E. D. FALES.

TELEPHONE TRUNKING SYSTEM.

APPLICATION FILED MAR. 30, 1909.

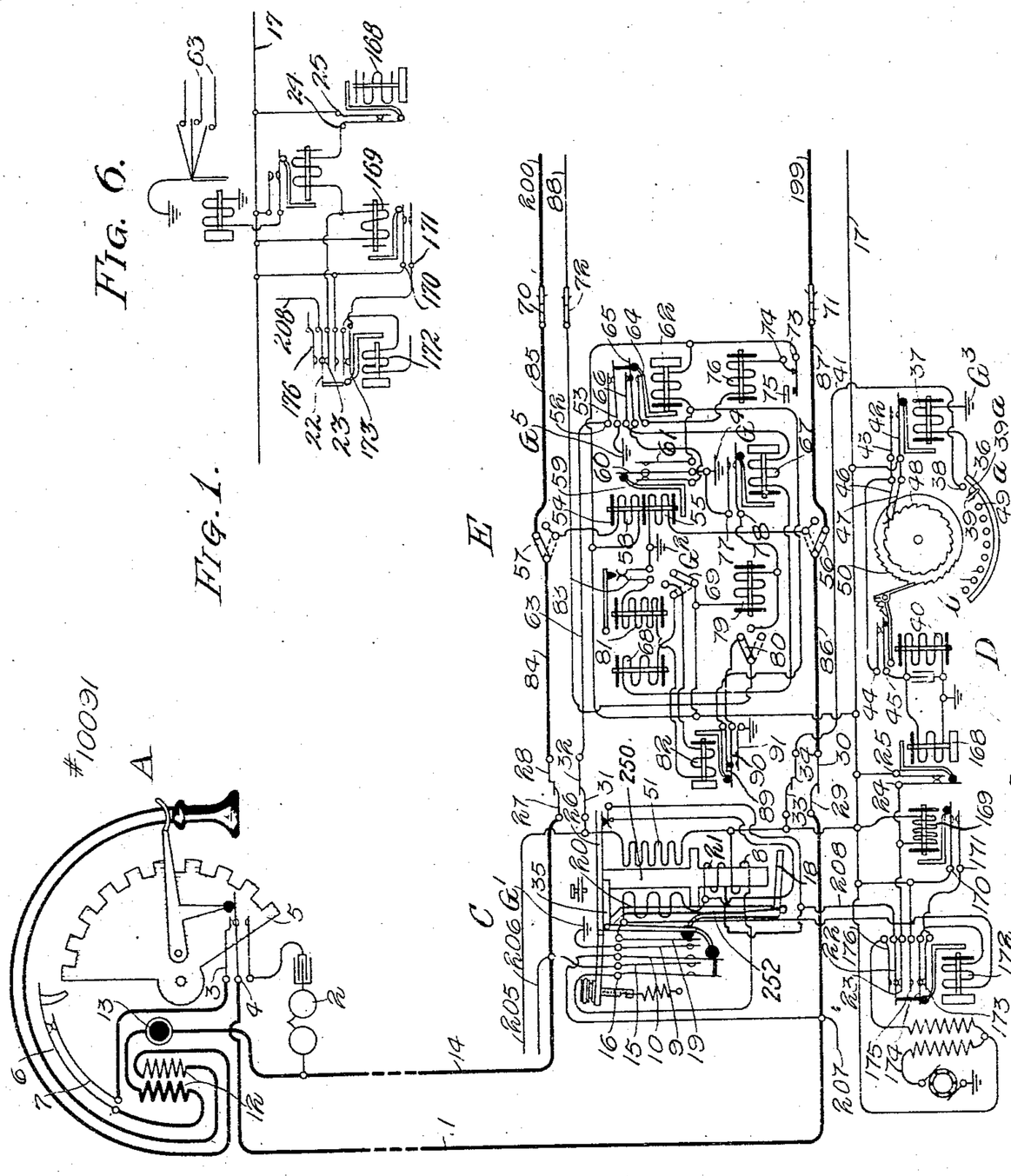
1,143,820.

Patented June 22, 1915.

5 SHEETS—SHEET 1.

FIG. 6.

FIG. 1.



WITNESSES

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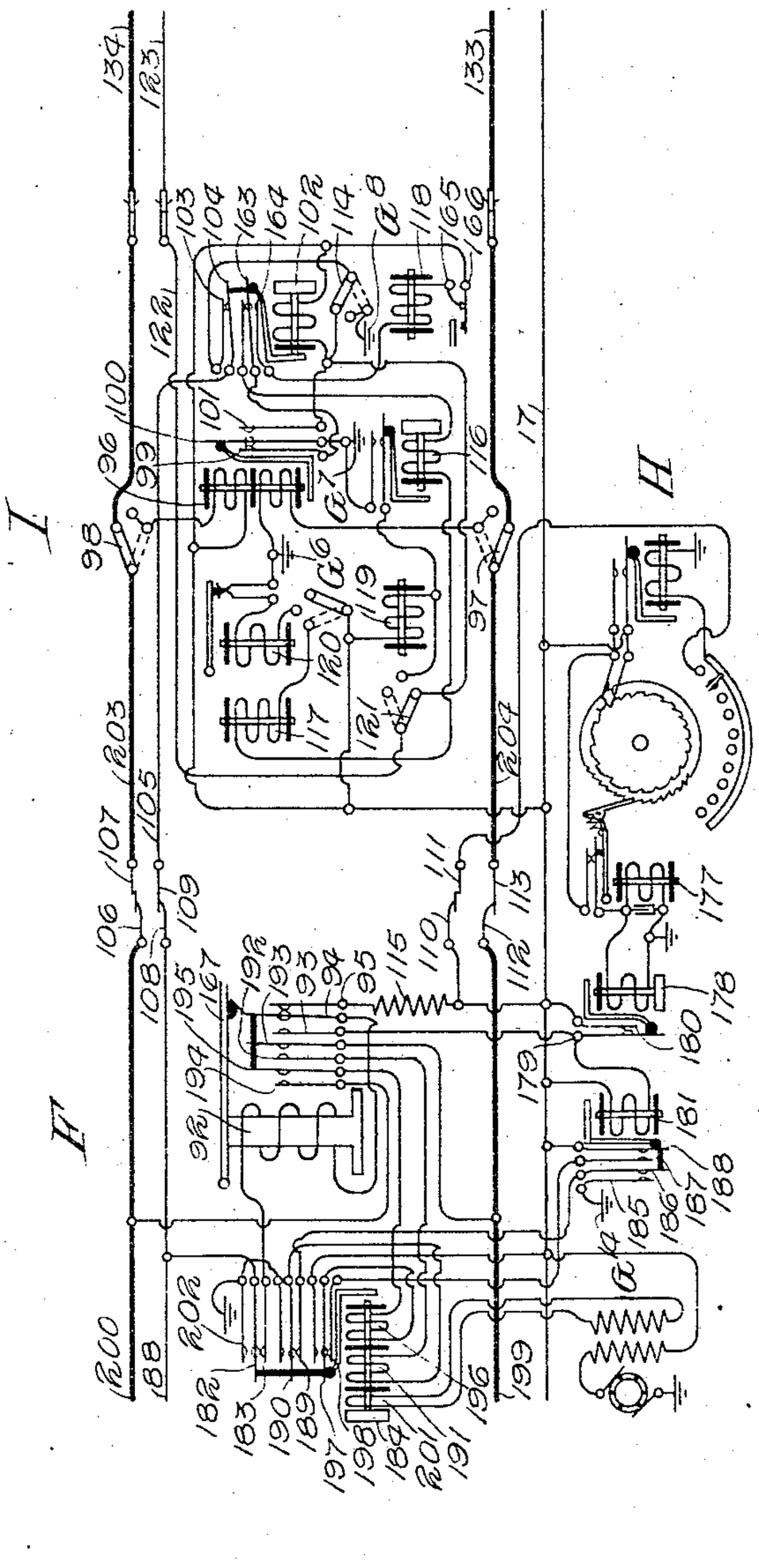
5 SHEETS—SHEET 2.

Fig. 2.



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5 SHEETS—SHEET 3.

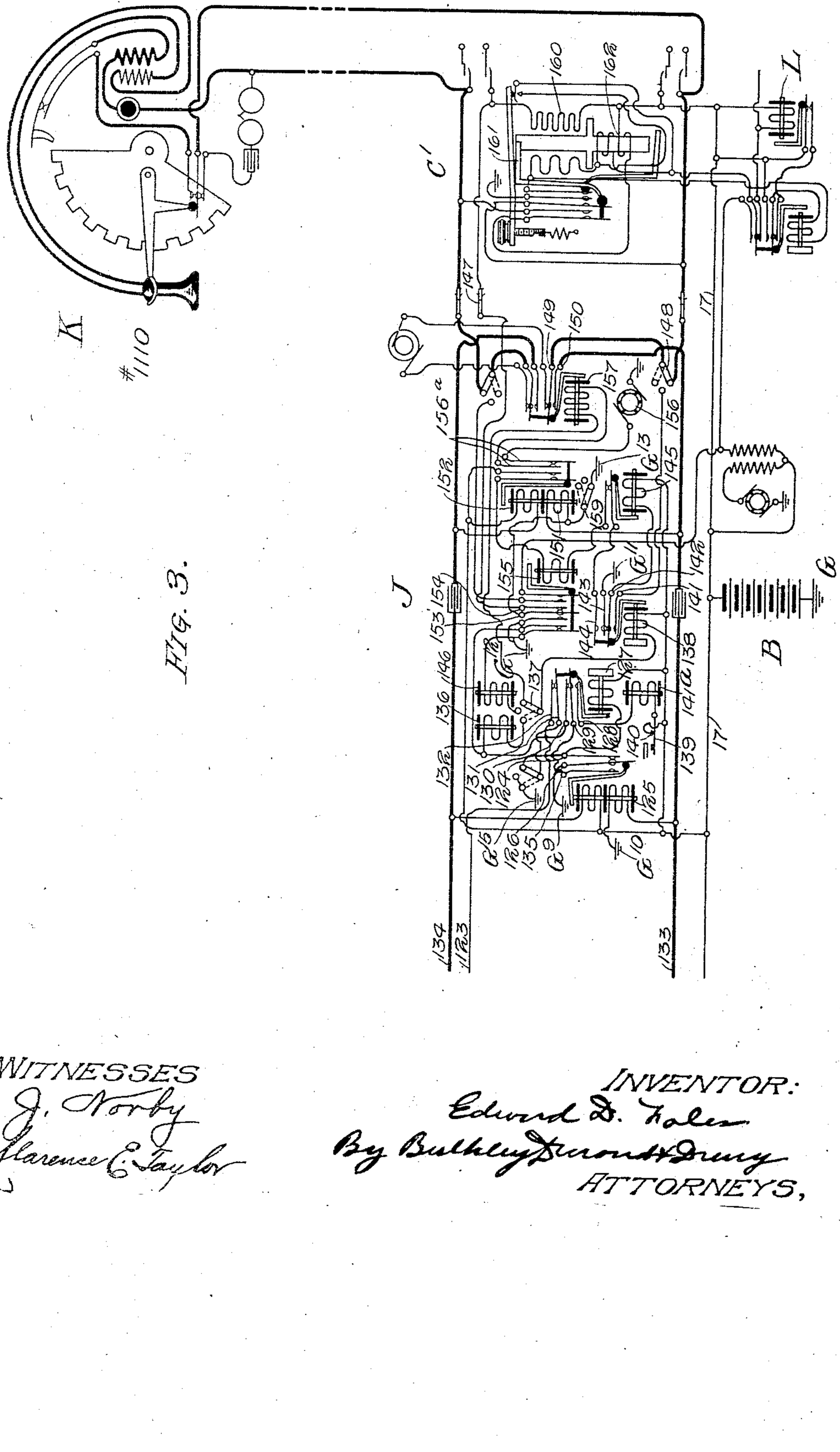

Fig. 3.

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5 SHEETS—SHEET 4.

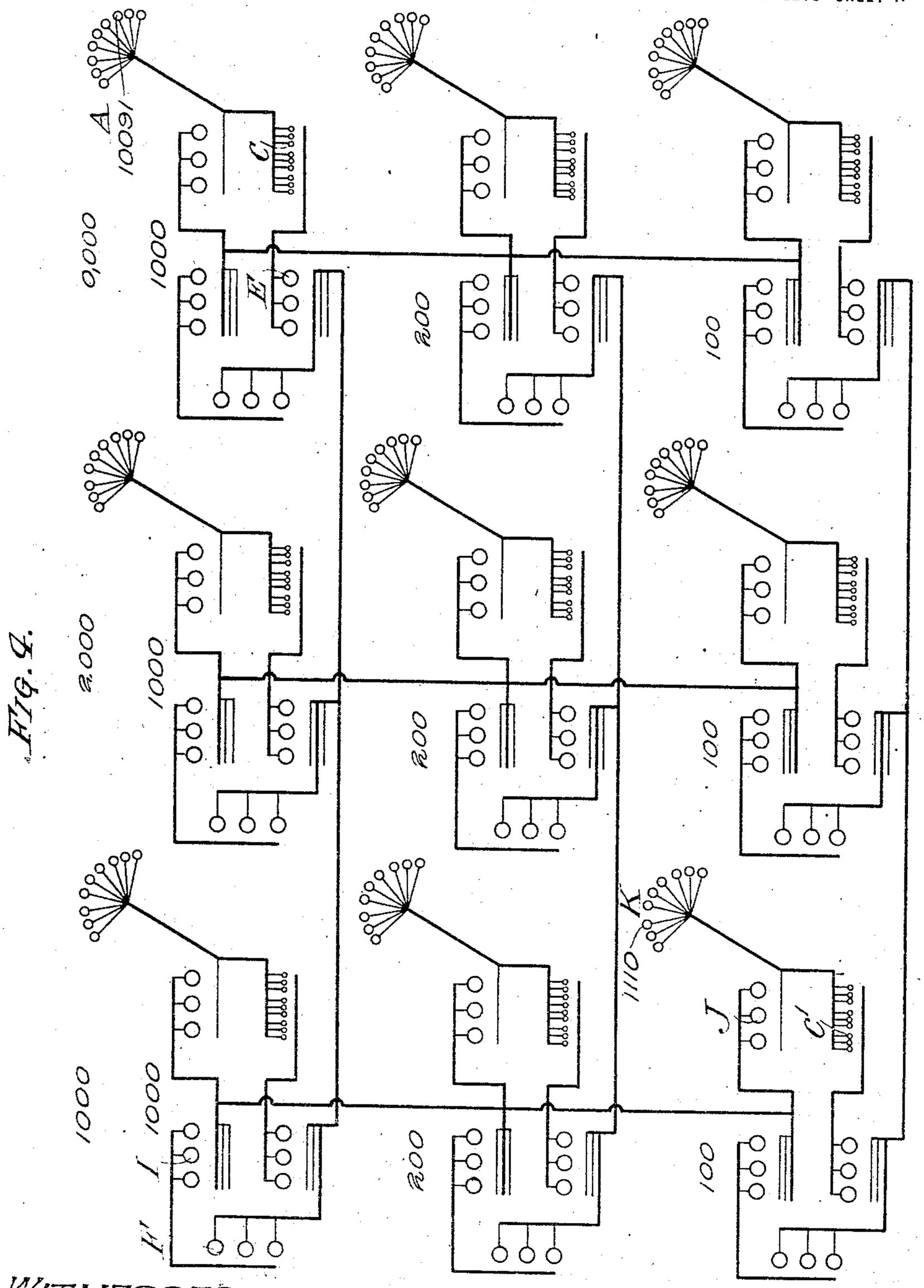

Fig. 4.

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5 SHEETS—SHEET 5.

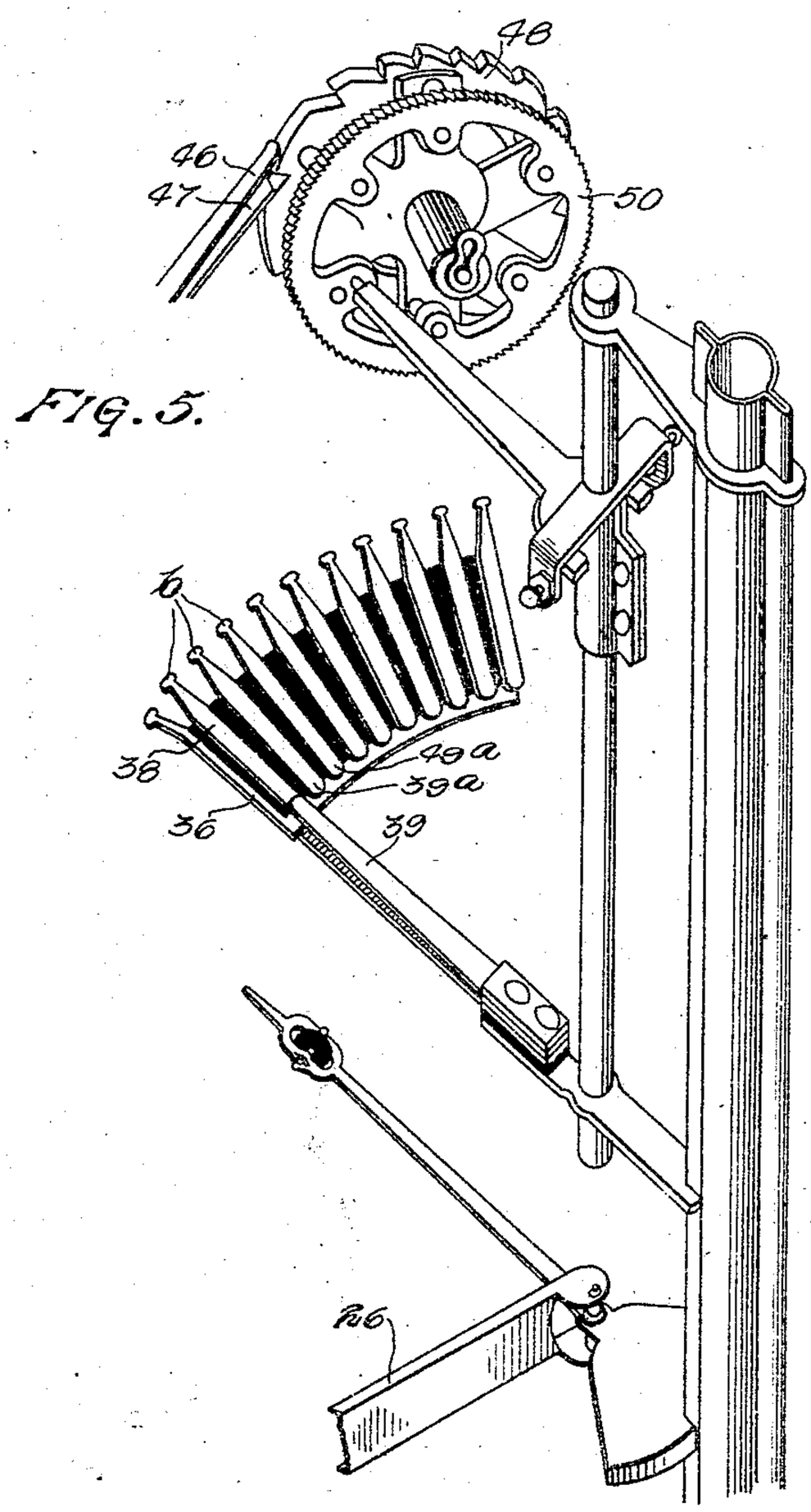

FIG. 5.

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UNITED STATES PATENT OFFICE.

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TELEPHONE TRUNKING SYSTEM.

1,143,820. Specification of Letters Patent. Patented June 22, 1915.

Application filed March 30, 1909. Serial No. 486,725.

To all whom it may concern:

Be it known that I, EDWARD D. FALES, a citizen of the United States of America, and resident of La Grange, Cook county, Illinois, have invented a certain new and useful Improvement in Telephone Trunking Systems, of which the following is a specification.

My invention relates to automatic telephone systems in general, for example, automatic telephone systems in which switches of the Strowger type are employed, such as selectors and connectors of the general type shown and described in United States Letters Patent Nos. 815,321 and 815,176, issued March 13, 1906, to Keith, Erickson and Erickson; and is especially applicable to automatic telephone systems in which switches of the so-called Keith type are also employed. My invention is applicable where Keith switches are used individual to each subscriber's line, and where they are used as secondary switches—that is, where they are used for the purpose of making all of the numerical switches of a certain denomination, such as second selectors, common to all of the subscribers of an exchange, or common to more than one group of one hundred subscribers, as far example, common to a number of groups of the so-called Keith units.

More particularly, my invention relates to systems employing Keith switches of the kind that are controlled by a common mechanism known as the master switch, which master switch is designed to select the next idle trunk to be used by the next calling subscriber as soon as a subscriber has made a call, and which, while thus operating to find the next idle trunk line, prevents any subscriber from operating his line switch until the master switch comes to a standstill. The Keith switches aforesaid may be of the character which are normally ready, at any instant that the master switch is still, to seize a preselected idle trunk when a subscriber removes his receiver, and thus connect the calling line with the preselected idle trunk.

One objection heretofore has been that if two or more subscribers remove their receivers while the master switch is moving, the individual switches of these subscribers who have thus removed their receivers will operate simultaneously at the instant that the master switch stops and seize the same trunk.

Objects of my invention are, therefore, to provide means whereby the line switch of a subscriber who removes his receiver while the master switch is moving will be locked and so retained until the subscriber releases, said subscriber, of course, not getting a number until he calls again; to provide means whereby a subscriber who has been thus locked by attempting to call while the master switch is moving is enabled to release and restore his apparatus to normal upon receiving the busy signal, whereby he may make a call after releasing; to provide means whereby secondary switches which are seized while the master switch controlling the same is moving may also be locked in connection with the busy signal apparatus; same as the line switches; to provide means whereby a subscriber who, having seized a secondary switch and been thus locked on the busy apparatus, may release and restore the apparatus he has brought into use, so that another call may subsequently be made; and to provide other features of improvement tending to increase the efficiency and serviceability of an automatic telephone system.

To the foregoing and other useful ends, my invention consists in matters hereinafter set forth and claimed.

In the accompanying drawings, which are a part of this specification, Figure 1 is a diagrammatic representation of a circuit established through apparatus of the character described by a calling subscriber A. The current for establishing this connection is here shown supplied by a centralized battery B (see Fig. 3). It is not necessary, however, that a single battery should be used. It is to be understood that any number of batteries may be used, depending upon whether all of the switches are in one exchange or not, and even in one exchange it is not necessary to use a single battery. The said circuit (Fig. 1) is established through the subscriber's individual line switch C, as shown. This individual switch C is, of course, one of a group of individual switches, one hundred, for example, all of which may be controlled by a common master switch

indicated in this figure at D. It should be understood that the coil at the extreme left of the master switch D, located between the said master switch and the busy coil, is not a part of the master switch, but is individual to the subscriber A. After passing through the line switch C the circuit is shown extending through the so-called first selector E.

Fig. 2 is likewise a diagram, showing a continuation of the circuit shown in Fig. 1. Said circuit is shown passing through a secondary switch F, which is also one of a group of similar switches. It may be well to call attention to the fact that these circuits are shown returning to battery B by way of the grounded terminal G; but this, of course, is not a necessary arrangement, and battery B need not be grounded at all. The secondary switch F, as well as all of the remaining secondary switches of the same group, may be controlled by the master switch H. It should be stated that the switches which a master switch may control need not be a definite number; one master switch may, for example, be arranged to control only twenty-five switches, or only fifty switches, or any other number which may be convenient. After passing through the secondary switch F in Fig. 2 the circuit is shown passing through the second selector I.

Fig. 3 is also a diagram, and shows an extension of the circuits after passing through Fig. 2. This circuit, it will be seen, extends first to the switch J, known as a connector switch, thence through the line switch C′ of the called subscriber, and then to the called subscriber K. It will be obvious, of course, that the line switch C′ may be a line switch of the same group as the line switch C, in which case it would be controlled by the master switch D. It is assumed, however, for convenience of illustration, that the switches C and C′ do not belong to the same group, and are, therefore, not controlled by the same master switch. The only part of the controlling master switch of the line switch C′ shown is the relay L. The switches C and C′ are, of course, the same in all respects.

Fig. 4 is a simplified diagram illustrating all of the switches in a ten thousand system. In this figure, 3 is intended to represent ten, and three groups of three is intended to represent ten times ten, or one hundred. On this sheet the calling subscriber No. 10,091 and the called subscriber No. 1,110 are shown. The general mode of operation of the line and master switches is similar to that described in the *Western Electrician* of Chicago of January 11, 18 and 25, 1908. The general operation of the secondary switches is quite similar to that of the line switches, and the general operation of the selectors and connectors is quite well known. The general mode of operation of the line switches is also described in British Patent No. 26,301 of 1906.

Fig. 5 illustrates diagrammatically the essential mechanical features of the master switch D shown in Fig. 1.

Fig. 6 is a modification of the circuits of the master switch D shown in Fig. 1.

In the particular form of line switch herein illustrated the usual plunger is carried upon the end of the plunger arm 26 which is controlled by the magnet 250. This magnet also controls the two relay armatures 18 and 35, and comprises four windings, namely, a pull-in winding 20, a cut-off winding 51, a line winding 8 and an auxiliary winding 21. Owing to the fact that the core of the magnet 250 is attached near the center of its length to the bracket 252, to which latter are pivoted the armatures 26, 35 and 18, the magnetic circuit of the windings 20 and 51 is separate from that of the windings 21 and 8. With this arrangement the armatures on the upper end of the magnet are not affected by the windings on the lower end, and vice versa. Of the two windings on the upper end of the magnet the winding 20 is the stronger and, when energized, operates both the plunger arm 26 and the armature 35. The winding 51 is not strong enough to attract the plunger arm 26 from its normal position, but will hold it in its operated position after it has once been pulled down by the winding 20.

My invention is illustrated in the drawings in combination with a two-wire system, and when the calling subscriber removes his receiver he disconnects his bell 2 from across the line and closes the line circuit through the springs 3 and 4. The calling device at the telephone is the ordinary automatic calling device used in connection with the Strowger system and apparatus of the general character already described. There is this difference however, that the impulse wheel 5, instead of operating to close a circuit intermittently as it returns toward normal to send impulses to the central office, opens the line circuit intermittently for the same purpose. This opening of the circuit for producing the operating impulses is accomplished through the medium of the impulse springs 6 and 7. It will be understood, of course, that impulse wheel is shown in Fig. 1 in back view, the dial being behind the impulse wheel. In Fig. 3, however, the reverse is the case.

When the subscriber removes his receiver and closes the switch hook springs 3 and 4, an energizing circuit is closed through the line winding 8 of the line switch C. The current in this circuit, it will be seen, flows from ground G′ through the line switch springs 9 and 10 to the positive line conductor 11, thence through the telephone

springs 4 and 3 and the impulse springs 7 and 6, through the primary winding of the induction coil 12 and the transmitter 13 to the negative side of the line 14, thence via the line switch springs 15 and 16 to and through the line winding 8 to the battery lead 17, and through battery B to ground G. As soon as the line winding 8 receives energizing current, the line armature 18 is attracted and the spring 19 is carried into engagement with the ground spring 9. As a result a local energizing circuit is set up through the pull-in winding 20 of the line switch magnet. The current in this circuit, it will be seen, flows from ground G' through the springs 9 and 19, through the pull-in winding 20, holding winding 21 on the same section of the line switch magnet core with the line winding 8, thence through the individual springs 22 and 23, and through the common springs 24 and 25 to the battery lead 17, thence through battery B to ground G. When the pull-in winding 20 energizes, the plunger armature 26 is attracted, and the line switch bank springs 27 and 28 are pressed into contact as a result. By the same act the bank springs 29 and 30 are pressed into contact, and the springs 31 and 32 are pressed into contact, and the springs 33 and 34 are pressed into contact. The bridge-cut-off armature 35, which is a much lighter armature than the armature 26, is attracted at the same time with the armature 26; but its operation is insured by the armature 26 which, upon being attracted, drives the bridge-cut-off armature 35 to its attracted position. It will be understood, of course, that the plunger of the line switch C, at the time that the line switch C is energized, is standing opposite an idle trunk line, which trunk line, it is assumed, in this instance is the trunk line running to the first selector E. This trunk line, it should be stated, has a set of multiple contacts, not only in the line switch C, but in every other line switch of the same group. The multiples are not shown, as it is not considered necessary. It is through the medium of these multiple contacts that the various line switches in the group controlled by the master switch D have access to the first selector E.

The master switch D is provided with a bank *a* having a number of contacts equal to the number of trunks allotted the master switch to be presented to the line switches which it controls, one at a time. These contacts are indicated at *b*. Common to these contacts there is provided in the bank *a* a segment 36 connected to the master switch relay 37. As indicated in the drawing, the contact in the bank *a* representing the trunk which terminates in the selector E is the contact 38, and before the line switch C operates, the master switch bank wiper 39, which is under the control of the master switch motor magnet 40, is in a position to connect the contact 38 with the segment 36, thus maintaining the master switch relay 37 in connection with the conductor 41 and with the multiple contact 34 and all other multiple contacts 34 of the group controlled by the master switch D, one of which is provided for each line switch C. It will be obvious that when the circuit is closed by the bank springs 33 and 34, when the line switch C operates, the master switch relay 37 will energize. The current will flow from ground G^3 through said relay, through the master switch bank segment 36, wiper 39 and contact 38 to the conductor 41, thence through the line switch bank springs 34 and 33 to the battery lead 17, thence through battery B to ground G. The relay 37, upon energizing, closes an energizing circuit through the motor magnet 40 by pressing the springs 42 and 43 into contact. The magnet 40 is provided with an interrupter arrangement comprising the springs 44 and 45, so that it will continue to energize intermittently as long as a circuit is maintained between the spring 44 and the battery lead 17. The arrangement shown is such that as soon as the magnet 40 energizes the first time, the springs 46 and 47 are pressed into contact by the cam wheel 48 and are maintained in contact until the master switch wiper 39 engages a contact *b* of the next idle trunk which, as shown, is the contact between the contacts 38 and 49. Of course, it is evident that had the trunk represented by this contact been busy, this contact would have been found connected to the battery lead 17, and the master switch would not have stopped on the contact 39^a for the reason that, although the springs 46 and 47 break contact as soon as the wiper 39 reaches the said contact intermediate the contacts 38 and 49, and although the relay 37 deënergizes as soon as the wiper 39 leaves the contact 38, the relay 37 again energizes as soon as the wiper strikes the said intermediate contact, if the said contact is connected to the battery lead as stated. Of course, it is obvious that under these conditions the master switch will not stop until a contact *b* is found which is not guarded. If all of the trunks are busy, then the master switch D will continue to operate, thereby moving back and forth the master switch wiper 39 and all idle plungers in engagement with the shaft. The connection between the master switch wiper 39 and the gear wheel 50, which is rigid with the cam 48, is not direct. The wiper 39 is rigid with the plunger shaft—that is, the shaft which is engaged by all of the plungers when they are absolutely restored. The reciprocating action between the gear wheel 50 and the plunger shaft that

carries the wiper 39 is made possible by connecting the shaft with the gear 50 through the medium of an arm. This arm is connected with the wheel 50 by a ball and socket joint at a point on the side of the gear 50 somewhere between the periphery and the center. The said arm is also connected at the other end with the plunger arm by a forked pivot. This arm may be moved in a plane parallel to the plunger shaft, but not in a plane at an angle thereto.

When the line switch C operates to press the bank springs 31 and 32 into contact, as already explained, it will be seen that a connection is established between the bridge-cut-off winding 51 of the line switch magnet and the spring 52 of the first selector E. It will presently be pointed out how, as soon as this circuit is established, the spring 53 is carried into engagement with the spring 52, and the whole circuit set up through the bridge-cut-off winding 51 for retaining the plunger arm 26 attracted. As soon as the bank springs 27 and 28 on the negative side of the line, and the springs 29 and 30 on the positive side of the line, are pressed into contact, as described, an energizing circuit is established through the line relay 54 of the first selector E. The current in this energizing circuit flows from ground G^2 through the winding 55 of the line relay 54, through the side switch wiper 56 (in first position) to the positive side of the line, thence through the telephone to the negative side of the line, through the side switch wiper 57 (in first position), through the winding 58 of the line relay 54 and to battery. The line relay 54, upon energizing, separates the springs 59 and 60, carrying the spring 60 into engagement with the spring 61. An energizing circuit is, therefore, established through the slow-acting relay 62. It will be seen that current flows from ground G^4 through the springs 60 and 61, relay 62 and to battery. The relay 62, upon energizing, presses the springs 52 and 53 into contact, as already stated, thereby sending holding current through the bridge-cut-off winding 51 of the line switch C. This current flows from ground G^5 through the said springs 53 and 52, conductor 63, line switch bank springs 32 and 31, bridge-cut-off winding 51 to battery. The armature 26 being already attracted, the energy supplied through the medium of the winding 51 is sufficient to retain it in the position shown. While in this position, it will be seen that through the medium of the bridge-cut-off armature 35 the springs 9 and 10 are separated, as well as the springs 15 and 16. The object in separating these springs is to disconnect the line relay winding 8 from across the line. In order to insure against a buzzing action when the springs 9, 10 and 15, 16 are operated, the winding 21 is provided on that section of the core with the line winding 8, in order to retard the deënergizing action of this part of the magnet of the line switch C, whereby the line armature 18 will not allow the spring 19 to leave the spring 9 before the first selector E has had time to press the springs 52 and 53 into contact. It will be seen that when the armature 26 is in operated position, the winding 21 is short-circuited, thereby rendering that section of the magnet sluggish for the purpose stated. The slow-acting relay 62 of the first selector E, upon energizing, not only operates the springs 52 and 53, but also separates the springs 64 and 65, carrying the spring 65 into engagement with the spring 66, whereby connection is extended from the spring 59 of the line relay 54 through the private magnet relay 67, and through said relay to the vertical magnet 68.

Assuming, now, that the subscriber A desires connection with the subscriber No. 1,110, he is ready to operate his dial by putting his finger in the number 1 hole, drawing the dial down until his finger strikes the usual finger stop, and turning the dial loose. By this operation he causes the impulse wheel 5 to separate the impulse springs 6 and 7 once momentarily. In so doing he breaks the energizing circuit for the line relay 54 of the first seclector E, thereby allowing the spring 60 to disengage from the spring 61, engage the spring 59, and return into engagement with the spring 61. Although the separation of the springs 60 and 61 breaks the energizing circuit of the relay 62, the armature of this relay does not fall back, because of the slow-acting character of the relay 62. This character is retained by slipping a spool of copper onto the core, as indicated by the square portion on the right. The engagement of the springs 60 and 59 sends an impulse through the private magnet relay 67, which is also slow-acting, and through the vertical magnet 68. The current in this circuit flows from ground G^4 through the springs 60 and 59 of the line relay 54, springs 65 and 66 of the slow-acting and so-called release relay 62, through the private magnet relay 67 and the vertical magnet 68, side switch wiper 69 (in first position) to battery. By energizing the vertical magnet 68, the shaft of the selector E is raised vertically one step, carrying the line wipers 70 and 71 and the private wiper 72 up one step opposite the first contact of the first level of the first selector bank. By this operation the off-normal springs 73 and 74 are permitted to engage as soon as the normal arm 75 attached to the shaft is raised. By the closure of contact between these springs the release magnet 76 is placed in connection with battery, so that whenever the release relay 62 deënergizes, the switch E will be restored.

At the same time that the vertical magnet 68 energizes, the private magnet relay 67 energizes, closing the springs 77 and 78 into contact, whereby a flow of current is sent through the private magnet 79 from ground G^4 through the said private magnet to battery. The private magnet relay 67, being sluggish in character, remains energized as long as impulses are being sent in; but as soon as the impulses stop coming in, this relay 67 has enough time to deënergize, which in turn deënergizes the private magnet 79. The private magnet, of course, as is well known, and through the medium of an escapement, controls the side switch comprising the side switch wipers 56, 57, 69 and 30. With this arrangement, as soon as the private magnet 79 deënergizes the first time. the side switch is allowed to pass to second position. One result of this operation is that a circuit is established through the rotary magnet 81 and the auxiliary relay 82. Current flows in this circuit from ground G^2 through a set of interrupter springs 83, rotary magnet 81, coil 82, side switch 69 to battery. The rotary magnet 81 now, of course, as is well known, intermittently energizes, rotating the selector shaft step by step into engagement successively with the trunks running from the first level of the first selector. This step-by-step operation continues until the first idle trunk is found. These trunks are, of course, protected by ground potential, and if the first trunk is busy, the private wiper 72 will be rotated onto a grounded contact, and an energizing circuit will be established through the private magnet 79 a second time, through the side switch wiper 80 in second position. The private magnet now holds its armature, which has been carried into attracted position by the armature of the rotary magnet 81, in the usual manner, as long as the private wiper 72 continues to find ground. As soon as the first idle trunk is found, the circuit through the private magnet 79 is, of course, broken, and as the rotary armature returns toward normal position, after having advanced the private wiper onto the idle trunk, it permits the armature of the private magnet 79 to also return to normal, permitting the side switch to escape to third position. By passing to third position, the side switch cuts the calling line through to the secondary switch F, and disconnects everything from across the talking line at the selector E, which talking line comprises the conductors 84 and 85 on the negative side, and the conductors 86 and 87 on the positive side. But, if the first trunk is idle, the rotary magnet, by depressing the armature of the private magnet 79 once, trips the side switch to third position as the rotary armature falls back, cutting the line through to the first trunk. Of course, as soon as the line relay 54 is cut off, it deënergizes and the springs return to normal, as shown; but the release relay 62 does not deënergize, because at the same time that the circuit is broken by the separation of the springs 60 and 61 at the line relay 54, a holding circuit is set up through the third position of the side switch 80 and trunk-release conductor 88 to the secondary switch F. The way this energizing circuit is set up is as follows: The relay 82, which energizes in series with the rotary magnet 81, is a slow-acting relay and remains energized for a short period after the side switch trips to third position, and, of course, after the rotary magnet ceases to operate. By thus energizing, the said relay 82 separates the springs 89 and 90, and carries the spring 90 into engagement with the grounded spring 91. This condition of the relay 82 maintains ground at the third-position contact of the side switch wiper 80. Therefore, at the instant that the side switch trips to third position, a circuit is closed over the trunk-release conductor 88, through the magnet 92 of the secondary line switch F. This line switch, upon tripping, separates the springs 93 and 94, carrying the spring 94 into engagement with the spring 95. The object of this arrangement is to disconnect the magnet 92 from the open main spring 93, in order to prevent the magnet 92 from being deënergized when the master switch H operates. Of course, as soon as the secondary line switch F trips, a circuit is extended through the line relay 96 of the second selector I, which causes the said relay to pull up. The current in this energizing circuit flows as follows: from ground G^6 through the lower winding of the relay 96 and through the side switch wiper 97 (first position) to the positive side of the line, thence through the telephone to the negative side of the line, through the side switch wiper 98 (first position) and upper winding of the relay 96 to battery. The relay 96 operates in a manner similar to that of the relay 54 of the first selector E, separating the springs 99 and 100, and carrying the spring 100 into engagement with the spring 101. The closure of these two springs 100 and 101 energizes the slow-acting release relay 102. The current in this last circuit flows from ground G^7 through the springs 100 and 101 and through the release relay 102 to battery. One of the results of energizing this relay is that the springs 103 and 104 are pressed into contact, thereby grounding the trunk conductor 105.

The secondary line switch F, being similar in manner of operation to the line switch C, upon operating presses the springs 106 and 107 into contact, as well as the springs 108 and 109, the springs 110 and 111, and the springs 112 and 113, as shown. The springs 108 and 109 being closed at the time that the

conductor 105 is grounded, by the action of the relay 102, a locking circuit is set up for the magnet 92 of the secondary line switch F. The current through this locking circuit flows from ground G^8 through the side switch wiper 114 (first position), springs 103 and 104, secondary switch bank springs 109 and 108, through the secondary line switch magnet 92, springs 94 and 95 and resistance coil 115 to battery. Just about this time the slow-acting auxiliary relay 82 deënergizes, extending the circuit from the slow-acting release relay 62 through the springs 89 and 90 of the relay 82 and side switch wiper 80 (third position) to the trunk conductor 88, whereby the said release relay 62 is locked in multiple with the magnet 92 of the secondary switch F from ground G^8. It should be stated that the relay 82 is not quite as slow-acting as the relay 62 and deënergizes in time to catch the relay 62 before the latter falls back. Connection having been extended to the second selector I, the calling subscriber is now ready to operate his dial a second time for the hundreds digit 1. By operating his dial he again sends one impulse, as in the previous instance, thereby operating the line relay 96, which is identical with the line relay 54 of the first selector E. As a result the private magnet relay 116 is also operated in series with the vertical magnet 117, which are identical with the similar magnets 67 and 68 of the first selector E. The vertical magnet 117, like the vertical magnet of the first selector, raises the switch shaft to the proper level (the first level in this instance), and closes the circuit from the release magnet 118 to battery through the off-normal springs, as was done in the first selector. The private magnet relay 116, in operating, operates in turn the private magnet 119, which is similar to the private magnet 79 of the first selector, whereby the second selector is caused to select an idle trunk line running to a connector, and extend the circuit thereto as shown. It is assumed that the second selector, in operating, extends the circuit to the connector J. It will be noted that the rotary magnet 120 of the second selector is not connected in series with any other relay, such as the relay 82 of the first selector, but goes direct to the second-position contact of the side switch. As soon as an idle trunk line is found, of course, the side switch passes to third position, exactly as the side switch of the first selector does, and disconnects the line relay 96 from across the line. In falling back, the line relay 96 separates the springs 100 and 101, and breaks the retaining circuit of the release relay 102 at this point. This also breaks the energizing circuit for the release relay 62 of the first selector, and for the trip magnet of the secondary line switch F; but a new circuit is provided through the side switch wiper 121 (third position), conductor 122, trunk conductor 123, connector release relay springs 132 and 131 to ground G^{15}. This circuit is also dependent for its closure upon the energization of the line relay 125 of the connector, which occurs at the instant that connection is established with the said connector. It should here be stated that, if necessary, the magnet of the line switch F may also be made a little slow-acting in order to insure that the connection shall not be broken while the ground is being shifted from one point to another.

The line relay 125 of the connector J, having pressed the springs 124 and 126 into contact, causes an energizing circuit to be established through the slow-acting release relay 127. This relay 127 thereupon separates the springs 128 and 129, and carries the spring 129 into engagement with the spring 130, and the springs 131 and 132 are also carried into contact.

The subscriber at the calling station is now ready to operate his dial for the tens digit 1. In so doing the energizing circuit of the line relay 125 is interrupted once in the usual manner. It will be seen that in this energizing circuit the current flows from ground G^{10} through the lower winding of the relay 125 to the positive side 133 of the talking line, thence through the telephone to the negative side of the line, through conductor 134, and through the upper winding of the relay 125 to battery. The impulse transmitted by the subscriber A allows the relay 125 to fall back once, thereby permitting the spring 126 to fall into engagement with the spring 135. As a result an energizing circuit is closed through the vertical magnet 136, said circuit extending from ground G^9 through the springs 126 and 135 of the line relay 125, thence through the springs 129 and 130 of the slow-acting release relay 127, and through the vertical magnet 136, side switch wiper 137 (first position), and slow-acting private magnet relay 138 to battery. The vertical magnet 136 operates just as the vertical magnet in the selectors, raising the switch shaft one step, thereby raising the shaft wipers opposite the first contact of the first bank level. At the same time the off-normal springs 139 and 140 are closed in contact, thereby connecting the release magnet 141^a to battery. At the same time that the vertical magnet 136 energizes, the private magnet relay 138 energizes, disconnecting the springs 141 and 142 and pressing the spring 142 into engagement with the spring 143, and the spring 144 is also disconnected from the spring 143. By closing the springs 142 and 143 an energizing circuit is established through the private magnet 145. Current through this circuit, it will be seen, flows from ground G^{11} through the said springs and through the

private magnet 145 to battery. The private magnet therefore energizes and remains energized while the impulses are being sent in through the vertical magnet 136. However, as soon as the impulses cease to come in, the private magnet relay 138 deënergizes and breaks the circuit of the private magnet 145, at which instant the side switch passes to second position. The calling subscriber is now ready to send in the last set of impulses for the digit 0 of the desired number. Again, the line relay 125 is operated, in this instance ten times. The side switch wiper 137 having been shifted to second position, the impulses due to the closure of contact between the springs 135 and 126 of the line relay 125 pass through the rotary magnet 146 instead of through the vertical magnet 136. By the operation of the rotary magnet the shaft wipers are carried into engagement with the line contacts of the desired line. The private magnet relay 138 is again maintained energized while the impulses are being sent through the rotary magnet 146. When the impulses cease to come in, however, the relay 138, as in the previous instance, falls back, breaking the circuit through the private magnet 145 if the called line is not busy, and permitting the side switch to pass to third position. It will be seen, however, that if the called line is busy, the private wiper 147 will encounter a ground potential, whereby the energizing circuit of the private magnet 145 is maintained even after the spring 142 leaves the spring 143. This circuit is maintained by way of the springs 142 and 141, and is not broken when the spring 142 shifts from the spring 143 to the spring 141, because these three springs are permitted to engage for a short interval. This holding circuit continues through the side switch wiper 148 (in second position) through the ringer relay springs 149 and 150, through the lower winding 151 of the back-bridge double-wound coil 152, through the springs 153 and 154 of the auxiliary relay 155 to the private wiper 147 and to ground. Since this locking circuit for the private magnet 145 contains one winding of the relay 152, the relay 152 will energize, and it in turn energizes the auxiliary relay 155 which gives the busy signal to the calling line. The side switch being unable to pass to third position, the calling subscriber is prevented from connecting his own line with the desired, but busy, line. It will be seen that this locking circuit for the private magnet 145 is shifted from the private wiper to the ground G^{12} as soon as the auxiliary relay 155 energizes. If the called subscriber is not busy, however, connection is established as explained, and the interrupter 156 intermittently energizes the ringer relay 157, which continues to send ringing current periodically to the called line until the called subscriber answers, at which time the relay 152 is energized, breaking the circuit of the ringer relay 157 at the springs 156^a. The energizing circuit of the relay 157 extends from ground through the interrupter 156, springs 156^a, relay 157, side switch wiper 137 and relay 138 to the battery lead 17. The relay 152 is energized by the talking battery current of the called substation, which current flows from ground G^{13} through the side switch wiper 159, lower winding of the relay 152, thence over the heavy talking conductors to and through the substation K and back over the other side of the line and through the upper winding of the relay 152 to the battery lead 17. The relay 138 is not energized over this circuit due to the comparatively high resistance of the ringing relay.

It will also be seen that as soon as the side switch of the connector passes to third position, a ground guarding potential is applied to the private wiper 147 from ground G^{13}, through the side switch wiper 159 and the springs 153 and 154 of the relay 155. This guarding potential protects the called line from being called by anyone else and sends a flow of current through the bridge-cut-off winding 160 of the called subscriber's line switch C', which winding, upon being excited, attracts the bridge-cut-off armature 161, thus disconnecting the line winding 162 from the line.

After the subscribers are through talking, if the calling subscriber hangs up his receiver, he opens his line and thereby causes the line relay 125 of the connector to deënergize and, as a result, the slow-acting release relay 127 deënergizes also. The former relay 125 cuts off ground from the conductor 123 by separating the springs 126 and 124, thereby permitting the release relay 102 of the second selector to deënergize, also the trip magnet 92 of the secondary line switch F and the release relay 62 of the first selector E. The release relay 102 of the second selector I, upon deënergizing, closes a circuit through the release magnet 118 by permitting the springs 163 and 164 to engage. The current through this energizing circuit, it will be seen, flows from ground G through the line relay springs 100 and 99, through the said springs 163 and 164, release magnet 118 and off-normal springs 165 and 166 to battery. The release magnet 118, upon energizing, withdraws the retaining pawls from the second selector, permitting the shaft to restore, which shaft, upon reaching normal, breaks the energizing circuit of the release magnet 118 by separating the springs 165 and 166. Of course, when the magnet 92 of the secondary line switch F deënergizes, the plunger arm 167 is restored, the springs 95 and 94 are separated and the spring 94 reëngages the spring 93. The re-

lease relay 62 of the selector E, upon de-energizing, operates in a manner similar to the release relay 102 of the second selector, and causes the release of the first selector E by energizing the release magnet 76. The energizing current for said release magnet flows from ground G^4 through the springs 60 and 59, through the springs 65 and 64, release magnet 76 and off-normal springs 74 and 73 to battery. The release relay 62 of the first selector E, upon falling back, also permits the springs 52 and 53 to separate, thereby breaking the holding circuit through the bridge-cut-off winding 51 of the line switch C, at which time the line switch C restores to normal. In the meantime the release relay 127 of the connector falls back, carrying the springs 128 and 129 into engagement, thereby closing the circuit through the release magnet 141^a. Current in this circuit flows from ground G^9 through the line relay springs 126 and 135, through the release relay springs 129 and 128, release magnet 141^a, and through the off-normal springs 140 and 139 to battery. The connector is likewise restored and the release circuit broken when the shaft reaches normal and separates the off-normal springs. It is obvious that upon the release of the connector the circuit through the winding 160 of the line switch C′ is broken, and the line switch C′ is permitted to assume its normal position.

By referring to the master switch D in Fig. 1, it will be seen that the motor magnet 40 has a slow-acting relay 168 in multiple therewith. This relay is adapted to remain energized and retain the main springs 24 and 25 open while the master switch is rotating. The function of these springs is to prevent a subscriber from connecting with a busy trunk should a subscriber remove his receiver while the master switch is rotating. In carrying out my invention I provide a relay 169 which is designed to be inserted between the pull-in winding 20 of the line switch and the battery lead whenever the said springs 24 and 25 are separated. The relay 169, when energized, presses the springs 170 and 171 into contact, thereby putting battery current on the slow-acting relay 172 through its springs 173 and 174. It should be stated that the spring 173 is a multiple spring, there being as many springs 173 connected with the spring 171 as there are line switches. Also, it should be stated that the relay 169 is a relay common to a group. Therefore, if any subscriber removes his receiver while the springs 24 and 25 are separated, the relay 169 will energize as a result of the attraction of the line armature 18 of the subscriber who has thus removed his receiver. This energizing circuit may be traced from ground G′ at the line switch C through the springs 9 and 19, through the pull-in winding 20, winding 21, springs 22 and 23, relay 169 to battery. The relay 169 is a high resistance relay, so that not enough current is permitted to pass through the winding 20 of the line switch to operatively energize the same. The relay 169, being energized, and the armature 18 being attracted at the same time, an energizing circuit is closed through the slow-acting relay 172 from ground G′ through the springs 9 and 19, through the said relay 172, and through the springs 174 and 173 and springs 171 and 170 to battery. The relay 172, upon energizing, disconnects itself from the spring 171 by shifting the spring 174 from the spring 173, and locks itself onto main battery direct by carrying the spring 174 into engagement with the spring 175. At the same time the relay 172, by separating the springs 22 and 23, opens the circuit of the pull-in magnet 20 at a point which is retained open as long as the relay 172 is retained energized. It will be seen that when the spring 22 separates from the spring 23 it is carried into engagement with the busy spring 176. Thus a circuit is closed from the battery lead 17 through the secondary winding of the busy signaling machine, springs 176 and 22, windings 21 and 20 and springs 19 and 9 to ground G′, thence back through the battery to the starting point. The battery current flowing over this circuit is not sufficient to operatively energize the winding 20, but the alternating current produced by the busy signaling machine, in passing through the winding 21, induces a busy signal in the winding 8, which signal is carried to the subscriber's telephone. Upon hearing the signal the subscriber hangs up, and thereby opens his line circuit, which permits the armature 18 to fall back. As a result the energizing circuit through the relay 172 is broken and permits the said relay to restore to normal, again connecting the pull-in magnet 20 to the spring 24 and its own coil to the open main spring 171. It will be obvious that the relay 169 will cause as many relays 172 to energize, when it pulls up, as there may be subscribers in the group who remove their receivers while the springs 24 and 25 are separated. It will be seen, therefore, that any subscriber who removes his receiver while the master switch is rotating will be locked on busy and kept there until he hangs up. In this way two or more subscribers, who may have removed their receivers while the master switch is moving, will not plunge into the same trunk at the instant that the master switch stops.

At the secondary line switch F the arrangement is as follows: The motor magnet relay 177 is, as in the master switch D, multipled by the relay 178, so that while the master switch is moving, the relay 178 is en-

ergized, whereby the springs 179 and 180 are separated to prevent any secondary switch F from tripping while the master switch is rotating. If, while the springs 179, and 180 are separated, connection is established with the trunk terminating in the secondary switch F, the auxiliary relay 181 is energized by the same current which would otherwise energize the pull-in magnet 92. The current, of course, flows from the conductor 88, through the springs 182 and 183 and through the winding of the magnet 92, through the springs 94 and 93 and magnet 181 to battery. This magnet 181 thereupon energizes the relay 184 by pressing the springs 185 and 186 in contact and the springs 187 and 188 into contact. The energizing current will flow from ground G^{14} through the springs 185 and 186, through the springs 189 and 190, winding 191, springs 192 and 193 to the positive side of the line, thence through the telephone and back to the negative side of the line, whence the circuit is continued to the springs 194 and 195, through the winding 196, springs 197 and 198 and springs 187 and 188 to battery. The relay 184, upon energizing, disconnects itself from the springs 186 and 187, and connects itself with the positive and negative terminals of the battery direct. Under this condition the busy current which is passing through the winding 201 is induced in the line, and the calling subscriber is given the busy signal. It will be seen that the relay 184, by pressing the spring 182 onto the spring 202, also grounds the trunk conductor 88 for holding up the first selector E. When the calling subscriber hears the busy signal he hangs up his receiver, opens the line and permits the relay 184 to fall back, which thereupon restores and permits the release of the switches E and C. It will be seen that the relay 184, while energized, holds the springs 182 and 183 separated, thereby making it impossible for the pull-in magnet 92 to energize after the open main springs 179 and 180 reëngage, and before the calling subscriber releases. It is thus seen how a secondary line switch is locked on busy and held there if a calling subscriber should obtain connection therewith while the master switch is operating. It will be understood, of course, that the master switch H is the same as the master switch D and is advanced each time that a trunk is seized, as, for example, when a trunk to the second selector I is seized. This, of course, is done by the closure of contact between the bank springs 110 and 111, exactly as was done in the master switch D.

It is obvious that in a system of the character described the subscribers' switches may alone be provided with the means herein described, in which case the relay 184 of the secondary switch F would be discarded, the springs 182 and 183 short-circuited, and the relay 181 also discarded; likewise, the springs 194 and 195 and 192 and 193 will be discarded. Likewise, in this system the secondary switches alone might be provided with the arrangement whereby they may be locked on the busy apparatus, if seized while the master switch is operating, in which case the relays 172 and 169 would be discarded and the springs 22 and 23 short-circuited. It is also obvious that the system may operate without secondary switches F, or without line switches C. If the secondary switches are discarded, the trunk conductors 199, 200 and 88 would be a continuation of the conductors 203, 204 and 105. In case the line switches C are discarded, each subscriber would be provided with a selector switch E, normal conductors, such as the normal conductors 205, 206 and 207, and a bridge-cut-off relay, corresponding to the winding 51, which would be adapted to disconnect the line relay 54 from the line when the line is called. The springs 52 and 53 might, of course, be discarded. In a system using Keith switches it is sometimes customary to insert a relay between the spring 24 and the lead 208, as shown in Fig. 6. Such a relay is common to the subscribers of the group, and is adapted to close a local energizing circuit through a second relay, slow-acting in character, which operates a ten point side switch. Each one of these points is connected to a corresponding trunk conductor 63 running from the line switch to the next switch. The arrangement is such that normally the conductors 63 are disconnected from each other, but as soon as the relay pulls up, all of these conductors are grounded until the slow-acting relay deënergizes. Said relay, of course, deënergizes as soon as the circuit is opened through the pull-in winding 20. This insures the action of the line switch C—that is, it insures that the line switch C will not fall back, because of the possible slow action, for example, of the line relay 54, and of the slow-acting relay 62. The same arrangement is applicable to the secondary switches F. The first relay would be inserted in the circuit connecting the spring 179 with the spring 93. This relay would close the circuit of the slow-acting relay 62, and trip winding 92 until the relay 102 pulls up.

My invention is, therefore, applicable to a two-wire system for the purpose of preventing subscribers from interfering with each other by attempting to make a call while the master switch of the calling subscriber is in operation. It is applicable to a two-wire system for preventing subscribers from interfering with each other by attempting to call through secondary line

switches while the controlling master switch is in operation.

My invention provides means for efficiently holding a subscriber, either at a line switch or at a secondary switch, if he has attempted to pass a call through either while the controlling master switch of either is in operation. And it also provides means for giving the subscriber a signal when thus locked, whereby he may restore his apparatus and call again.

What I claim as my invention is:—

1. In a telephone system, a calling subscriber's line, a called subscriber's line, means for extending a connection between said lines, including a switch, a second calling subscriber's line, a second called subscriber's line, means for extending connection between the said second lines, also including a second switch, a common controlling mechanism for both of said switches, said common mechanism adapted to be operated when either of said switches is operated, together with means whereby, when the first switch causes the operation of said common mechanism, the said second switch is rendered inoperative for calling while the common mechanism is operating, and means whereby, if an attempt is made to use the said second switch for calling, the call is blocked and a signal given to the calling party indicating that he cannot get his call and should release.

2. A subscriber's line, a switch for calling purposes adapted to be used by said line, a controlling device for said switch, said controlling device adapted to be operated, means whereby, while the said controlling device is operated, the said switch is rendered inoperative for calling, together with means whereby, if an attempt is made to make a call through the said switch, the call is blocked and the subscriber is given a signal indicating that he cannot get his call and should release.

3. In a telephone system, a switch for calling purposes, a device for controlling said switch, means for operating said device, means for rendering the said switch incapable of transmitting a call while the device is operating, together with means whereby, if an attempt is made to use the said switch for calling while the said device is operating, the calling party is signaled to that effect.

4. In a telephone system, a subscriber's line, a switch for said line for establishing connection with another line, an operating magnet for closing said connection, a controlling master switch adapted to be operated when such a connection is made by said switch, or by some other switch, means for rendering the said operating magnet inoperative while the master switch is operating, together with means whereby, if an attempt is made to operate the said operating magnet, the first-mentioned switch is locked and made unresponsive to a call until the switch is released.

5. In a telephone system, a switch for establishing connection between two lines, an auxiliary switching mechanism adapted to be operated, means for rendering said switch inoperative for connecting purposes while the said auxiliary mechanism is in operation, together with means for preventing the said switch from becoming operative for calling purposes as soon as the auxiliary mechanism stops its operation, if an attempt has been made to use the said switch for connecting purposes while the auxiliary mechanism was operating.

6. In a telephone system, a line, a switch adapted to be operated from said line for calling purposes, an auxiliary switching mechanism adapted to be operated, means for rendering the said switch inoperative for calling while the auxiliary mechanism is operating, together with means for preventing the said switch from becoming operative for calling purposes as soon as the auxiliary mechanism stops its operation after an attempt has been made from said line to use the said switch for calling purposes while the auxiliary mechanism was operating, and means for signaling the subscriber who attempted the call that he has failed to make the connection.

7. In a telephone system, subscribers' lines, an individual trunking switch for each line, a master switch for controlling said individual switches, adapted to select trunks ahead of the calls, and means operative in the event that two or more subscribers call at the same time, and while the master switch is in operation, to prevent seizure of the same trunk by two or more subscribers.

8. In a telephone system, a plurality of lines, an individual trunking switch for each line, a master switch controlling said individual switches, adapted to select trunks ahead of the calls, trunks leading from said switches, numerical switches at the other ends of said trunks, and means operative in the event that two or more subscribers call at the same time, and while the master switch is in operation, to prevent seizure of the same numerical switch by two or more subscribers.

9. In a telephone system, a plurality of subscribers' lines, an individual trunking switch for each line, a master switch controlling said individual switches, an operating magnet for said trunking switch, a pair of relay-controlled contacts in the energizing circuits for said magnet, and a second relay in shunt of said contacts for controlling said switch.

10. In a telephone system, a plurality of subscribers' lines, an individual trunking

switch for each line, a master switch controlling said individual switches, an operating magnet for said trunking switch, an energizing circuit for said magnet including a pair of contacts, a relay for controlling said contacts, means for maintaining said relay energized while said master switch is operating, a second relay connected in shunt of said contacts for controlling said switch, and means for energizing said second relay if a subscriber takes off his receiver while said contacts are separated by the energization of said first-mentioned relay.

11. In a telephone system, a plurality of subscribers' lines, an individual trunking switch for each line, a master switch controlling said individual switches, an operating magnet for said trunking switch, a pair of relay-controlled contacts in the energizing circuits for said magnet, a second relay in shunt of said contacts, and a third controlling relay adapted to be energized when said operating magnet and second relay are energized at the same time.

12. In a telephone system, subscribers' lines, an individual trunking switch for each line, a master switch controlling said individual switches, a line relay for one of said individual switches permanently connected to battery, an operating magnet connected to battery through a pair of contacts controlled by said master switch, a relay in shunt of said contacts, and means controlled by said relay for controlling the operation of said trunking switch.

13. In a telephone system, subscribers' lines, an individual trunking switch for each line, a master switch controlling said individual switches, a line relay for one of said individual switches permanently connected to battery, an operating magnet connected to battery through a pair of contacts controlled by said master switch, a relay in shunt of said contacts, a second relay controlled by said last-mentioned relay, and means controlled by said second relay for controlling the operation of said trunking switch.

14. In a telephone system, subscribers' lines, individual non-numerical trunking switches for each of said lines, a master switch controlling a plurality of said individual switches, a relay controlling the operative connection of said trunking switches to said subscribers' lines, means for energizing said relay over a circuit including a contact common to a plurality of said trunking switches, and means for locking said relay over an individual local circuit.

15. In a telephone system, subscribers' lines, an individual non-numerical trunking switch for each line, a master switch controlling a plurality of such trunking switches, an operating magnet for said trunking switch, a pair of contacts common to a plurality of said switches and a pair of contacts individual to each switch, and an energizing circuit for said operating magnet including said common and individual contacts.

16. In a telephone system, subscribers' lines, an individual non-numerical trunking switch for each line, a master switch controlling a plurality of such trunking switches, an operating magnet for said trunking switch, a pair of contacts common to a plurality of said switches and a pair of contacts individual to each switch, an energizing circuit for said operating magnet including said common and individual contacts, means for closing said common contacts, and means for maintaining said individual contacts open after said common contacts are closed.

17. In a telephone system, a non-numerical trunking switch, a master switch controlling a plurality of such trunking switches, an operating magnet for said trunking switch, a line relay for said switch, a second relay under the control of said master switch, a third relay controlling the circuit of said operating magnet, and means whereby said third relay will be energized if said line relay is energized while said second relay is energized.

18. In a telephone system, subscribers' lines, an individual trunking switch for each line, a plurality of secondary trunking switches, a master switch for controlling said secondary switches, adapted to select trunks ahead of the calls, and means to prevent seizure of the same trunk by two or more secondary switches while said master switch is operating.

19. In a telephone system, a plurality of lines, an individual trunking switch for each line, a master switch controlling said individual switches, adapted to select trunks ahead of the calls, trunks leading from said switches, numerical switches at the other ends of said trunks, means operative in the event that two or more subscribers call at the same time, and while the master switch is in operation, to prevent seizure of the same numerical switch by two or more subscribers, secondary non-numerical switches with which said numerical switches connect, adapted to select an idle trunk, and means for preventing two or more of said secondary switches from seizing the same trunk.

20. In a telephone system, a plurality of trunk lines, non-numerical trunking switches, a master switch for controlling said non-numerical switches adapted to select trunks ahead of the calls, and means to prevent seizure of a trunk by other of said non-numerical switches when it has been seized by one of said switches.

21. In a telephone system, a plurality of

trunk lines, non-numerical trunking switches, a master switch for controlling said non-numerical switches adapted to select trunks ahead of the calls, and means to prevent seizure of a trunk by other of said non-numerical switches when it has been seized by one of said switches and while said master switch is in operation.

22. In a telephone system, a calling subscriber's line, a called subscriber's line, means for extending a connection between said lines, including a switch, a second calling subscriber's line, a second called subscriber's line, means for extending connection between the said second lines, also including a second switch, a common controlling mechanism for both of said switches, a controlling circuit for said common mechanism common to said switches and means for closing said controlling circuit when any one of said switches is operated for operating the common mechanism, together with means whereby, when the first switch causes the operation of said common mechanism, the said second switch is rendered inoperative for calling while the common mechanism is operating, and means whereby, if an attempt is made to use the said second switch for calling, the call is blocked and a signal given to the calling party indicating that he cannot get his call and should release.

23. A subscriber's line, a progressively movable trunking switch under the control of the said line through the medium of suitable circuits, a device for controlling the progressive motion of said switch, electromagnetic means for operating said device, said circuits under the control of said device for rendering the switch inoperative while the device is in operation, together with means whereby, if an attempt is made to make a call through the said switch, the call is blocked and the subscriber is given a signal indicating that he cannot get his call and should release.

24. In a telephone system, a subscriber's line, a switch for said line for establishing connection with another line, an operating magnet for closing said connection, a controlling master switch, means for operating said master switch when a connection is made by said line switch, means for rendering the said operating magnet inoperative while the master switch is operating, together with means whereby, if an attempt is made to operate the said operating magnet, the first mentioned switch is locked and made unresponsive to a call until the switch is released.

25. In a telephone system, a switch for establishing connection between two lines, an auxiliary switching mechanism, means for operating said switching mechanism when a connection is established, means for rendering said switch inoperative for connecting purposes while the said auxiliary mechanism is in operation, together with means for preventing the said switch from becoming operative for calling purposes as soon as the auxiliary mechanism stops its operation if an attempt has been made to use the said switch for connecting purposes while the auxiliary mechanism was operating.

26. In a telephone system, a line, a progressively movable switch for said line controlled thereover for calling purposes through the medium of suitable circuits, an auxiliary automatic electromagnetic mechanism for controlling the progressive movements of said switch, means for operating said mechanism comprising suitable circuits under the control of said progressively movable switch, said auxiliary mechanism controlling the circuits of said progressively movable switch to render the switch inoperative for calling purposes when the auxiliary mechanism is operated, together with means for preventing the said switch from becoming operative for calling purposes as soon as the auxiliary mechanism stops its operation after an attempt has been made from said line to use the said switch for calling purposes while the auxiliary mechanism was operating, and means for signaling the subscriber who attempted the call that he has failed to make the connection.

27. In a telephone system, subscribers' lines, a progressively movable trunking switch for each line, each switch controlled over its own line through the medium of suitable circuits, a master switch for controlling the progressive movements of said switch, trunks associated with said individual switches and with said selector switch, busy test circuits for said trunks, means for applying a busy potential to said busy test circuits when they are brought into use, means for initiating the operation of said master switch when a call is made and means for continuing the operation of said master switch comprising said busy test circuit for locating an idle trunk for the next call, and means operative in the event that two or more subscribers call at the same time, and while the master switch is in operation, to prevent seizure of the same trunk by two or more subscribers.

28. In a telephone system, a plurality of lines, a progressively movable trunking switch for each line, each switch controlled over its own line through the medium of suitable circuits, a master switch for controlling the progressive movements of said switch, trunks associated with said individual switches and with said master switch, busy test circuits for said trunks, means for applying a busy potential to said busy test circuits when they are brought into use, means for initiating the operation of said

master switch when a call is made and means for continuing the operation of said master switch comprising said busy test circuits for locating an idle trunk for the next call, said trunks leading from said switches, numerical switches at the other ends of said trunks, and means operative in the event that two or more subscribers call at the same time, and while the master switch is in operation, to prevent seizure of the same numerical switch by two or more subscribers.

Signed by me at Chicago, Cook county, Illinois, this 24 day of March, 1909.

EDWARD D. FALES.

Witnesses:

ETHEL A. EDGELL,

ARTHUR J. RAY.