the relay d' associated with the next line selector.

In this figure, I have also illustrated at the substation a relay 298 having its winding included in parallel with the transmitter t and controlling a locking armature 299 for holding the disk 8 against rotation. The relay 298 is energized upon the removal of the receiver r from its hook, over a circuit which causes the energization of relay 14 at the exchange. This circuit extends from the live pole of the battery B^2, through the

protective resistance r', normal contact 21, line limb S, contacts 9—10, winding of the relay 298 and the transmitter t in parallel, switch-hook 1, line limb P, normal contact 23, winding of relay 14 to ground at G^4. As long as this circuit is maintained, the disk 8 of the transmitting device T is locked against rotation. As soon, however, as the line selector has completed its work and the relay 20 has consequently been energized, this circuit is broken and the disk 8 may be operated at will to complete the calling operation. This locking relay obviously may be employed with the systems illustrated in the other figures.

In the systems illustrated in Figs. 1 and 14, in which the arrangement is such that a second line selector may be set in operation before the first selector has completed its connection, some provision must be made against the improper operation in selecting a group in case two of the group selecting contacts 39 are simultaneously ungrounded. For this purpose, each group of bank contacts is provided with an additional contact or set of contacts which will be instrumental in releasing the selector in case they are engaged by the wipers of the selector. This arrangement of bank contacts is diagrammatically illustrated in Fig. 17, wherein contacts 33′, 35′ and 37′ are provided for each group in addition to the regular number of sets of contacts 33, 35 and 37. The contacts 33′ of these extra sets are connected through a resistance r^2 to the live pole of the battery B^2. Now if, in the operation of the system, a second line selector is started immediately after a first line selector has been started, and if it be assumed that the first line selector is started after contacts in the second group, while the second line selector is started after contacts in the tenth group, it will be apparent that, as the wiper 40 of the second line selector moves over the contacts 39, it will stop in engagement with the contact 39 of the second group, in case the first line selector has not already engaged its contacts in said group and thereby restore ground to the contact 39 of said second group. In case the wiper 40 of the second line selector reaches the contact 39 of the second group before it has had ground restored to it as described above, its wipers 34, 36 and 38 will immediately begin to move over the contacts in said second group, but will not stop in engagement with any of them, since the operation of the first line selector in making connection will restore ground to the only ungrounded contacts in said group. Consequently, these wipers of the second line selector will pass over the contacts 33, 35 and 37 associated with subscribers' lines, and into engagement with the contacts 33′, 35′ and 37′ of which 33′ is associated with the live pole of the battery B^2. As soon as the wipers reach this position, a circuit will be completed from the live pole of the battery B^2 through the resistance r^2, contact 33′ engaged by wiper 34, wiper 34, conductor 34^a, normal contact 56, winding of the release magnet RM to ground. The completion of this circuit will sufficiently energize the release magnet RM to cause it to operate to restore the switch parts to their normal condition and thereby leave the second line selector free to again begin its operation.

The provide against the improper operation of the line selector, resulting from a momentary crossing of the line limbs S—P, a locking circuit for the relay 14 in Figs. 1 and 14 was employed. Where this locking circuit is omitted, as in Figs. 15 and 16, additional contacts 33^2, 35^2 and 37^2, occupying the first position in the eleventh level or group of line selector bank contacts, are provided. The private contact 33^2 of this group is connected through the resistance r^2 to the live pole of the battery B^2 and is instrumental in causing a restoration of the switch parts whenever engaged by the wiper 34 of said selector. Thus in operation, if a line selector is started in response to a momentary connection of the line limbs S—P, a contact 39, corresponding to the level or group of the calling line bank contacts, will be momentarily ungrounded. If, by the time the co-operating wiper 40 comes into engagement with its contact 39, it is again grounded, then the wiper will not stop at this position, but will continue over the other contacts 39 until the last contact 39′, which is an additional contact corresponding to the group including contacts 33^2, 35^2 and 37^2, is encountered. Then upon the first secondary movement of the wiper 34, the contact 33^2 will be engaged and a circuit similar to that previously traced will be completed, and the line selector thereby released and restored to a position to begin its primary and secondary traverses over again.

In Figs. 18 and 19, I have illustrated substitute arrangements for the relays 26 of Figs. 1 and 14 respectively. In this arrangement, a relay 26′, having a single winding, is provided in association with resistances 300 and 301. The winding of the relay 26′ is included in circuit between the conductors 42 and 44, and the resistances 300 and 301 are included between the live pole of the battery B^2 and the conductors 42 and 44 respectively. With this arrangement, it will be seen that when a ground is placed on the conductor 42 alone, current will flow from the live pole of the battery B^2 to said conductor over two paths, one including the resistance 300, and the other including the resistance 301 and the winding of the relay 26′. The flow of current over the latter path will be sufficient to energize the relay 26′ to cause

it to close its contacts. Now, as soon as a ground is placed upon the conductor 44 in addition to that on the conductor 42, current will flow from the live pole of the battery B^2 to the conductor 44 over two paths, one including the resistance 301, and the other including the resistance 300 and the winding of relay 26'. The resistances 300 and 301 are so proportioned that at this time the flow of current through the winding of the relay 26' is insufficient to maintain its contacts closed, the said relay being substantially in the galvanometer branch of a balanced bridge. Therefore, during the existence of grounds on both conductors 42 and 44, the relay contacts are open. From this it will be seen that this arrangement accurately performs the functions of the differential relay 26 in the systems of Figs. 1 and 14.

Although, in the several systems herein disclosed, I have shown separate and independent batteries, it is to be understood that they may be replaced by a single battery as, in practice, would ordinarily be the case.

It will, of course, be apparent to those skilled in the art that in carrying out my invention, many other alterations and modifications in its mechanical and electrical features may be made without departing from the spirit and scope of the invention. It will also be apparent that many of the features and details are capable of use in other relations. I therefore do not wish to be limited to the exact matter disclosed, but aim to cover by the terms of the appended claims all such alterations, modifications and varying adaptations.

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

1. A telephone exchange system comprising a plurality of subscribers' telephone lines divided into groups, a plurality of interconnecting link-circuits, a plurality of electrically controlled switches for completing connections between any calling lines and any called lines, said switches including line selectors assigned by groups to groups of lines, and the total number of said switches being less than the total number of said telephone lines no matter how many of the latter there may be in the exchange, said electrically controlled switches being controllable over the two sides of the subscriber's lines in series, and means for establishing as many simultaneously existing conversational circuits between pairs of lines all in the same group as there are line selectors for the group.

2. A telephone exchange system comprising a plurality of subscribers' telephone lines, a plurality of interconnecting link-circuits, a plurality of two motion electrically controlled selectors for completing connections between any calling line and any called line, the total number of said switches being less than the total number of said telephone lines no matter how many of the latter there may be in the exchange, switch contacts for each of said selectors adapted to be traversed by the voice currents when the selectors are included in connections, means whereby the switching of a calling line to connection with a called line will operate only those selectors whose contacts are included in the finally completed talking circuit, and release circuits for said switches controlled by the opening of a subscriber's line circuit.

3. A telephone exchange system comprising a plurality of subscribers' metallic circuit telephone lines, interconnecting link-circuits, means, including an electrically controlled switch, for connecting said link circuits so as to establish conversational connection between calling and called lines, line relays for said lines energizable over the two sides thereof in series for assisting in the control of said means, and means whereby one of the connected substations, independently of the other sub-station, may restore said switch to normal by breaking a metallic circuit.

4. A telephone exchange system comprising a subscriber's line extending from a substation to an exchange, a link-circuit, electrically controlled switching means for establishing connection between said telephone line and said link-circuit means at the substation for controlling the operation of said switching means, a manually operated directive impulse device at the substation, and means for preventing the manual operation of said device until said electrically controlled switching means has reached a pre-determined point in its operation.

5. A telephone exchange system comprising a subscriber's line extending from a substation to an exchange, a link-circuit, electrically controlled switching means for establishing connection between said telephone line and said link-circuit, means at the substation for controlling the operation of said switching means, manually operated directive impulse means for transmitting current impulses over the line, and means for preventing the manual operation of said impulse transmitting means until said electrically controlled switching means has reached a pre-determined point in its operation.

6. A telephone exchange system comprising a plurality of subscribers' telephone lines, interconnecting link-circuits, means, comprising electrically controlled switches, for connecting said link-circuits so as to establish a conversational connection between a calling line and a called line, means at the calling station for setting one of said electrically controlled switches in operation, manually operated directive impulse means

at the calling station for subsequently causing the operation of other of said electrically controlled switches, and means for preventing the manual operation of said latter means until the electrically controlled switch first set in operation has reached a pre-determined point in its said operation.

7. A telephone exchange system comprising a plurality of subscribers' telephone lines, interconnecting link-circuits, means, comprising electrically controlled switches, for connecting said link-circuits so as to establish a conversational connection between a calling line and a called line, means at the calling station for setting one of said electrically controlled switches in operation, manually operated directive impulse transmitting means at the said calling station for subsequently transmitting current impulses over the calling line to cause the operation of other of said electrically controlled switches, and means for preventing the manual operation of said transmitting means until the electrically controlled switch first set in operation has reached a pre-determined point in its said operation.

8. A telephone exchange system comprising a subscriber's line extending from a substation to an exchange, electrically controlled two motion connecting switches associated with said line, a control relay energizable over the two sides of said subscriber's line in series, means actuated thereby to establish a condition such as to cause a connecting switch to establish connection with said line, means controlled by said relay for starting travel of one only of said switches on initiation of a call, means under the control of the subscriber for actuating said relay, a locking circuit for said relay closed upon said actuation, and means for causing the de-energization of said relay as soon as said switch has completed the connection.

9. A telephone system including telephone lines, link-circuits having electrically controlled selective switches at each end, the switches at the answering ends of said link-circuits serving to select calling lines, line relays for said lines energizable over the two sides thereof in series, a circuit for starting the switches at the answering ends of the link-circuits, said circuit having normal starting connections, means for rendering said circuit effective when any line relay is operated, and means rendering said circuit ineffective with respect to subsequently established starting connections until another line relay is operated.

10. A telephone exchange system comprising subscribers' telephone lines, a plurality of electrically controlled connecting switches associated with said lines, means under the control of any one of said subscribers for establishing a condition such as to cause one of said switches to establish a definite connection, means under the control of a second subscriber for establishing a condition such as to cause another of said switches to establish a second definite connection, and means for causing the second connected switch to return to normal in case of improper operation due to the condition established by said first subscriber.

11. A telephone exchange system comprising a subscriber's telephone line, an electrically controlled switch having fixed and movable contacts, means under the control of the subscriber for establishing a condition such as to cause the movable contact of said switch to pick out and stop upon a desired fixed contact, additional fixed contacts adapted to be engaged by said movable contacts in case said condition is removed before said movable contact engages said desired fixed contact, and means associated with said additional contacts for causing the return of the switch parts to normal when engaged by said movable contact.

12. A telephone exchange system comprising a plurality of subscribers' telephone lines, a plurality of interconnecting link-circuits, a plurality of electrically controlled switches for automatically joining said link-circuits to complete a circuit between a calling line and a called line, and protective devices responsive to abnormal electrical conditions to render the associated switches non-selectable.

13. A telephone exchange system comprising a subscriber's telephone line, a plurality of link-circuits associated therewith, electrically controlled switches for automatically establishing connection between said line and one of said link-circuits, and a protective device associated with each link-circuit and responsive to abnormal electrical conditions to render its link-circuit nonselectable.

14. A telephone exchange system comprising a plurality of subscribers' telephone lines, a plurality of link-circuits associated therewith, electrically controlled switches for establishing connection between said lines and said link-circuits, master switch mechanism for setting an idle switch in operation to establish such a connection, and a protective device associated with each such switch and responsive to pre-determined electrical conditions to render its switch non-selectable.

15. An automatic telephone system including telephone lines, a plurality of classes of two motion selector switches at the exchange, the classes and the switches of each class being provided in numbers proportioned respectively to the number of said telephone lines and to the number of expected co-existing calls, means whereby the operation of a series of switches composed of one switch of each class will connect a calling line with a called line by a complete talking circuit, means for preventing false

operations of switches, and release circuits controllable by the opening of one of said lines.

16. A telephone system including telephone lines, two motion line selectors for selecting calling lines provided in number determined by the expected co-existing calls from said lines, connectors for connecting to the called line provided in number based upon the expected percentage of co-existing calls, one or more classes of intermediate group selecting switches, the switches of each class being provided in number similarly determined, and the classes being provided in number dependent upon the number of said telephone lines, electromagnetic switching mechanism to adjust one switch of each class to establish a complete talking circuit between a calling line and a called line, means for operating said line selectors to connect each with a different line, and release means for said selectors operable by the opening of a subscriber's line circuit.

17. A telephone system including telephone lines, link-circuits at the exchange having electrically operated selective switches at both ends, the switches at the answering ends of said link-circuits serving when started to connect link-circuits with calling lines, a starting conductor for initiating travel of predetermined numbers of idle ones of said last-mentioned selective switches, and line relays for said lines energizable over the two sides of the lines in series, and branch connections from said conductor to said relays whereby any line may control said conductor to start a switch.

18. A telephone system including telephone lines, link-circuits at the exchange having electrically operated two motion selective switches at both ends, the switches at the answering ends of said link-circuits serving when started to connect link-circuits with calling lines, a starting conductor for initiating travel of one idle switch only of said last-mentioned selective switches, line relays for said lines energizable over the two sides of lines in series, and branch connections from said conductor to said relays whereby any line may control said conductor to start a switch, and means for connecting the selective switches at the calling ends of said link-circuits with definite conductors.

19. A telephone system including telephone lines, link-circuits at the exchange having electrically operated selective switches at both ends, the switches at the answering ends of said link-circuits serving when started to connect link-circuits with calling lines, one line relay for each of said lines energizable over the two sides of the line in series for controlling said last-mentioned switches, a starting conductor for initiating travel of an idle one of said last-mentioned selective switches, and operatively associated with all said lines at one time, an automatic switch at the end of said starting conductor, terminals of said selective switches at said automatic switch, and test means enabling said automatic switch to select a terminal of an idle selective switch.

20. A telephone system including telephone lines, link-circuits at the exchange having electrically operated selective switches at both ends, the switches at the answering ends of said link-circuits serving when started to connect link-circuits with calling lines, a starting conductor for initiating travel of an idle one of said last-mentioned selective switches, an individual line relay for each of said lines and a branch connection from said conductor to said relays whereby any line may control said conductor to start a switch, an automatic switch at the end of said starting conductor, terminals of said selective switches at said automatic switch, test means enabling said automatic switch to select a terminal of an idle selective switch, and release mechanism controllable by the opening of a subscriber's line circuit.

21. A telephone system including telephone lines, link-circuits at the exchange having electrically operated two motion selective switches at both ends, the switches at the answering ends of said link-circuits serving to connect them with calling lines, a starting conductor for initiating travel of an idle one of said last-mentioned selective switches, means for connecting the selective switches at the calling ends of said link-circuits with definite line conductors, line relays for said lines energizable over the two sides thereof in series and a branch connection from said conductor to said relays whereby any line may control said conductor to start a switch, an automatic switch at the end of said starting conductor, terminals of said selective switches at said automatic switch, and test means enabling said automatic switch to select a terminal of an idle selective switch.

22. A telephone system including a group of telephone lines, terminals therefor at the exchange grouped together and arranged in sub-groups, link-circuits at the exchange and selective switches therefor to connect idle link-circuits with calling lines, a common starting circuit, for initiating travel of an idle selective switch, operatively associated with said lines at one time, normally quiescent switching means at the exchange and at the substations of said lines effective on initiations of calls to actuate said starting circuit, electromagnetic switching mechanism at the exchange automatically responsive to said means to control travel of a started switch to select the sub-group and

then the terminals of the calling line, and release mechanism for said switch effected by the opening of a subscriber's line circuit.

23. A telephone system including a group of telephone lines, terminals therefor at the exchange grouped together and arranged in sub-groups, link-circuits at the exchange and selective switches therefor to connect idle link-circuits with calling lines, a common starting circuit, for initiating travel of an idle selective switch, line relays, one for each line and branch connections from said starting circuit to said relays whereby any relay may actuate said circuit, substation switching means to actuate said line relays, a common sub-group terminal for each said sub-group, electromagnetic switching mechanism at the exchange responsive to said means to alter the electrical conditions of the sub-group terminal and an individual terminal of the calling line, and apparatus controlled by the conditions of said terminals to cause a started switch to select the sub-group and the individual terminal of the calling line.

24. A telephone system including a group of telephone lines, individual line relays for said lines energizable over the two sides of said lines in series, terminals for said lines at the exchange grouped together and arranged in sub-groups, link-circuits at the exchange and selective switches therefor controllable by said line relays to connect idle link-circuits with calling lines, a common starting circuit, for initiating travel of an idle selective switch, operatively associated with said lines at one time, normally quiescent switching means at the exchange and at the substations of said lines effective on initiations of calls to actuate said starting circuit, electromagnetic switching mechanism at the exchange automatically responsive to said means to control travel of a started switch to select the sub-group and then the terminals of the calling line, and an automatic switch at the end of said starting circuit serving to determine the idle switch to be started.

25. A telephone system including a group of telephone lines, terminals therefor at the exchange grouped together and arranged in sub-groups, link-circuits at the exchange and selective switches therefor to connect idle link-circuits with calling lines, a common starting circuit for initiating travel of an idle selective switch, line relays, one for each line and branch connections from said starting circuit to said relays whereby any relay may actuate said circuit, substation switching means to actuate said line relays, a common sub-group terminal for each said sub-group, electromagnetic switching mechanism at the exchange responsive to said means to alter the electrical conditions of the sub-group terminal and an individual terminal of the calling line, apparatus controlled by the conditions of said terminals to cause a started switch to select the sub-group and the individual terminal of the calling line, and an automatic switch at the end of said starting circuit serving to determine the idle switch to be started.

26. A telephone system including telephone lines, selective switches to select said lines as calling lines, trunk selecting switches paired with said first-mentioned switches serving to extend the circuits of selected calling lines, master-switch mechanism normally common to said lines for selecting an idle selective switch, means for initiating travel of said mechanism including line relays individual to said lines and energizable over the two sides thereof in series, and off-normal switches for said selective switches serving when shifted to continue travel of said mechanism to select a selective switch having its off-normal switch unshifted or at normal.

27. A telephone system including telephone lines, individual line relays for said telephone lines controllable over the two sides of said lines in series, selective switches to select said lines as calling lines, trunk selecting switches paired with said first-mentioned switches serving to extend the circuits of selected calling lines, master-switch mechanism normally common to said lines for selecting an idle selective switch, means including said line relays for initiating travel of said mechanism, and off-normal switches for said selective switches controlling the extent of travel of said mechanism.

28. A telephone system including telephone lines, selective switches to select said lines as calling lines, trunk selecting switches paired with said first-mentioned switches serving to extend the circuits of selected calling lines, master-switch mechanism common to said lines for selecting an idle selective switch, means for initiating travel of said mechanism, off-normal switches for said selective switches serving when shifted to continue travel of said mechanism to select a selective switch having its off-normal switch unshifted or at normal, a master-switch circuit for initiating travel of the selected switch, multiple terminals of said lines, and line relays, one for each line responsive to currents over the respective lines to render said terminals selectable by said switches.

29. A telephone system including telephone lines, selective switches to select said lines as calling lines, two motion trunk selecting switches paired with said first-mentioned switches serving to extend the circuits of selected calling lines, a common starting conductor for said selective switches and lines, means for rendering said conductor operative to start an idle switch responsive to cur-

rent over a line, multiple terminals of said lines, private contacts included in said terminals and insulated from said lines, and line relays, one for each line responsive to currents over the respective lines to render said contacts selectable by said switches.

30. A telephone system including telephone lines, selective switches to select said lines as calling lines, trunk selecting switches paired with said first-mentioned switches serving to extend the circuits of selected calling lines, a common starting conductor for said selective switches and lines, means for rendering said conductor operative to start an idle switch responsive to current over a line, off-normal switches for said selective switches serving to determine the switch to be started for each call, multiple terminals of said lines, private contacts included in said terminals and insulated from said lines, and line relays, one for each line responsive to currents over the respective lines to render said contacts selectable by said switches.

31. A telephone exchange system comprising a plurality of telephone lines, a plurality of selecting switches each having access to said lines, a master-switch for selecting and starting idle selecting switches to establish connection with calling lines, means actuated by a selected selecting switch prior to its final selecting movement to free said master-switch for further use, and means for preventing the operation of said master-switch more than once per call.

32. A telephone exchange system comprising a telephone line, link-circuits, automatic switching means for establishing connection between said telephone line and an idle one of said link-circuits, control mechanism including a differential relay. means for initially completing a circuit through one of the windings of said relay to set said switching means in operation, means for completing a circuit through the other winding of said relay to neutralize the effect of said first winding, and means for interrupting said circuits upon the establishment of said connection between the telephone line and link-circuit.

33. A telephone system including a telephone line, a line relay at the exchange, multiple terminals for said line, each including a talking contact and a contact insulated from the line circuit, means for operating said relay by current controlled at the station to alter the normal electrical condition of said last-mentioned contacts, a locking circuit for said relay to continue it energized independently of the substation, an automatic switch having wipers for engaging certain of said multiple terminals, and means responsive to the engagement of said one of said wipers with a terminal having its normal electrical condition changed to stop said switch.

34. A telephone system including telephone lines, line relays at the exchange for said lines, multiple terminals for said lines, means for operating said relays by current controlled from the substations to alter the normal electrical condition of said terminals, locking circuits for said relays to continue them energized independent of the substations, line selectors adapted to select said terminals, a starting conductor controlled by said relays, and a common relay connected in said starting conductor and having an armature switch for initiating travel of said selectors distributively.

35. A telephone system including a telephone line, a line relay at the exchange, multiple terminals for said line, means for operating said relay over a circuit including the two sides of said line in series and controlled at the substation to alter the normal electrical condition of said terminals, a locking circuit for said relay to continue it energized independently of the substation, a plurality of automatic line selectors, any one of which is adapted to make connection with said terminals, and distributing mechanism responsive to said line relay to start an idle one of said line selectors.

36. A telephone system including a group of telephone lines energizable over the two sides thereof in series, a line relay for each of said lines, a group relay common to said lines adapted to be operated responsive to any of said line relays, a plurality of automatic switches adapted to connect with said lines, a switch contact of said group relay for interchangeable association with said switches whereby the operation of said group relay automatically starts an idle switch, and selective switches connected to said automatic switches for operation responsive to currents controlled at the substations.

37. A telephone system including a group of telephone lines energizable over the two sides thereof in series, a line relay for each of said lines, a group relay common to said lines adapted to be operated responsive to any of said line relays, a plurality of automatic switches adapted to connect with said lines, a switch contact of said group relay for interchangeable association with said switches whereby the operation of said group relay automatically starts an idle switch, selective switches connected to said automatic switches for operation responsive to currents controlled at the substations, and link-circuits connected with said automatic switches for use in extending the circuits of calling lines to called lines.

38. A telephone system including a telephone line, a line relay therefor, a cut-off relay for operatively dissociating said line

relay from the line, a central source of current, a switch at the substation for actuation to operate said line relay, a locking circuit for said relay, multiple terminals of said line at the exchange, automatic switches having contacts for engaging said terminals, means controlled by said line relay for altering the normal electrical character of said terminals to render them selectable by said switches, means including said source of current and a conductor of a selective switch effective on selection made to operate said cut-off relay, a front contact of the line relay included in said means, and a locking circuit for said cut-off relay excluding said contact.

39. A telephone system including a telephone line, a line relay therefor, a cut-off relay for operatively dissociating said line relay from the line, a central source of current, a switch at the substation for actuation to operate said line relay, multiple terminals of said line at the exchange, automatic switches having contacts for engaging said terminals, means controlled by said line relay for altering the normal electrical character of said terminals to render them selectable by said switches, means including said source of current and a conductor of a selective switch effective on selection made to operate said cut-off relay, a front contact of the line relay included in said means, and a locking circuit for said cut-off relay excluding said contact.

40. A telephone system including a telephone line, a line relay therefor, a cut-off relay for operatively dissociating said line relay from the line, a central source of current, a switch at the substation for actuation to operate said line relay, multiple terminals of said line at the exchange, automatic switches having contacts for engaging said terminals, means controlled by said line relay for altering the normal electrical character of said terminals to render them selectable by said switches, a starting circuit responsive to the operation of said line relay to cause an idle selective switch to initiate travel in search of said terminals, an electromagnet for controlling travel of the started switch sensitive to the electrical character of said terminals, and a circuit including said source of current, a contact of a line terminal and a back contact of said electromagnet to energize said cut-off relay.

41. A telephone system including a telephone line, a line relay therefor, a cut-off relay for operatively dissociating said line relay from the line, a central source of current, a switch at the substation for actuation to operate said line relay, multiple terminals of said line at the exchange, automatic switches having contacts for engaging said terminals, means controlled by said line relay for altering the normal electrical character of said terminals to render them selectable by said switches, a starting circuit responsive to the operation of said line relay to cause an idle selective switch to initiate travel in search of said terminal, an electromagnet for controlling travel of the started switch sensitive to the electrical character of said terminals, a circuit including said source of current, a contact of a line terminal and a back contact of said electromagnet to energize said cut-off relay, a front contact of said line relay included in said circuit, and a locking circuit for said cut-off relay excluding said contact.

42. A telephone system including telephone lines, selectors for selecting said lines, multiple terminals of said lines at said selectors arranged in groups whereby said lines are divided into corresponding groups, test means for said selectors enabling them to select the group and then terminals of the calling line included therein, group contacts for the line group co-operating in such selection, a group relay one for each line group for determining the electrical condition of its contact, line relays one for each line, switches at the substations of said lines for controlling their respective line relays, a starting circuit for said selectors for initiating travel of an idle one responsive to the operation of any line relay, means controlled by an operated line relay for altering the electrical condition of its line's terminals in the group, a circuit controlled by the line relay for actuating the group relay of the respective line group, cut-off relays one for each line, and means for operating the same effective on selection made to render inert the line relays of their respective lines and to alter the connections of the group relay.

43. A telephone system including metallic circuit telephone lines divided into groups, a link circuit, a directively controlled step-by-step switch at one end of said link circuit, automatic means for connecting a calling one of said lines to said link circuit, means controlled over the two sides of said calling line in series for actuating said automatic means, directive current impulses for causing a step-by-step operation of said switch, first to a group of lines and then to a line in a group to complete a connection with a called one of said lines, and electromagnetic release means for said switch capable of being operated solely by the opening of the metallic circuit of one of said connected lines.

44. A telephone system including telephone lines, a directively controlled step-by-step selective switch at a central exchange provided with wipers, non-numerical means controlled over the two sides of a calling one of said lines in series for connecting said line to said switch, means for stepping the

wipers of said switch, first to a group of lines then to a line in a group to connect said first line with another for conversation, a release relay for said selective switch held energized during conversation, electromagnetic release means, substation controlled means for opening the metallic circuit of a connected one of said telephone lines to de-energize said relay, and circuits controlled by such operation of said relay to actuate said electromagnetic means to restore said switch to normal.

45. A telephone system including a subscriber's line, a calling device associated therewith, means for locking said calling device, switching mechanism at the exchange capable of directive operation responsive to currents transmitted over said line but normally disconnected from said line, means at the substation for automatically causing the connection of one of said mechanisms with said line on initiation of a call, apparatus at the exchange for changing the electrical condition of said line when said connection is caused, and a device at the substation responsive to said changed condition to unlock said calling device to render it manually movable.

46. An automatic telephone exchange system including a group of telephone lines, calling devices at the substations, means for locking said devices against actuation, passive calling terminals of said lines at the exchange appearing at each of a plurality of contact banks, line selectors, one for each bank, having wipers capable of automatically selecting the terminals of any line, means for automatically unlocking the calling device of a line to render it manually movable after initiation of a call, operated responsive to currents traversing the wiper of a line selector that has selected the terminals of the calling line.

47. An automatic telephone system including a subscriber's line, a calling device at the substation, means for locking said calling device, passive terminals for said line at the exchange, link-circuits at the exchange having at their ends normally at rest automatic switches adapted to connect with said terminals, selector switches at the other ends of said link-circuits, electromagnetic mechanism automatically effective only on connection of one of said first-mentioned switches with said passive terminals to unlock said calling device, and a circuit for said electromagnetic mechanism including two sides of the subscriber's line in series.

48. In an automatic telephone exchange system, the combination with a subscriber's line, of a calling device at the substation including an actuating member, means for locking said actuating member, passive calling terminals for said line at the exchange, a plurality of normally at rest automatic switches for connecting with said terminals, means controlled over the two sides of the subscriber's line in series and operated from the substation to initiate travel of one of said switches to connect with said calling terminals, and mechanism operated responsive to connection made with said calling terminals only to unlock said actuating member.

49. In a telephone system, a subscriber's line, a calling device therefor, means for locking said calling device, a selector switch at the exchange capable of directive operation responsive to currents over said line, an automatic switch adapted to connect said selector with said line after initiation of a call, and means for unlocking said calling device to render it movable, effective only at a time subsequent to the initiation of a call, said time varying definitely for a call according to the extent of travel of the automatic switch.

50. In an automatic telephone exchange system, a calling line and a called line extending from their respective stations to the exchange, a plurality of selective switches, operated responsive to successive sets of current impulses controlled at the calling station, connecting said lines, non-numerical means responsive to the closure of the line circuit at the calling substation to connect the calling line to one of said switches, switching mechanisms at the stations adapted to be operated to open the metallic circuits of their lines, and apparatus at the exchange actuated responsive to the opening of a line circuit metallically to restore all of said switches to normal.

51. A telephone system including telephone lines, line relays for said lines, line selectors to select said lines, auxiliary selective switches associated with said line selectors for extending calling lines, a starting circuit operable from any calling line's relay to start a selector in search of such line, means for shifting said circuit to different selectors, and means preventing said circuit from being shifted after a selector first so starts in search of a calling line until a second line initiates a call.

52. A telephone system including telephone lines, line relays for said lines, line selectors to select said lines, auxiliary selective switches associated with said line selectors for extending calling lines, a starting circuit operable from any calling line's relay, means for causing said circuit to operate responsive to initiation of a call to start a selector in search of the calling line, and means rendering said circuit ineffective from the time it first so starts a selector until a second line initiates a call.

53. A telephone system including telephone lines, line selectors to select said lines, a common starting conductor for said selec-

tors and lines, off-normal contacts for said selectors included in said starting conductor whereby a started selector operatively shifts said conductor to the next selector, a source of current, line relays one for each line, means controlled by any of said line relays for connecting said starting conductor to said source to start a line selector, and means automatically effective by the starting of a line selector to disconnect said conductor from said source prior to the operative extension of said conductor to the next selector.

54. A telephone system including telephone lines, line selectors each adapted to select any of said lines, a starting conductor common to said selectors and lines, off-normal contacts for said selectors in circuit relation with said conductor whereby each started selector will shift said conductor to operative relation with the next selector, line relays for said lines, means whereby any line relay may control said conductor to start a selector, and a contact in said conductor controlled by a started selector to render said conductor ineffective when shifted to connection with the adjacent selector to start the same.

55. A telephone system including telephone lines, a plurality of line selectors each adapted to select any of said lines, a starting conductor common to said lines and selectors, each said selector having a normally open off-normal contact adapted to be directly connected with said conductor, the closing of said contact of each selector being arranged to extend said conductor to connection with the next selector, line relays for said lines, each adapted to alter the electrical condition of said conductor to start a line selector, and means controlled by a started line selector to restore said conductor to its normal electrical condition before it can be extended to the next selector by the closing of the off-normal contact of the started selector.

56. A telephone exchange system comprising subscribers' telephone lines divided into groups, inter-connecting link-circuits, line selectors assigned by groups to the groups of lines, electrically directively controlled two motion switches for co-operating with said line selectors to unite calling and called lines for conversation through said link-circuits, manual impulse transmitting means at the substations for directively controlling said latter switches, means for establishing as many simultaneously existing conversational circuits between pairs of lines all in the same group as there are line selectors for the group, and release mechanism for said switches controlled over the two sides of a line in series.

57. A telephone exchange system comprising subscribers' telephone lines, inter-connecting link-circuits, two motion line selectors, line relays for said lines energizable over the two sides of the lines in series for controlling said line selectors, and electrically directively controlled switches for co-operating with said line selectors to unite said lines into conversational circuits, manual impulse transmitting means at the substations for controlling said directively controlled switches, and means whereby the act of establishing such a conversational circuit will operate only those switches whose contacts are included in the finally completed talking circuit.

58. A telephone exchange system comprising calling lines, two motion line selectors operative to connect each with a different calling line, line relays for said lines energizable over the two sides thereof in series, called lines, connectors for establishing connection with the called lines, inter-connecting link-circuits, and intermediate switches of different classes for uniting said link-circuits and lines into conversational circuits, each class of intermediate switches having a total number of switches not exceeding the total number of line selectors for exchanges of any number of lines.

59. A telephone exchange system comprising calling lines, two motion line selectors operative to connect each with a different calling line, line relays for said lines energizable over the two sides thereof in series for controlling said line selectors, called lines, connectors for establishing connection with the called lines, inter-connecting link-circuits, and intermediate switches of different classes for uniting said link-circuits and lines into conversational circuits, each class of intermediate switches having a total number of switches not exceeding the total number of connectors for exchanges of any number of lines.

60. A telephone exchange system comprising upwards of a thousand telephone lines, interconnecting link-circuits, a plurality of classes of two motion automatic switches for uniting said link-circuits and lines into conversational circuits, the number of switches of each class being the same and proportioned to the number of expected co-existing calls, means for preventing false operations of switches, and release means for said switches controllable with the two sides of a line in series.

61. A telephone system including telephone lines, line selectors for selecting calling lines, line relays energizable over the two sides of said lines in series for controlling said line selectors, connectors for connecting to called lines, one or more classes of intermediate group selecting switches, the classes being provided in number proportioned to the number of said telephone lines,

electromagnetic switching mechanism to adjust one switch of each class to establish a complete talking circuit between a calling line and a called line, and means for operating said line selectors to connect each with a different line.

62. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, means for starting said movable contact in a primary direction, automatic means for causing its further primary movement to a definite group and then its secondary movement to a definite contact in said group and release means for said switch mechanism controllable over the two sides of a line in series.

63. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, means for starting said movable contact in a primary direction, means for changing the normal relative condition of the waiting contacts, and automatic means dependent upon such changed condition to cause the further primary movement of said movable contact to a definite group and then its secondary movement to a definite contact in said group.

64. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, a second contact movable in a primary direction only to waiting contacts corresponding to said groups, means for changing the normal electrical condition both of a waiting contact corresponding to a definite group, and of a waiting contact in said group, means for starting said movable contacts in a primary direction, and automatic means dependent upon the unchanged condition of the latter group contact to cause the further movement of said movable contacts to the changed group contact and dependent upon the unchanged condition of the former waiting contacts in the group to cause a movement of the first mentioned movable contact into engagement with the desired contact in the group.

65. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, means for starting said movable contact in a primary direction, automatic means for causing its further primary movement to a definite group, and means for causing its secondary movement to a definite contact in said group.

66. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, means for starting said movable contact in a primary direction, means for changing the normal relative condition of the waiting contacts, automatic means dependent upon such changed condition to cause the further primary movement of said movable contact to a definite group, and means for causing its secondary movement to a definite contact in said group.

67. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, group contacts equal in number to the number of groups of contacts, a cooperating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, means for changing the normal electrical condition of two of said contacts, means for starting said movable contact in a primary direction, automatic means dependent upon the unchanged condition of the group contacts to cause the further primary movement of said movable contact to the group containing the other of said two contacts, and means for causing a secondary movement of said movable contact into engagement with said other contact.

68. A telephone system comprising telephone lines and associated electric switch mechanism having waiting contacts arranged in groups, a co-operating contact movable in a primary direction to the different groups and in a secondary direction to the waiting contacts in the groups, a second contact movable in a primary direction only to waiting contacts corresponding to said groups, means for changing the normal electrical condition of a waiting contact corresponding to a definite group, means for starting said movable contacts in a primary direction, automatic means dependent upon the unchanged condition of said group contacts to cause the further movement of said movable contacts to the group corresponding to said changed group contact, and means for causing a secondary movement of the first mentioned movable contact to a definite waiting contact.

69. A telephone system including a telephone line, selective switches for selecting said line, a master switch for starting an

idle selective switch, a magnet for causing travel of said master switch, an operating relay controlling the actuations of said magnet, a movable contact member for said master switch, contacts of said selective switches for engagement by said member, and means for closing successive circuits for said operating relay as the master switch travels, each circuit including said member, a contact of a different selective switch, and a common return from all said selective switches to said relay.

70. A telephone system comprising telephone conductors and associated electric switch mechanism having waiting contacts forming terminals of said conductors and arranged in groups, a co-operating contact movable primarily to the different groups and secondarily to the waiting contacts in the groups, means for starting said movable contact, automatic means for continuing its movement to a definite group and then to a definite contact in the group, and line relays energizable over the two sides of the telephone lines in series for controlling said first means.

71. A telephone system comprising telephone conductors, waiting contacts in which said conductors terminate, arranged in groups, co-operating movable contacts, and means for moving said contacts to test said waiting contacts individually and by groups.

72. A telephone system comprising telephone conductors and associated electric switch mechanism having waiting contacts forming terminals of said conductors and arranged in groups, a co-operating contact movable primarily to the different groups and secondarily to the waiting contacts in the groups, and means for moving said contact primarily and secondarily and at the same time testing said waiting contacts by groups and individually.

73. A telephone exchange system including subscribers' telephone lines, line terminals for said lines arranged in groups, and normally at rest means controllable over the two sides of a calling line for testing said terminals individually and by groups.

74. A telephone exchange system including subscribers' telephone lines, a relay individual to each of said lines, groups of line terminals for said lines, selective apparatus controllable by said relays for testing said groups of terminals, one after the other, to select groups containing definite terminals.

75. The combination with groups of lines, of selectors carrying terminals for said groups, a test contact for each group of line terminals, a source of current, a relay for each group controllable by the lines in the group, conductors connecting said source of current through contacts on said relays to said group contacts, and means controlled over the two sides of the lines in series for varying the continuity of said conductors by operating said relays.

76. A telephone exchange system comprising electric-switch mechanism having a plurality of passive contacts arranged in groups, conductors extending therefrom, a co-operating contact movable in a primary direction to the said groups and in a secondary direction to the contacts in the groups, means for moving said movable contact in a primary direction to a group, means dependent upon the busy or idle condition of the contacts in said group for determining whether the further movement of said movable contact shall be in a primary or a secondary direction, and means for producing such further movement.

77. The combination with a subscriber's telephone line, of a manually operated impulse transmitter, a locking device therefor, a receiving device co-operating with said transmitter normally disconnected from but adapted to be brought into circuit with said telephone line, and means for operating said locking device to unlock said transmitter when said receiving device is brought into circuit, as specified.

78. In an automatic telephone system, a subscriber's telephone line, a finder switch for finding said line, an impulse transmitter for sending impulses over said line through said finder switch, an electrically-operated locking device for said impulse transmitter, and means for operating said locking device for unlocking said transmitter when the finder switch is stopped on the subscriber's line terminals.

79. In a telephone system, a called subscriber's line, a plurality of connectors by which said line is temporarily seized, means for automatically selecting idle connectors, and automatic means operated when a called line is found for transmitting audible busy-signals through all the connectors except the one first seizing the line.

80. In a telephone system, a called subscriber's line, means for making said line busy, a connector for seizing said line, means for automatically selecting idle connectors, means for preventing the connector from releasing when it seizes the busy line, and automatic means operated when a called line is found for transmitting an audible busy-signal to the calling subscriber to notify him that the said line is already in use.

81. In a telephone system, a called subscriber's line a plurality of connectors by which said line is temporarily sezied, means for automatically selecting idle connectors, and automatic means brought into operation after a called line is found for transmitting busy-signals through all the connectors except the one first seizing the line.

82. In a telephone system, a called subscriber's line, means for making said line

busy, a connector for seizing said line, means for automatically selecting idle connectors, means for preventing the connector from releasing when it seizes the busy line, and automatic means brought into operation after a called line is found for transmitting a busy signal to the calling subscriber to notify him that the said line is already in use.

83. In a telephone system, a called line, connectors for calling said line, means for automatically selecting idle connectors, a busy signaling means normally inaccessible to said connector until a called line is found, means for then making said means accessible to said connector for then transmitting busy signals.

84. In a telephone system, a called line, a central source of current for talking purposes, means for making the called line busy, means including a progressively movable switch for finding the called line, and means associated with said first means to retain said switch in its operated position for preventing the called line from being signaled.

85. In a telephone system, a called line, a central source of current for talking purposes, means for making the called line busy, means including a progressively movable switch for finding the called line, and means in said switch associated with said first means to retain said switch in its operated position for preventing the called line from being signaled.

86. In a telephone system, a called line, a central source of current for talking purposes, means for making the called line busy, means including a progressively movable switch for finding the called line, and means controlled by said first means to retain said switch in its operated position and to prevent a connection from being extended to said called line.

87. In a telephone system, a called line, a central source of current for talking purposes, means for making the called line busy, means including a progressively movable switch for finding the called line, and means associated with said first means to retain said switch in its operated position for preventing a circuit from being extended from the switch to a station on the called line.

88. In a telephone system, a called line, a central source of current for talking purposes, progressively movable switching mechanism for finding said line, means to retain said switching mechanism in its operated position upon finding said line busy.

89. In a telephone system, a called line, a central source of current for talking purposes, progressively movable switching mechanism for finding said line, and means in said switching mechanism to retain the same in its operated position upon finding said line busy.

90. In a telephone system, a called line, a central source of current for talking purposes, progressively movable switching mechanism for finding said line, means to retain said switching mechanism in its operated position upon finding said line busy, and means for preventing a connection being completed with said called line.

91. In a telephone system, a called line, a central source of current for talking purposes, progressively movable switching mechanism for finding said line, and means to retain said switching mechanism in its operated position upon finding said line busy and for preventing the called line being signaled.

92. In a telephone system, a calling and a called line, a centralized source of current for talking purposes progressively movable switching mechanism for establishing a connection to the called line, means for making the called line busy, and means for determining the busy condition of the called line and for locking thereon to maintain the connection uncompleted.

93. In a telephone system, a calling and a called line, a centralized source of current for talking purposes, progressively movable switching mechanism for establishing a connection to the called line, means for making the called line busy, and means in said switching mechanism for determining the busy condition of the called line and for locking thereon to maintain the connection uncompleted.

94. In a telephone system, a calling and a called line, progressively movable switching mechanism for establishing a connection to the called line, means for making the called line busy, means for determining the busy condition of the called line and for locking thereon to maintain the connection uncompleted, and means brought into operation after the busy called line is found for transmitting a signal to the calling line.

95. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay, and instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines.

96. In a common battery system, subscrib-

ers' lines, means for establishing a talking circuit between two of said lines, said means including trunks divided into groups, an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, and instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines.

97. In a common battery telephone system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including an automatic step-by-step switch, means for controlling the operation of said switch by a varying number of impulses corresponding to the digits of the called number, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay, the said energizing circuit including a ground connection controlled by said relay, and instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines.

98. In a common battery system, subscribers' lines, means for establishing a talking circuit between two of said lines, said means including trunks divided into groups, an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a circuit including a trunk conductor for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, the said energizing circuit including a ground connection controlled by said relay, and instrumentalities independent of said trunk conductor for supplying talking current to the calling and called lines.

99. In a telephone exchange repeater system, a plurality of trunks, a plurality of automatic switches, means for controlling the operation of said switches by a varying number of impulses corresponding to the digits of the called number, each switch provided with a propelling mechanism, an actuating magnet for directly operating said propelling mechanism, ground circuits including only one side of said trunks for energizing said magnets, a relay for successively controlling said circuits, means including a metallic line circuit for controlling said relay, and means at the central station for supplying talking current over said metallic circuits.

100. In a telephone exchange repeater system having trunks divided into groups, the combination of an automatic step-by-step trunk-selecting switch, a magnet having its armature provided with means for directly actuating or propelling said switch, a ground circuit including only one side of a trunk for energizing said magnet, a relay for controlling said circuit, means including a metallic line circuit for controlling said relay, an automatic switch mechanism normally connected to and controlled by said relay, said automatic switch mechanism having motion first in one plane to select a group and then motion in a plane at right-angles to said other plane to automatically select an idle trunk in the predetermined group, and means at the central station for supplying talking current over said metallic circuit.

101. In an automatic telephone system, a subscriber's line, a talking circuit including said line, an automatic switch for extending connection to a connector, and means for operating said connector to extend connection to a called line, means for automatically ringing the called subscriber comprising a ringing relay, means for energizing said relay to throw ringing current on the called line, a ring cut-off relay, means for energizing said relay when the called subscriber answers to disconnect the ringing current from the called line and for locking said relay, a trunk release circuit for restoring the automatic apparatus when the subscribers are through talking and for restoring the locking relay.

102. In an automatic telephone system, a subscriber's line, a talking circuit including said line, an automatic switch for extending connection to a connector, and means for operating said connector to extend connection to a called line, means for automatically ringing the called subscriber comprising a ringing relay, means for energizing said relay to throw ringing current on the called line, a ring-cut-off relay, means for energizing said relay when the called subscriber answers to disconnect the ringing current from the called line and for locking said relay, a

trunk release circuit for restoring the automatic apparatus when the subscribers are through talking, and for restoring the automatic ringing apparatus to normal.

103. A telephone system including a group of telephone lines, a line relay for each of said lines at the exchange, a group relay common to the lines of the group, a further division of said groups into sub-groups, a sub-group relay common to the lines of a sub-group, means for operating the line relay of a line initially by currents controlled over the two sides of the line in series at the substation, and energizing circuits for said group and sub-group relays controlled by said line relay.

104. A telephone exchange system including a telephone line, selective switches for selecting said line, a distributor switch for starting said selective switches having contacts for said selective switches and a co-operating movable contact engaging, when at rest, the contact of the last operated selective switch, an off-normal contact for each selective switch, and a starting circuit for said distributor switch including the movable contact of said switch and an off-normal contact of a busy selective switch.

105. A telephone exchange system including a telephone line, selective switches for selecting said line, a distributor switch for starting said selective switches having contacts corresponding to said selective switches and a co-operating movable contact engaging, when at rest, the contact of the last operated selective switch, an off-normal contact for each selective switch, a starting circuit for a selective switch including the off-normal contact of said selective switch and the removable contact of the distributor switch.

106. A telephone exchange system including a telephone line, selective switches for selecting said line, a distributor switch for starting said selecting switches having a pair of contacts corresponding to each selective switch and a pair of co-operating movable contacts engaging, when at rest, the pair of contacts of the last operated selective switch, off-normal contacts for each selective switch, a starting circuit for said distributor switch including the movable contact of said switch and an off-normal contact of a busy selective switch, and a starting circuit for a selective switch including an off-normal contact of said selective switch and the second movable contact of said distributor switch.

107. In a telephone exchange system, the combination of a calling telephone line, an automatic switch, an idle trunk line leading to said switch, a selector switch mechanism for extending a talking circuit from the calling telephone line to the said idle trunk line, a pair of line relays allotted to said selector switch mechanism and adapted to control the operations thereof, means by which the calling subscriber also employs said relays for controlling the operations of the said automatic switch, a motor magnet for said mechanism, and a circuit for said magnet independent of said talking circuit and extending through contacts of one of said relays.

108. In a telephone exchange system, the combination of an idle trunk line, an automatic selector switch mechanism for extending a talking circuit to said trunk line, a pair of line relays for controlling said selector switch mechanism, an automatic switch responsive to said relays and forming the terminal of the other end of said idle trunk line, means for causing said pair of relays to successively control the said switch mechanism and automatic switch, a motor magnet for said mechanism, and a circuit for said magnet independent of said talking circuit and extending through contacts of one of said relays.

109. In a telephone exchange system, the combination of trunk lines, an automatic trunk-selecting switch for extending a talking circuit over any one of said trunk lines, a pair of relays for controlling said trunk-selecting switch, an automatic switch at the other end of each trunk line, each automatic switch being responsive to said relays after connection is made with the trunk line allotted to such switch, a calling subscriber's impulse-transmitting device by which said relays are caused to successively control the said trunk-selecting switch and an idle one of said automatic switches, a motor magnet for said first switch, and a circuit for said magnet independent of said talking circuit and extending through contacts of one of said relays.

110. The combination of a line, a plurality of trunks, a trunk selector in which said line terminates, automatic switches in which the said trunks terminate, a pair of line relays associated with the said trunk selector and adapted to control the trunk-selecting operations thereof, and means by which said relays are caused to repeat switch-operating impulses from said line to an idle trunk after a selection of the latter is made, a motor magnet for said trunk selector, and a circuit for said magnet independent of said line and trunk extending through contacts of one of said relays.

111. The combination of an automatic switch, another automatic switch, a pair of relays, a trunk line for joining one switch to the other to extend a talking circuit, local circuits independent of said talking circuit by which said relays directly control the operations of one of said switches, and trunk

line circuits by which said relays control the operation of the other switch after the two switches are joined together.

112. In a telephone exchange system, the combination of a selector switch adapted to perform a trunking operation in accordance with the first digit of any called number, relays associated with said selector switch and controlling the operations thereof, an automatic switch responsive to said relays, means for energizing said relays to control the selector switch and thereafter control the said automatic switch, a motor magnet for said selector switch, and a circuit for said magnet extending through contacts of one of said relays.

113. In an automatic telephone exchange system, a subscriber's calling mechanism and apparatus responsive thereto adapted to come to rest after each digit of the called number, an automatic switch provided with a relay for controlling the operation thereof to extend a talking circuit, another switch then subject to control by the same relay, a motor magnet for said automatic switch, and a circuit for said magnet independent of said talking circuit and extending through contacts of said relay.

114. In an automatic telephone exchange system in which the subscriber's calling mechanism and the apparatus responsive thereto come to rest after each digit of the called number, an automatic switch provided with a relay for controlling the operation thereof to extend a talking circuit, another switch then subject to control by the same relay, a motor magnet for said first switch, a circuit for said magnet independent of said talking circuit and extending through contacts of said relay, and a central source of current for switching and talking purposes.

115. In an automatic telephone exchange system in which the subscriber's calling mechanism and the apparatus responsive thereto come to rest after each digit of the called number, a first selector switch provided with a relay controlling the operation thereof for extending a talking circuit, a plurality of other switches then successively controllable by the same relay, a motor magnet for said first switch, a circuit for said magnet independent of said talking circuit and extending through contacts of said relay, and a central source of current for switching and talking purposes.

116. In a telephone system, a calling mechanism adapted to come to rest after operation thereof for each digit of the called number, means responsive to the operation of the calling mechanism for extending a talking circuit, said means comprising a second selector switch provided with a relay controlling the operation thereof, another switch then subject to control by the same relay, a motor magnet for said first switch, a circuit for said magnet independent of said talking circuit and extending through contacts of said relay.

117. In a telephone system, a calling mechanism adapted to come to rest after operation thereof for each digit of the called number, and means responsive to the operation of the calling mechanism for extending a talking circuit, said means comprising a second selector switch provided with a relay controlling the operation thereof, a plurality of switches then successively controllable by the same relay, a motor magnet for said first switch, a circuit for said magnet independent of said talking circuit and extending through contacts of said relay.

118. In a telephone system, a subscriber's line, a selector switch operative in accordance with the first digit of the called number for selecting an idle trunk extending from said line, and a differential relay in said selector for controlling the release of said selector.

119. In an automatic telephone exchange trunking system divided into groups, a subscriber's line, a combined selector and repeater provided with a vertical line relay connected to battery at one side and to the subscriber's line at the other side, a rotary line relay connected to battery at one side and to the subscriber's line at the other side, said selector having one motion to select groups and another motion to automatically select an idle trunk in the selected group and means controlled by said relays for then repeating impulses over the seized trunk.

120. A telephone system, means for establishing a talking circuit between two subscribers, comprising trunk lines, an automatic trunk selector including relays, automatic switches in which said trunk lines terminate, said relays controlling said trunk selector via circuits excluding said talking circuit, and means by which said relays may also be employed for controlling said automatic switches.

121. A telephone system, means for establishing a talking circuit between two subscribers, comprising trunk lines, an automatic trunk selector, an automatic switch for each trunk line, said trunk selector including a pair of line relays, and means by which said relays may be employed for successively controlling said selector and one of said switches, the relays controlling the selector over circuits excluding said talking circuit.

122. A telephone system, means for establishing a talking circuit between two subscribers, comprising a trunk line, an automatic switch to which the said trunk line leads, a pair of line relays, means associated with said relays and controlled thereby for extending connection to said trunk line,

electromagnetic means for said switch, and means by which a calling subscriber controls the energizing of the first mentioned means through the medium of said relays, via circuits excluding said talking circuit.

123. A telephone system, means for establishing a talking circuit, comprising a temporarily established talking circuit, a plurality of trunk selecting switches in said circuit, and a relay to which said switches are successively responsive, the first switch in the series being responsive to said relay via circuits excluded from said talking circuit.

124. A telephone system, means for establishing a talking circuit comprising trunk lines, an automatic trunk selector, a connector, a called subscriber's telephone line adapted to be seized by said connector, a calling subscriber's telephone line, a relay to which the selector and connector are successively responsive, said relay associated with and included in said selector, said selector being responsive to said relay via circuit excluded from said talking circuit.

125. A telephone system, means for establishing a talking circuit comprising a selector, a trunk line running to said selector, trunk lines running from and adapted to be seized by said selector, and means in said selector for relaying or repeating impulses to any idle trunk line seized by the selector, magnets in said selector for operating the same, said magnets controlled by said means via circuits excluded from said talking circuit.

126. A telephone system, means for establishing a talking circuit comprising automatic connectors, a selector for extending connection to an idle connector, and means in the selector for controlling the transmission of ringing or signaling current to the called subscriber, magnets in said selector for operating the same, said magnets controlled by said means via circuits excluded from said talking circuit.

127. In a telephone system, the combination of a trunk, a switch for extending a talking connection thereto, said switch including a pair of line relays, and means by which the said relays are first employed for operating the switch over circuits excluding said talking connection for extending connection to said trunk line, and then employed for repeating or relaying electrical impulses over said trunk.

128. In a telephone system, subscribers' lines, means for establishing a talking circuit comprising said lines, a plurality of trunk lines, a plurality of connectors any one of which is adapted for use in extending connection to one of said subscribers' lines, said connectors being less in number than said telephone lines, selecting mechanism including a line relay, said line relay controlling the selecting mechanism over circuits excluding the talking circuit, and for extending connection to an idle one of said connections, and means for then controlling said connector through the medium of said relay.

129. In a telephone system, a calling telephone line, a called telephone line, means including an automatic trunk selector for extending a talking circuit to the called telephone line, operating magnets for said selector, a magnet controlling relay in said selector, circuits for controlling said magnets excluding the talking circuit, a source of talking current, and means in said selector responsive to the called subscriber for feeding talking current to the calling line.

130. A telephone system, means for establishing a talking circuit, comprising trunk lines, an automatic trunk selector, automatic switches in which said trunk lines terminate having one motion to select groups and another motion to connect with a line in the selected group, relays controlling said trunk selector via circuits excluded from said talking circuit, said relays included therein and individual thereto, and means by which said relays may also be employed for controlling said automatic switches.

131. A telephone system, means for establishing a talking circuit, comprising trunk lines, an automatic trunk selector, an automatic switch for each trunk line having one motion to select groups and another motion to connect with a line in the selected group, a pair of line relays for said trunk selector, included therein and indivdual thereto, and means by which said relays may be employed for successively controlling said selector and one of said switches, said relays controlling the selector over circuits excluding said talking circuit.

132. A telephone system, means for establishing a talking circuit comprising a trunk line, an automatic switch to which said trunk line leads having one motion to select groups and another motion to connect with a line in the selected group, line relays, means including said relays and controlled thereby via circuits excluding said talking circuit, for extending connection to said trunk line, electromagnetic means for said switch, and means by which a calling subscriber controls the energizing of said electromagnetic means through the medium of said relays.

133. A telephone system, means for establishing a talking circuit, comprising a temporarily established talking circuit, a plurality of switches in said circuit having one motion to select groups and another motion to connect with a line in the selected group, and a relay to which said switches are successively responsive, the first switch in the series being responsive to said relay via circuits excluded from said talking circuit, said relay associated with and included in one of said switches.

134. A telephone system, means for establishing a talking circuit, comprising trunk line, an automatic trunk selector, a connector having one motion to select groups and another motion to connect with a line in the selected group, a called subscriber's telephone line adapted to be seized by said connector, a calling subscriber's telephone line, a relay to which the selector and connector are successively responsive, said selector responsive to said relay via circuits excluded from said talking circuit, said relay associated with and included in said selector.

135. A telephone system, means for establishing a talking circuit, comprising a selector having one motion to select groups and another motion to connect with a line in the selected group, a trunk line running to said selector, trunk lines running from and adapted to be seized by said selector, and means included in said selector for relaying or repeating impulses to any idle trunk line seized by the selector, magnets in said selector for operating the same, said magnets controlled by said means via circuits excluded from said talking circuit.

136. A telephone system, means for establishing a talking circuit, comprising automatic connectors, a selector for extending connection to an idle connector having one motion to select groups and another motion to connect with a line in the selected group, and means included in the selector for controlling the transmission of ringing or signaling current to the called subscriber, magnets in said selector for operating the same, said magnets controlled by said means via circuits excluded from said talking circuit.

137. In a telephone system, subscribers' lines, means for establishing a talking circuit comprising said lines, a plurality of trunk lines, a plurality of connectors any one of which is adapted for use in extending connection to one of said subscribers' lines, having one motion to select groups and another motion to connect with a line in the selected group, said connectors being less in number than said telephone lines, means including a line relay and selecting mechanism of which said line relay is a part and comprising magnets controlled by said line over circuits excluding the talking circuit for extending connection to an idle one of said connectors, and means for then controlling said connector through the medium of said relay.

138. In a telephone system, a calling telephone line, a called telephone line, means including an automotic trunk selector for extending a talking circuit to the called telephone line, having one motion to select groups and another motion to connect with a line in the selected group, said selector having a controlling relay connected to the talking circuit and operating magnets controlled over circuits excluding said talking circuit, a source of talking current, and means in said selector responsive to the called subscriber for feeding talking current to the calling line.

139. In a telephone system, means for establishing a talking circuit comprising an automatic switch, another automatic switch, a relay individual to one of said switches and included therein, a local circuit excluding said talking circuit by which said relay controls its own switch, and a trunk circuit by which said relay subsequently controls the other switch, whereby said switches are successively responsive to the same relay.

140. In a telephone system, means for establishing a talking circuit comprising an automatic switch, another switch, a pair of line relays individual to one of said switches and included therein, local circuits excluding said talking circuit by which said relays control their own switch, and trunk circuits by which said relays subsequently control the other switch, whereby said switches are successively responsive to the same pair of line relays.

141. A telephone system, means for establishing a talking circuit comprising a trunk having an automatic switch at one end thereof, responsive to calling impulses sent over said trunk, and a combined trunk selector and repeater mechanism for seizing the other end of said trunk, when the latter is idle, having means for transmitting the said calling impulses to operate the said automatic switch, said mechanism comprising a relay connected to the talking circuit and operating magnets controlled over circuits excluding said talking circuit.

142. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising trunk lines, an automatic trunk selector including relays, automatic switches in which said trunk lines terminate, said relays controlling said trunk selector over circuits excluding said talking circuit, and means by which said relays may also be employed for controlling said automatic switches, said selector having one motion to select groups and another motion to automatically select an idle trunk in a predetermined group.

143. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising trunk lines, an automatic trunk selector including a pair of line relays, an automatic switch for each trunk line, and means by which said relays may be employed for successively controlling said selector and one of said switches, said selector having operating magnets controlled by said relays over circuits excluding said talking circuit, said selector having one mo-

tion to select groups and another motion to automatically select an idle trunk in any predetermined group.

144. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising a trunk line, an automatic switch including a relay to which said trunk line leads, a second relay connected to said talking circuit, means associated with said second relay for extending connection to said trunk line, said means comprising magnets operated by said second relay over circuits excluding said talking circuit, and means for controlling said switch through the medium of said second relay, said switch having one motion to select groups and another motion to connect with the desired line in any predetermined group.

145. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising a trunk line, an automatic switch including a pair of line relays to which the said trunk line leads, a second pair of line relays connected to said talking circuit, means associated with said second relays and controlled thereby over circuits excluding said talking circuit for extending connection to said trunk line, electromagnetic means for said switch, and means by which a calling subscriber controls the energizing of said electromagnetic means through the medium of said second relays, said switch having one motion to select groups and another motion to connect with the desired line in any predetermined group.

146. In a trunking system in which the trunks are in groups, a temporarily established talking circuit, a plurality of switches in said circuit, and a relay to which said switches are successively responsive, the first switch in the series having operating magnets controlled over circuits excluding the talking circuit, said relay associated with and included in one of said switches, said first switch having one motion to select groups and another motion to automatically select an idle trunk in any predetermined group.

147. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising trunk line, an automatic trunk selector, a connector, a called subscriber's telephone line adapted to be seized by said connector, a calling subscriber's telephone line, a relay to which the selector and connector are successively responsive, said selector having magnets controlled by said relay over circuits excluding the talking circuit, said relay associated with and included in said selector, said selector having one motion to select groups and another motion to automatically select an idle trunk in any predetermined group.

148. In a trunking system in which the trunks are in groups, means for establishing a talking circuit comprising a selector, a trunk line running to said selector, trunk lines running from and adapted to be seized by said selector, and means included in said selector for relaying or repeating impulses to any idle trunk line seized by the selector wipers in said selector having one motion to select groups and another motion to automatically select an idle trunk in any predetermined group, said wipers controlled by said repeating means over circuits excluding the talking circuit.

149. A telephone system, means for establishing a talking circuit comprising trunk lines, an automatic trunk selector including relays, automatic switches in which said trunk lines terminate, said relays controlling said trunk selector via circuits excluding said talking circuit, and an automatic electromagnetically controlled auxiliary switch to enable the relays to control the automatic switches after the selector is operated.

150. A telephone system, means for establishing a talking circuit comprising trunk lines, an automatic trunk selector, an automatic switch for each trunk line, said trunk selector including a pair of line relays, and an automatic electromagnetically controlled auxiliary switch to enable said relays to control the connector after the selector has been operated, the relays controlling the selector over circuits excluding the said talking circuit.

151. A telephone system, means for establishing a talking circuit comprising a selector, a trunk line running to said selector, trunk lines running from and adapted to be seized by said selector, and a relay connected to said line in said selector for relaying or repeating impulses to any idle trunk line seized by the selector, magnets in said selector for operating the same, said magnets controlled by said relay via circuits excluded from said talking circuit.

152. A telephone system comprising talking circuit conductors, automatic connectors, a selector for extending connection to an idle connector, and a source of signaling current, signaling circuits, and a signaling circuit controlling relay in the selector for controlling the transmission of ringing or signaling current to the called subscriber, magnets in the selector for operating the same, said magnets controlled by said relay via circuits excluded from said talking conductors.

153. In a telephone system, a calling telephone line, a called telephone line, trunk lines common to said lines, an impulse sender in the calling line, an automatic trunk selector for selecting an idle one of said trunk lines to extend a talking circuit toward the called telephone line, operating magnets for

said selector, a magnet controlling relay in said selector, circuits for controlling said magnets excluding the talking circuit, a source of talking current, and an auxiliary electromagnetically controlled switch and a relay in said selector responsive to the called subscriber for feeding talking current to the calling line.

154. A telephone system comprising talking circuit conductors, trunk lines, an automatic trunk selector, automatic switches in which said trunk lines terminate having one motion to select groups and another motion to connect with a line in the selected group, relays controlling said trunk selector via circuits excluded from said talking conductors, said relays included therein and individual thereto, and other circuits comprising said talking conductors, under the control of said relays for controlling said automatic switches.

155. A telephone system comprising talking circuit conductors, trunk lines, an automatic trunk selector, an automatic switch for each trunk line having one motion to select groups and another motion to connect with a line in the selected group, a pair of line relays for controlling said trunk selector via circuits excluding said talking conductors, said relays included therein and individual thereto, and other circuits comprising said talking conductors, under the control of said relays for controlling one of said switches.

156. A telephone system, means for establishing a talking circuit comprising a trunk line, an automatic switch to which said trunk line leads having one motion to select groups and another motion to connect with a line in the selected group, line relays, a progressively movable switch including said relays and controlled thereby for extending connection to said trunk line via circuits excluding said talking circuit, a pair of electromagnets for said automatic switch, an impulse sender by which the calling subscriber controls the energizing of said electromagnets through the medium of said relays.

157. A telephone system, means for establishing a talking circuit comprising a selector having one motion to select groups and another motion to connect with a line in the selected group, a trunk line running to said selector, trunk lines running from and adapted to be seized by said selector, and relays and auxiliary circuits included in said selector for relaying or repeating impulses to any idle trunk line seized by the selector, magnets in said selector for operating the same, said magnets controlled by said means via circuits excluded from said talking circuit.

158. In a telephone system, a combined repeater and selector provided with a local release circuit, and with a pair of line relays controlling the single normally open switch point in said release circuit and for controlling the selecting and repeating operations of said combined selector and repeater, and switching means responsive to said repeater.

159. A telephone exchange system including a subscriber's telephone line, a bridge on said line, a bridge cut-off relay, automatic means for energizing said relay when the line calls controlled by the calling subscriber, automatic means for energizing the relay when the line is called, an automatic switch operative in response to the closure of a series circuit over said telephone line and through said bridge to extend a connection from said line, other automatic switches for extending a connection to a called line and controllable over the two sides of a line in series.

160. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a normally at rest switching apparatus comprising a plurality of switches, each provided with step-by-step propelling mechanism, a switch-operating device common to all of said switches, and automatic means for electrically connecting the said device with and disconnecting it from the said step-by-step mechanism, said device normally connected with one of said switches and adapted to be used for operating any one of said switches without interfering with its subsequent use for operating other switches while the said operated switch remains in use.

161. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a normally at rest switching apparatus comprising a plurality of switches, each provided with electromagnetically-actuated propelling means, a switch-operating machine common to all of said switches, said machine including automatic means for opening and closing electrical connection with the said propelling means of the different switches, one at a time, whereby said machine may be employed for operating any switch without interfering with its subsequent use for operating other switches while the said operated switch remains in use, and other automatic switches for completing connections, said other automatic switches adapted to be controlled over the two sides of subscribers' line circuits in series.

162. In a telephone system, the combination of means operative under substation control to supply current for talking pur-

poses from the exchange or central station to the telephones of the substations thereof, a plurality of subscribers' lines, a plurality of switches less in number than the total number of said subscribers, trunk-lines leading from said switches, a normally at rest switch-operating machine common to all of said switches and under the control of the subscribers, whereby any one of said subscribers may cause one of said switches to connect one of said trunk lines with his line before calling the number of any other subscriber, and other automatic switches for completing connections, said other automatic switches adapted to be controlled over the two sides of subscribers' line circuits in series.

163. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a group of subscribers' lines, a plurality of switches common to said lines, but less in number than the latter, trunk-lines leading from said switches, other switches in which the said trunk-lines terminate, a normally at rest switch-operating machine common to all of said first-mentioned switches, individual relay means under the control of the subscribers for causing said machine to operate said first-mentioned switches, whereby the calling subscriber may connect his line with one of said trunk-lines before operating one of said other switches in accordance with the first digit of the called number, and circuits including the two sides of subscribers' lines in series for controlling said other switches.

164. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a group of subscribers' lines, a plurality of switches allotted to and common to all of said lines, but less in number than the latter, other switches suitably connected with said first-mentioned switches, manually-controlled normally at rest means by which any subscriber may cause one of said first-mentioned switches to connect his line with one of said other switches preliminary to operating the latter in accordance with the first digit of the called number, and circuits including the two sides of subscribers' lines in series for controlling said other switches.

165. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a group of subscribers' telephone lines, a plurality of step-by-step trunk-connecting switches allotted to and common to all of said lines, but less in number than the latter, other step-by-step switches, manually-controlled normally at rest means by which any calling subscriber in said group may connect his line with one of said other switches preliminary to causing one of said other switches to begin operating in accordance with the first digit of the called number, and circuits including the two sides of subscribers' lines in series for controlling said other switches.

166. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a plurality of subscribers' telephone lines, individual line relays, a plurality of automatic switches common to all of said lines, but less in number than the latter, each line being connected with stationary multiple switch contacts of all of said switches, said contacts being adapted for use in making only outgoing calls from said lines, another group of automatic switches common to all of said lines, but less in number than the latter, said lines being also connected with stationary multiple switch contacts in all of said last-mentioned switches, but said last-mentioned contacts being adapted for use in making only incoming calls to said lines, and circuits including two sides of the subscribers' lines in series for controlling the said last-mentioned switches.

167. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a plurality of subscribers' telephone lines, individual line relays, subscribers' switching apparatus adapted for transmitting electrical impulses over the lines, according to the character and number of digits in any called number, and a plurality of automatic switches common to all of said lines, but less in number than the latter, each subscriber's apparatus being adapted for setting up a current-flow sufficient to cause the operation of one of said switches preliminary to the transmission of the current-flow to be employed exclusively in calling the number of the called subscriber, and other automatic switches for completing connections, said other automatic switches adapted to be controlled over the two sides of subscribers' line circuits in series.

168. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, subscribers' telephone lines, a plurality of preliminary connectors common to all of said lines, but less in number than the latter, a line relay normally in bridge of each line, a bridge-cut-off relay for each line, a plu-

rality of connectors common to said lines, but less in number than the latter, and means under the control of the subscribers for effecting the operation of said preliminary connectors, and also of said connectors, each preliminary connector being adapted, upon establishing connection with a calling subscriber's line, to energize the bridge-cut-off relay of such line, and also establish a guarding potential at all of the connectors having connection with such line, said last connectors adapted to be controlled over the two sides of the subscribers' lines in series.

169. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, trunks, and automatic trunk-selecting and connecting apparatus common to the lines by which each calling subscriber selects a trunk for the next call.

170. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a group of telephone lines, trunks less in number than said lines, said lines all normally in selective relation to the idle trunk next in order after the one last put in use, and automatic means common to the lines by which each calling line takes the waiting trunk and selects another for the next call.

171. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, telephone lines, a set of switches for use only in connecting directly with a calling line, preliminary to making connections in accordance with the called number, automatic means for maintaining all idle lines in selective relation to the first idle switch next in order after the switch last in use, automatic means for operating any selected switch in accordance with the number of the calling line, and individual line relays controlling said automatic means, whereby each calling subscriber selects a switch for the next call.

172. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a plurality of switches, trunk-lines leading from said switches, telephone lines, automatic trunk-selecting mechanism adapted to distinguish between idle and busy trunk-lines, automatic means by which said selecting mechanism maintains all idle telephone lines in selective relation to the first idle trunk-line next in order after the one last in use, and a switch-operating mechanism common to all of said switches, adapted for use by calling subscribers in operating said switches.

173. In a telephone system, the combination of means operative under substation control to supply current for talking purposes from the exchange or central station to the telephones of the substations thereof, a plurality of switches, trunk-lines leading from said switches, telephone lines, automatic trunk-selecting mechanism adapted to distinguish between idle and busy trunk-lines, automatic means by which said selecting mechanism maintains all idle telephone lines in selective relation to the first idle trunk-line next in order after the one last in use, a switch-operating mechanism common to all of said switches, adapted for use by calling subscribers in operating said switches, individual line relays for said telephone lines energizable over the two sides of the lines in series, and release circuits controllable by the opening of subscribers' lines.

174. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the subscribers' telephones at the substations thereof, a normally at rest switching apparatus comprising a plurality of switches, each provided with step-by-step propelling mechanism, a switch-operating device common to all of said switches, and automatic means for electrically connectingthe said device with and disconnecting it from the said step-by-step mechanism, said device normally connected with one of said switches, and adapted to be used for operating any one of said switches without interfering with its subsequent use for operating other switches while the said operated switch remains in use.

175. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the subscribers' telephones at the substations thereof, a plurality of subscribers' lines, a plurality of switches less in number than the total number of said subscribers, trunk-lines leading from said switches, and a normally at rest switch-operating machine common to all of said switches and under the control of the subscribers, whereby any one of said subscribers may cause one of said switches to connect one of said trunk-lines with his line before calling the number of any other subscriber.

176. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the

subscribers' telephones at the substations thereof, trunks, and automatic trunk-selecting and connecting apparatus by which each calling subscriber selects a trunk for the next call.

177. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the subscribers' telephones at the substations thereof, a group of telephone lines, trunks less in number than said lines, said lines all normally in selective relation to the idle trunk next in order after the one last put in use, and automatic means by which each calling line takes the waiting trunk and selects another for the next call.

178. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the subscribers' telephones at the substations thereof, trunk-lines, automatic mechanism by which each calling subscriber selects a trunk-line for the next call, and automatic means by which each calling subscriber simply closes connection with the preselected or waiting trunk-line.

179. In a telephone system, the combination of means operative only after the called line is found for supplying talking current from the exchange or central station to the subscribers' telephones at the substations thereof, the subscribers' lines divided in groups, of a plurality of preselectors and first-selectors for each line group, each comprising line contacts, a traveling contact device arranged to engage its line contacts, and means for moving the traveling contact device, the traveling contact device of each preselector being in electrical communication with that of one of the first-selectors, the contacts of the preselectors being connected to the corresponding subscribers' lines, trunk-lines, connected in multiple to the first-selectors, an auxiliary switch common to a plurality of preselectors, coupled for a call with one of said preselectors, and arranged to control its traveling contact device to bring the same as needed in engagement with the contacts of a calling line, means actuated at the calling station for moving the traveling contact device of the first-selector and for making the final connection over the selected trunk-line to the desired subscriber.

180. In a telephone system, a preselected idle trunk, automatic means for thus selecting the trunk-line ahead of the call, means comprising an energizing circuit including both sides of a line for obtaining connection with said trunk line, and switches for use in completing connections between lines controllable over the two sides of lines in series.

181. In a telephone system, a preselected idle trunk line, automatic means for thus selecting the trunk-line ahead of the call, means comprising an energizing circuit including both sides of a subscriber's line for obtaining connection with said trunk line, and automatic switches for use in completing connection between lines controllable over the two sides of subscribers' lines in series.

182. In a telephone system, subscriber's lines, a plurality of trunks, means for selecting idle trunks ahead of the calls, automatic means for connecting calling subscribers' lines with the preselected trunks, energizing circuits by which the calling subscribers initiate the operation of said automatic means, each energizing circuit including both sides of a subscriber's lines, and automatic switches for use in completing connections between lines controllable over the two sides of lines in series.

183. In a telephone system, a group of subscribers' telephone lines, automatic switches located at the exchange and controlled by the subscribers, adapted to enable a calling subscriber to establish connection with the called subscriber's line, and a source of switch-operating electric current normally in bridge of each subscriber's telephone line adapted for use by any calling subscriber in automatically switching his line into connection with the called subscriber's line, a common mechanism for controlling the trunking operations of said automatic switches, and release circuits for said switches controllable by the opening of subscribers' line-circuits.

184. In a telephone system, a plurality of trunks, automatic means for selecting the first idle trunk next in order after the one last in use, whereby each calling subscriber selects a trunk for the next calling subscriber, means comprising an energizing circuit including both sides of a subscriber's line in series for obtaining connection with the selected idle trunk, automatic switches for completing connections between lines, and release circuits for said switches controlled by the opening of the subscribers' line circuits.

185. In a telephone trunking system, the combination of means for selecting trunks ahead of the calls, a preselected idle trunk-line, means comprising an energizing circuit including both sides of a subscriber's line for obtaining connection with said trunk-line, means having one motion under substation control, to select groups or divisions of the exchange, and another motion to connect with a line in the selected group, for extending connection from the selected trunk-line in the direction of the called subscriber, a calling mechanism for causing the said two motions, said mechanism requiring a separate actuation thereof for each digit of the called number, operative to transmit

impulses by each operation, and release circuits for said two motion means responsive to the opening of a subscribers' line circuit.

186. In a telephone trunking system, the combination of means for selecting trunks ahead of the calls; a preselected idle trunk, means comprising an energizing circuit including both sides of a line for obtaining connection with said trunk-line, means having one motion under substation control, to select groups or divisions of the exchange, and another motion to connect with a line in the selected group, for extending connection from the selected trunk-line in the direction of the called subscriber, a calling mechanism for causing the said motions, said mechanism requiring a separate actuation thereof for each digit of the called number, operative to transmit impulses by each operation, and release apparatus for said two motion means controllable over the two sides of the subscriber's lines in series.

187. In a telephone system, trunk-lines, means for automatically selecting idle trunks ahead of the calls, a subscriber's hook-switch, means operated over a complete metallic talking circuit to seize the preselected idle trunk-line in response to closure of the talking circuit by the hook-switch, automatic switches for completing connections between lines, and release apparatus for said switches controllable over the two sides of a line in series.

188. In a telephone system, a subscriber's line including a pair of talking conductors, trunk lines, means for selecting idle trunk lines ahead of the calls, automatic means for closing connection with a preselected trunk line, a circuit for initiating the operation by which said automatic means closes connection with the preselected idle trunk line, said circuit including said talking conductors in series, automatic switches for completing connections between lines, and release apparatus for said switches controllable over the two sides of a line in series.

189. In a telephone system, a subscriber's line including a pair of talking conductors, trunk lines, means for selecting trunk lines ahead of the calls, an automatic trunking switch, a subscriber's hook switch and a circuit adapted to be closed by the movement of the hook switch to cause the operation of said switch and the seizure thereby of a preselected idle trunk line, said circuit including the two talking conductors of said line in series, and numerical switches for completing connections, said switches being controllable over the two sides of the subscriber's lines in series.

190. In a telephone system, a calling line, mechanism adapted to be operated over the two sides of said lines in series to extend a connection in the direction of an automatic switch having bank terminals divided into groups, the groups being disposed in planes, movable arms having motion in one direction to find a group and motion in another direction to find a terminal in the selected group, a line relay for controlling the operation of said arm, an electromagnet, means controlled thereby, a connecting link adapted by a single operation of said means to connect with said arms, means for controlling said switch over the two sides of said link in series, and mechanism operative under substation control to find the called subscriber's line.

191. In a telephone system, a calling line, mechanism adapted to be operated over the two sides of said line in series to extend a connection in the direction of an automatic switch having bank terminals divided into groups, the groups being disposed in planes, movable arms having motion in one direction to find a group and motion in another direction to find a terminal in the selected group, an electromagnet for producing the first motion, an electromagnet for producing the second motion, a relay, means controlled thereby, a line adapted by single movement of said means to connect with said arms, means for controlling said switch over two sides of said line in series, and mechanism operative under substation control to find the called subscriber's line.

192. In a telephone system, a plurality of subscribers' lines, an automatic switch for establishing connection with one of said lines, a trunk for extending a connection to said switch, inductive means separating the calling side of the trunk from the called line, and means in the calling side of said trunk controlled by the called subscriber for releasing said switch.

In witness whereof, I hereunto subscribe my name this 31st day of May, 1906.

ALFRED H. DYSON.