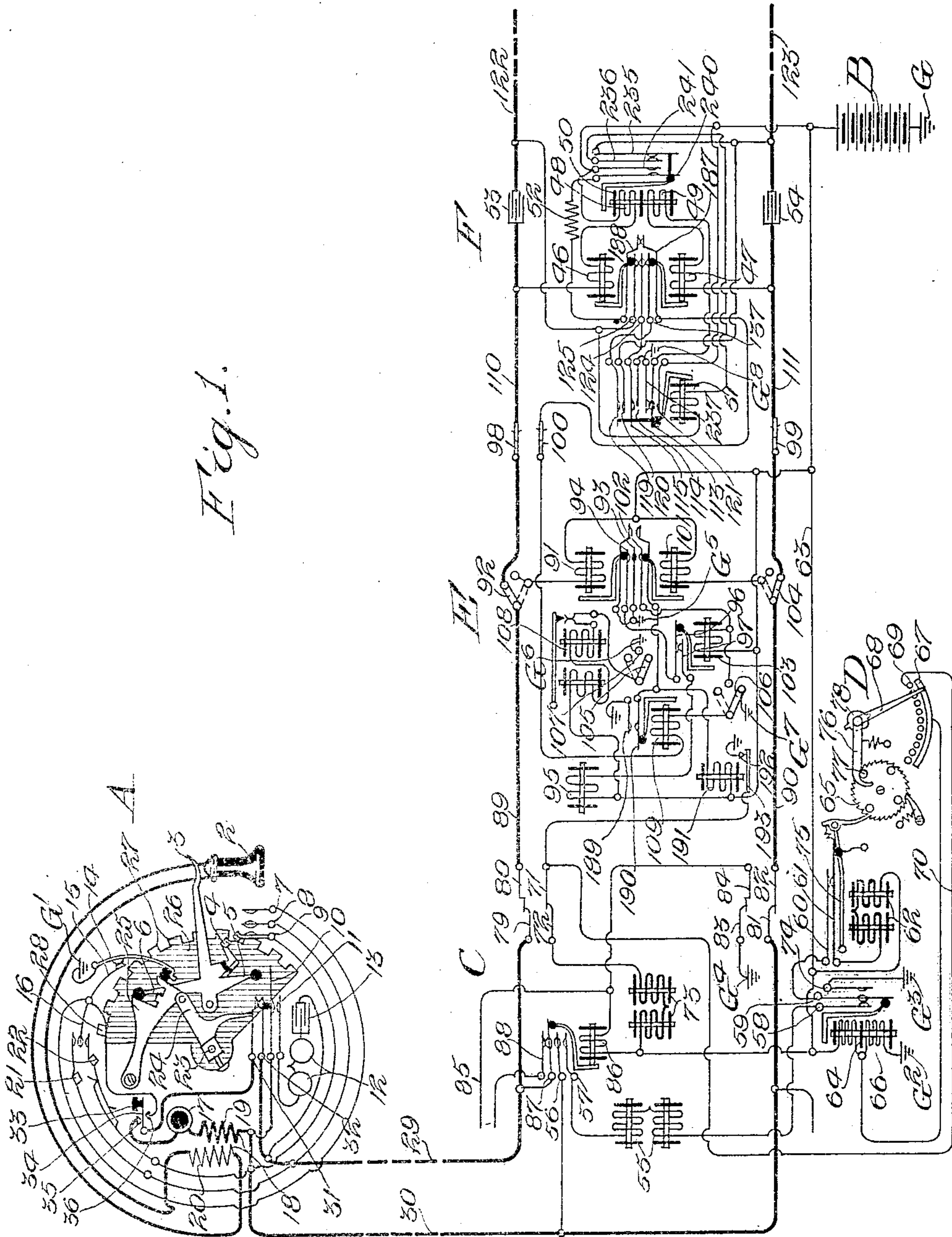


TELEPHONE EXCHANGE TRUNKING SYSTEM.

1,292,827.

Patented Jan. 28, 1919.

Fig. 1.



Witnesses.
P. H. Burfeind.
A. Andersen.

Inventor:
Fritz Lubberger,
By Cullley's Ward & Drury.
Attorneys.

F. LUBBERGER.

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APPLICATION FILED JUNE 10, 1909. RENEWED JUNE 15, 1918.

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3 SHEETS—SHEET 2.

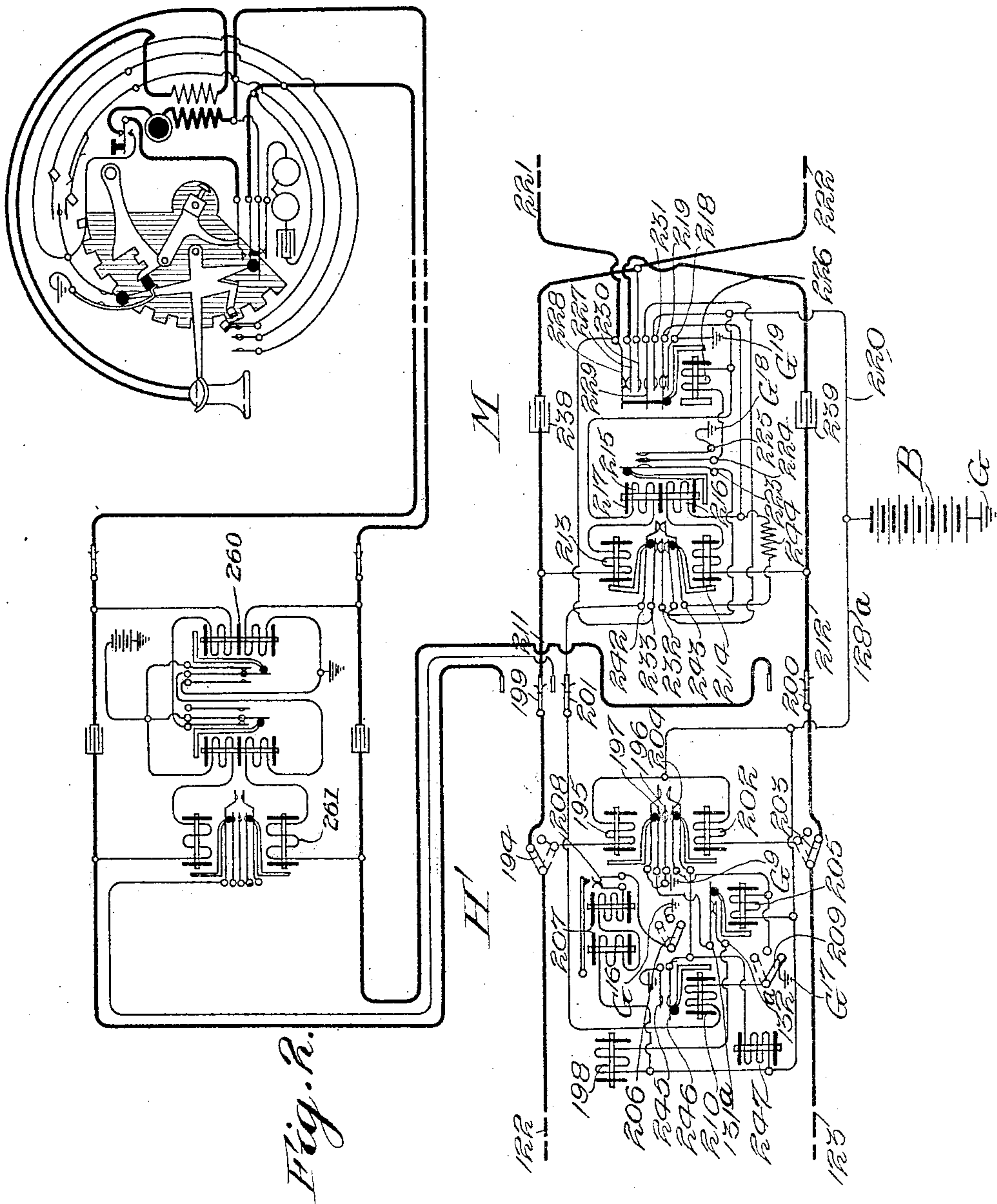


Fig. 2.

Witnesses.

P. H. Burfeind
A. Andersen.

Inventor:
Fritz Lubberger,
By Buckley and Drury
Attorneys.

F. LUBBERGER.

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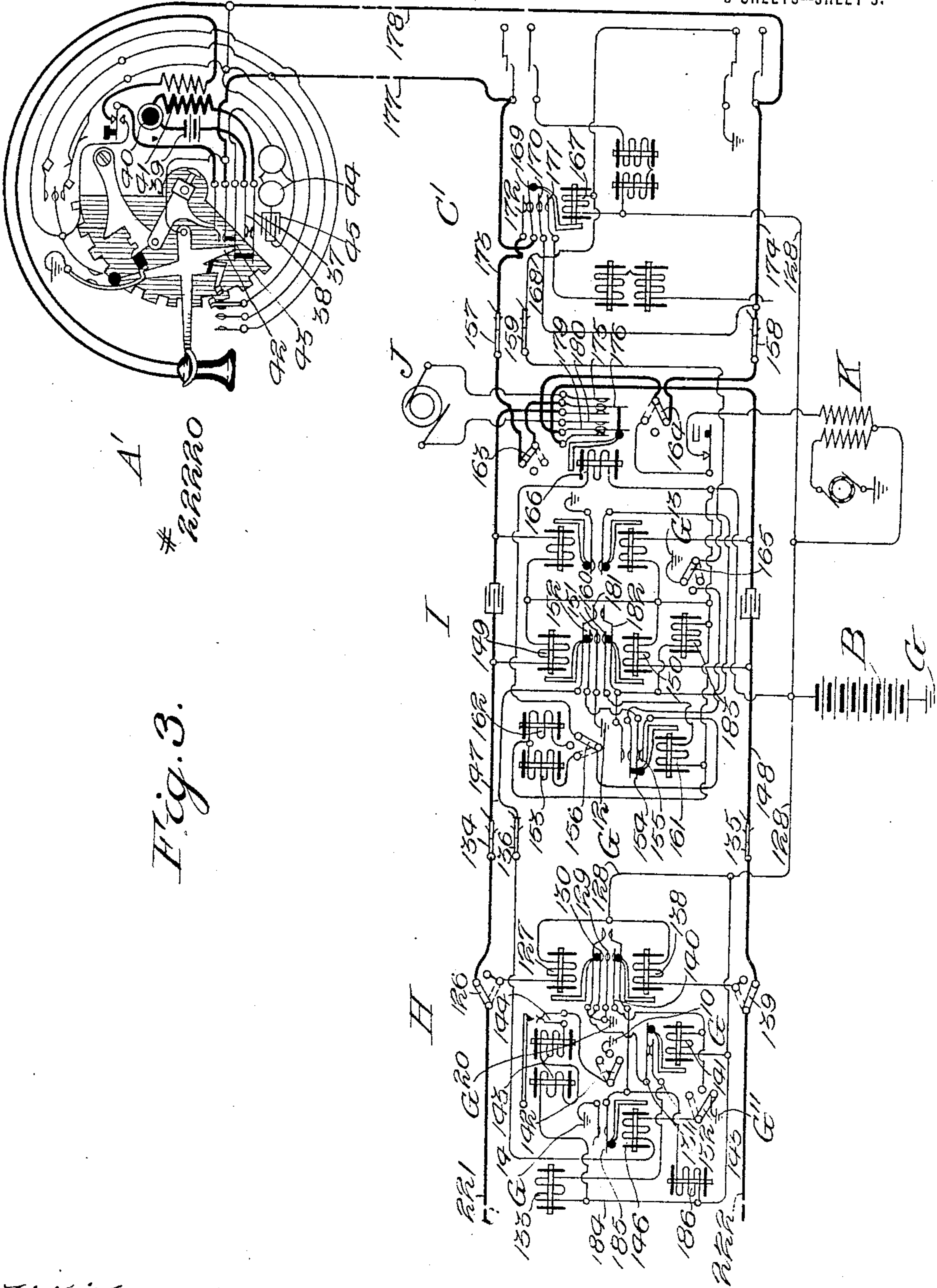


Fig. 3.

Witnesses:
R. H. Burfield
A. B. Sperry.

Inventor:
Fritz Lubberger,
By Culley & Ward & Drury.
Attorneys.

UNITED STATES PATENT OFFICE.

FRITZ LUBBERGER, OF CHICAGO, ILLINOIS, ASSIGNOR TO AUTOMATIC ELECTRIC COMPANY, OF CHICAGO, ILLINOIS, A CORPORATION OF ILLINOIS.

TELEPHONE-EXCHANGE TRUNKING SYSTEM.

1,292,827.

Specification of Letters Patent.

Patented Jan. 28, 1919.

Application filed June 10, 1909, Serial No. 501,259. Renewed June 15, 1918. Serial No. 240,253.

To all whom it may concern:

Be it known that I, FRITZ LUBBERGER, a subject of the Emperor of Germany, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Telephone-Exchange Trunking Systems, of which the following is a specification.

My invention contemplates an improvement in telephone exchange systems whereby the subscriber of one exchange may obtain trunking connection to another exchange, and there obtain connection with the line of a local subscriber, or obtain a trunking connection to a third exchange, for the purpose of extending the call to the line of a called subscriber thereof. For example, in an automatic system employing selectors and connectors I have found it desirable to provide means for trunking between two common battery automatic exchanges, whereby a subscriber of one may automatically call a subscriber of the other, and to provide means whereby a subscriber of one of said automatic exchanges may call through the other automatic exchange to a third or local battery automatic exchange, thus obtaining connection with the line of a subscriber of the latter exchange. This means, of course, that the common battery subscriber may trunk automatically from the one common battery exchange to the other, and thus obtain connection with the line of a common battery subscriber of the second exchange, or continue the call through the second exchange to the third exchange, in the manner stated. In trunking from the first common battery exchange to the second common battery exchange for either purpose, the same trunking connection may be employed—that is to say, the trunking connection between the two common battery exchanges will be the same for calling a subscriber of the second exchange as it will for calling a subscriber of the third exchange. Thus the repeaters employed at the first exchange for giving a common battery trunking connection between the two common battery exchanges will be included in the trunking connection, regardless of whether the call is for a subscriber of the second or third exchange. If the call be to the line of a subscriber of the second or common battery exchange, then the repeater at the first exchange will receive current from the

common battery connector at the second exchange, as soon as the called subscriber removes his receiver, and the said repeater will then furnish talking current to the calling subscriber. The repeater at the second exchange is, however, of a different character, inasmuch as it is to be employed in trunking to the line of a local battery subscriber, and is not, therefore, equipped with means for furnishing current back over the circuit in the direction of the calling subscriber when the called subscriber answers. In other words, such a local battery repeater is preferably of a character to supply talking current to the line of a calling common battery subscriber as soon as the repeater is included in the connection—that is to say, as soon as the call extends to the repeater. Ordinarily a repeater for extending connection between a calling common battery subscriber and a called local battery subscriber is only required to furnish sufficient current for talking purposes. In an arrangement such as described, however, where the call is to be extended through three exchanges, the second of which is a common battery exchange, the repeater at the second exchange must be of a character to supply enough current for operating the repeater at the first exchange, and for this purpose more current is required than for simply enabling the calling subscriber to use his transmitter. In other words, the repeater at the second exchange must supply enough current to operate a relay in the repeater at the first exchange, so that this relay may energize and thereby shift the battery at the first exchange into a bridge extending across the talking circuit, so that the calling subscriber will receive talking current therefrom. In this way a repeater is used at the first exchange for calling a subscriber of the third exchange, and this same repeater is used in calling a subscriber of the second exchange. When the repeater at the first exchange is used for calling a local battery subscriber at the third exchange, then the calling subscriber receives talking current as soon as connection is obtained with the repeater at the second exchange; but when this same repeater at the first exchange is used for calling a subscriber of the second exchange, then the calling subscriber receives talking current as soon as the called subscriber answers. Hence the necessity

for repeaters at the second exchange which are of a character to supply sufficient current for operating the relays of the repeaters at the first exchange, and in a system characterized by my invention the repeaters at the second exchange are adapted for use in extending connection to the local battery subscribers of the third exchange, and are also adapted to supply sufficient operating current to the repeaters of the first exchange; and these repeaters of the first exchange are adapted for extending connection to the lines of common battery subscribers, and are each adapted to supply talking current to the calling subscriber when the called common battery subscriber answers. The nature of my invention will, however, hereinafter more fully appear.

In the accompanying drawings are represented diagrammatically the central or subexchange equipment employed by a sub or central exchange subscriber in calling a subscriber of a local battery exchange through an intervening common battery exchange, in a system embodying the principles of my invention, illustrating the operation and utility of my improved repeater.

Figure 1 represents a subscriber's station A the line of which terminates at the central office in the line switch C; and at D is represented the master switch controlling the group of line switches of which C is a member. At E is shown diagrammatically a first selector switch in conjunction with a repeater F embodying the principles of my invention.

Fig. 2 represents a selector H' and a repeater M of the intermediate common battery central office, with trunk conductors leading from the repeater to the selector H of Fig. 3.

In Fig. 3 is shown diagrammatically a selector switch H of a local battery exchange and a connector switch I, and the selector is represented as connected with the trunk conductors leading to a connector switch that operates and establishes connection with the normal conductors of the line of substation A', which conductors terminate in the line switch C'.

These three exchanges may be separated and some distance apart, and may be connected by means of trunk lines which terminate in repeaters of my improved type, or the common and local battery substations may be regarded as belonging to the same exchange. The repeaters F and M, nevertheless, are the connecting links between the three exchanges. The substation A may be of any suitable or approved type. The one in connection with which I have elected to illustrate my invention comprises a receiver 2, switch-hook 3 for controlling the substation circuits, which controlling operations

are accomplished through the medium of any suitable means, such as the cam arms 4, 5 and 6. As the switch hook is lowered the cam arm 4 momentarily presses the release springs 7, 8 and 9 into engagement, whereby the substation line conductors may be grounded simultaneously. When the switch hook is down the cam arm 5 maintains a contact between the springs 10 and 11, thereby bridging the ringer 12 in series with the condenser 13 across the line. The substation ground circuit is normally broken between the ground springs 14 and 15 by the cam arm 6; but when said springs are together, then ground potential is provided from the battery to the ground post 16 and to the release spring 7, as is usually the case in telephones of this type. The said substation comprises the usual transmitter 17, and the induction coil 18 having the primary winding 19 and secondary winding 20. Being an automatic substation it is provided with the usual vertical and rotary impulse springs 21 and 22. Said substation is, of course, provided with a dial (not shown) which is secured to the shaft 23, together with the locking dog 24. Furthermore, there is a locking cam 25 that locks the dog 24 while the receiver is on the switch hook to prevent a rotation of the dial. For operating the impulse springs 21 and 22 the substation is provided with an impulse wheel 26 that is secured to the shaft 23, which impulse wheel carries on its periphery the so-called vertical impulse teeth 27 and one rotary impulse tooth 28. Furthermore, the rotary impulse spring 22 is of such construction that when the dial is turned forward for the first digit the rotary impulse tooth 28 momentarily presses the said impulse spring onto the ground post 16, whereby the rotary line conductor 30 is given a preliminary impulse for operating the line switch C. The said impulse teeth are so arranged that when the dial is drawn down the impulse spring 21 is not carried into contact with the ground post 16; but as the dial returns, first the vertical teeth engage the vertical impulse spring 21, and after they have completed their work the rotary impulse tooth operates the rotary impulse spring 22. In this operation the subscriber's vertical line conductor 29 is first given a number of ground impulses, and then the rotary line conductor 30 is given one ground impulse. It will be seen that as long as the dial is out of normal position the dog 24 permits the primary circuit springs 31 and 32 to separate, thus preventing the impulses that are delivered to either line conductor from passing to the other. The means whereby a subscriber may signal a called subscriber comprises the push button 33 which, when pressed, carries the spring 34 out of engagement with the contact point 35 and into engagement with the

contact point 36, whereby the vertical line conductor 29 is grounded.

The local battery substation A' (Fig. 1) is similar to the substation A, the only difference being in the arrangement to adapt one for common battery use and the other for local battery use. In the substation A' the springs 37 and 38 control the local circuit including the battery 39, transmitter 40 and primary winding 41. When the switch hook is down the cam arm 42 engages the spring 43, thereby bridging the ringer 44 in series with the condenser 45 across the substation line conductors. Otherwise the substation A' is the same as substation A in mechanical construction and operation.

The line switch C is like the line switch disclosed in English Patent No. 26,301 of 1906, and in the *Western Electrician* of Chicago, January 25, 1908. The master switch D is similar in construction and operation to the master switches shown in the above publications.

The selector switches E, H and H' are of the general type of selector switch disclosed in United States Patent No. 815,321, issued March 13, 1906, to Keith, Erickson & Erickson. In this case, however, the usual bridge-cut-off relay and normal conductors are omitted.

The repeater F comprises the usual vertical and rotary line relays 46 and 47 connected in series with the windings 48 and 49 of the differential relay 50. The relay 51 is bridged across the line conductors 122 and 123, and is operated when battery current for talking purposes is thrown on said conductors from the connector I or the repeater M. The resistance 52 is connected to the trunk-release circuit to reduce the flow of current through the back-release relay of the selector when the release is initiated. By means of the condensers 53 and 54 the trunk line is divided into two sections. On the left of the condensers the impulses are received by the line relays which operate to repeat the impulses to the conductors on the right of the condensers. My improved repeater M comprises the usual vertical and rotary line relays 213 and 214 connected in series with the windings 215 and 216 of the differential relay 217. The slow-acting relay 226 acts as a pole changer for the rotary line—that is, normally, when the subscribers' line conductors are extended to the repeater M, the trunk lines between the repeaters F and M are supplied with talking battery current from ground G¹⁹ through the springs 218 and 219 of the slow-acting relay 226 to the winding 216 and relay 214, through the relay 51 of the repeater F, windings 213 and 215 to battery. When impulses are being sent by the repeater M the slow-acting relay 226 energizes and dis-

connects ground from the rotary line and connects battery therewith instead. The relay is made slow-acting in order that it may remain in an operated position while the impulses are being delivered. By slow-acting is meant a relay so provided with a copper shield or other suitable arrangement that when the relay is once energized and the energizing circuit broken, the relay will remain in its energized position for a moment. When the repeater is operated to send impulses, the energizing circuit through the relay 226 is broken for an instant only on each impulse, and hence the relay remains in its operated position; but after the impulses are delivered the relay returns to normal position, connecting the rotary line relay in series with the winding 216 to ground. The repeater M is equipped with a resistance winding and two condensers for like purposes as in the repeater F.

The connector switch I is of the general type of connector switch disclosed in United States Letters Patent No. 815,176, issued March 13, 1906, to Keith, Erickson & Erickson, and is, as usual, connected to the ringer generator J and the busy signaling machine K.

The selector switches E, H and H' and the connector switch I, and the substation A' are also shown and described in said English Patent No. 26,301 of 1906.

In each of the drawings there is shown a battery B having its positive terminal grounded at G. If the local battery section of automatic substations is in a central office some distance from the common battery section, two batteries may be used; but if the two sections of substations, local and common battery, are in the same exchange building, or near by, one battery may be used.

A clearer understanding of my invention may be had from an explanation of its operation when employed by one subscriber to establish connection with another. Assume, for example, that the subscriber at substation A desires to call the subscriber at substation A', the number of which latter is No. 22220. To call this number the calling subscriber operates the dial in the usual manner for the first digit of the desired number. When the dial is turned forward for the first digit 2 the preliminary impulse tooth 28 momentarily presses the rotary impulse spring 22 onto the ground post 16, thereby closing an energizing circuit extending from the substation ground G' through the cooperating ground springs 14 and 15, ground post 16, rotary impulse spring 22 to the rotary line conductor 30, bridge-cut-off springs and 57, trip magnet 55, through the motor magnet relay springs 58 and 59, interrupter springs 60 and 61, and through the winding of the motor magnet 62 to the battery lead 63. The trip magnet 55 is energized over

this circuit, but has a sufficiently high resistance to prevent enough current from flowing to operate the motor magnet 62. As soon as the trip magnet is energized its armature is attracted and the plunger thrust into an idle bank terminal. When the plunger enters the bank terminal an energizing circuit is closed through the motor magnet relay 64 of the master switch. The motor magnet 62 in turn energizes and operates to rotate the ratchet wheel 65, thereby placing the idle plungers opposite the next idle bank terminal. The circuit through the relay 64 extends from ground G^2 through the winding 66 to the common segment 67 of the master switch bank, through the wiper 68 to the individual segment 69 (which corresponds to the trunk terminal just engaged), conductor 70, line switch bank springs 71 and 72, through the winding of the release magnet 73 to the battery lead 63, thence through battery B to ground G. Although this circuit includes the release magnet 73, the said magnet does not operatively energize, since the relay 64 is wound to a high resistance, while the winding of the release magnet 73 is of a comparatively low resistance. The relay 64, upon energizing, operates to place the spring 59 in contact with the spring 74, whereby the circuit is closed through the motor magnet 62, said circuit extending from ground G^3 through the relay springs 74 and 59, interrupter springs 60 and 61, through the winding of the motor magnet 62 to the battery lead 63, thence through battery B to ground G. The motor magnet, upon energizing, attracts its armature 75, whereby the pawl upon the end of said armature 75 engages the ratchet wheel 65 and rotates the latter one step. When the armature 75 is attracted against the magnet cores the interrupter springs 60 and 61 disengage, thereby breaking the energizing circuit of the motor magnet 62. The cam arm 76 being in engagement with the pin 77 is operated to advance the plunger shaft 78, and consequently all idle plungers that may be in normal position, one step to another bank terminal. Also, the master switch bank wiper 68 is carried from the contact 69 (which corresponds to the trunk line engaged) to another contact corresponding to the bank terminal before which the idle plungers are now resting. At the instant that the plunger enters the bank terminal the bank springs are pressed into contact as follows: 71 and 72, 79 and 80, 81 and 82 and 83 and 84. The engagement of the springs 83 and 84 establishes a positive guarding potential which is transmitted by the private normal conductor 85 to the connector private bank contact corresponding to the line of substation A. This potential protects the line of the calling subscriber from being called by another subscriber while the protected line is in use.

Also, when the springs 83 and 84 engage, an energizing circuit is established through the bridge-cut-off relay 86, said circuit extending from ground G^4 through the bank springs 83 and 84, through the bridge-cut-off relay 86 to the battery lead 63, thence through battery B to ground G. This relay, upon energizing, operates to break the contact between the springs 56, 57 and 87 and to carry the spring 87 into contact with the spring 88. The disengagement of the springs 56, 57 and 87 disconnects the subscribers' line conductors 29 and 30 from the line switch trip magnet 55. The guarding potential at the master switch bank for protecting the trunk line conductors 89 and 90 from being seized by another line switch extends from the battery lead 63, through the release magnet 73 and bank springs 72 and 71, conductor 70 to the individual contact 69. The closure of connection between the springs 79 and 80 extends the subscriber's vertical line conductor 29 to the trunk line conductor 89. In a similar manner the engagement of the bank springs 81 and 82 extends the subscriber's rotary line conductor 30 to the trunk line conductor 90. The trunk line conductors 89 and 90 terminate in the first selector switch E, and when the dial returns to normal position for the first digit the vertical line relay is energized a number of times, depending upon the digit called. The first digit called being 2, the vertical impulse spring 21 is pressed onto the ground post 16 twice, thereby closing an energizing circuit each time through the vertical line relay 91 of the first selector E. This circuit extends from the substation ground G' through the ground post and impulse spring 21 to the vertical line conductor 29, bank springs 79 and 80, side switch wiper 92, vertical line relay 91 to the battery lead 63, thence through battery B to ground G. Each time that the vertical line relay 91 energizes, the springs 93 and 94 are pressed into contact, thereby closing a circuit through the vertical magnet 95 extending from ground G^5 through the springs 93 and 94, private magnet springs 96 and 97, vertical magnet 95 to the battery lead 63, thence through battery B to ground G. The vertical magnet is thereby energized twice and the shaft and shaft wipers 98, 99 and 100 are raised one step at a time until the shaft wipers are carried up two steps and brought opposite the bank level in which are located the terminals of the trunk lines leading to a selector switch (Fig. 2). Immediately following the last vertical impulse the rotary impulse spring 22 is pressed onto the ground post 16, thereby energizing the rotary line relay 101 of the first selector E. The rotary line relay energizes and places the springs 102 and 93 in contact, whereby an energizing circuit is closed through the private magnet 103. The private magnet, as

is well known, controls the side switch wipers 92, 104, 105 and 106. The private magnet 103, upon energizing and deenergizing, permits the side switch wipers to engage their respective contacts of the second position. When the side switch wiper 105 engages the contact point 107 an energizing circuit is closed through the rotary magnet 108 from ground G^6 through the side switch wiper 105, interrupter springs and windings of the rotary magnet 108 to the battery lead 63, thence through battery B to ground G. The rotary magnet, upon energizing, operates to rotate the shaft wipers 98, 99 and 100 into engagement with the first bank contact of the second level. If the first contact is busy a positive guarding potential is present at the private bank contact, and as soon as this contact is engaged by the shaft private wiper 100 an energizing circuit is established through the private magnet 103 from the grounded private bank contact to the private wiper 100, through the back-release relay 109, side switch wiper 106 (bearing in mind that the side switch is still in second position), through the private magnet 103 to the battery lead 63, thence through battery B to ground G. This new energizing circuit maintains the private magnet in an energized position, thereby locking the side switch in second position until the private wiper 100 passes onto a contact upon which there is no guarding potential. The back-release relay 109 is not energized when included in the locking circuit of the private magnet 103 on account of the comparatively high resistance of said magnet. At the moment the energizing circuit through the private magnet is broken the said magnet deenergizes, permitting the side switch to pass to third position, whereby the energizing circuit through the rotary magnet is broken. Furthermore, when the side switch passes to third position a guarding potential is established at the private bank contact corresponding to the trunk line engaged. This potential extends from ground through the side switch wiper 106, back-release relay 109 to the shaft wiper 100 which engages the private bank contact. The subscribers' line conductors 29 and 30 are then extended to the conductors 110 and 111 leading to the repeater F. When the calling subscriber now operates his calling device for the second digit 2 the repeater F is operated to repeat the impulses to the trunk conductors 122 and 123 which lead to the selector H' (Fig. 2). The selector then responds to the impulses for the second digit, which are repeated by the repeater F. When the vertical impulse spring 21 is pressed onto the ground post 16 on the return motion of the dial, an energizing circuit is closed through the vertical line relay 46, said circuit extending from the substation ground G' over the vertical conductors 29, 89 and 110, through the vertical relay 46, winding 48 to the battery lead 63, thence through battery B to ground G. The vertical line relay 46 and the differential relay 50 energize, since the winding 48 alone carries current. The vertical line relay, upon energizing, presses the springs 124 and 125 into contact, thereby grounding the vertical trunk line conductor 122 from ground G^8 through the springs 114 and 115, 124 and 125, conductor 122, thence through the side switch wiper 194 and vertical line relay 195 to battery lead 128^a, thence through battery B to ground G. The vertical line relay operates to press the springs 196 and 197 into contact, which springs close a circuit through the vertical magnet 198 extending from ground G^9 through the springs 196 and 197, private magnet springs 131^a and 132^a to the vertical magnet 198, thence to battery lead 128^a, and through battery B to ground G. The vertical magnet operates to carry the shaft wipers 199, 200 and 201 two steps to a point opposite the second bank level. Following the vertical impulses, the rotary impulse spring 22 is pressed onto the ground post 16 and the rotary line relay 47 of the repeater is energized over a circuit extending from the substation ground G' over the rotary conductors 30, 90 and 111, through the rotary line relay 47, winding 49 of the differential relay 50, springs 113 and 121 to battery lead 63, thence through battery B to ground G. The rotary line relay then operates to press the springs 137 and 124 into contact, thereby repeating the rotary impulse to the rotary trunk conductor 123 for energizing the rotary line relay 202 of the selector H' . This circuit extends from ground G^8 through the springs 114 and 115, 124 and 137, 119 and 120 to the rotary trunk conductor 123, through the side switch wiper 203 (Fig. 2), rotary line relay 202 to the battery lead 128^a, thence through battery B to ground G. The rotary line relay of the selector H' then operates to press the springs 204 and 196 into contact, thereby closing an energizing circuit for the private magnet 205 which, upon energizing and deenergizing, permits the side switch to pass from first to second position. When the side switch wiper 206 engages its second contact point an energizing circuit is established through the rotary magnet 207 from ground G^{10} , through the side switch wiper 206, interrupter springs 208, through the winding of the rotary magnet 207 to the battery lead 128^a, thence through battery B to ground G. The rotary magnet operates in the manner explained in connection with the selector E to rotate the shaft wipers 199, 200 and 201 into engagement with bank contacts of an idle trunk line leading to a selector switch in the

third exchange, assumed to be the selector H. When an idle contact is engaged the private magnet 205 trips the side switch to third position. The side switch wiper 209, upon engaging its third-position contact point, establishes a positive guarding potential at the private bank contact of the trunk line engaged. This potential extends from ground G^{17} to the side switch wiper 209 through the winding of the back-release relay 210, to the private wiper 201. When the side switch wipers 194 and 203 engage their respective third-position contact points, the subscribers' line conductors 29 and 30 are extended to the trunk conductors 211 and 212 and to the repeater M. An energizing circuit is immediately established through the line relays 213 and 214 and the windings 215 and 216 of the double-wound relay 217. This circuit extends from ground G^{19} through the springs 218 and 219, through the winding 216 in series with the rotary line relay 214 to the conductors 212 and 123, through the springs 235 and 236, through the relay 51 to the conductors 122 and 211, through the vertical line relay 213 in series with the winding 215 of the relay 217 to the battery lead 220, thence through battery B to ground G. The relay 217, being wound differentially, does not operate and press the springs which they control into contact. This operation is, however, without effect. When the relay 51 energizes it carries the spring 113 out of contact with the spring 121 and into engagement with the spring 237, separating the springs 114 and 115, and the springs 119 and 120. As soon as the spring 113 engages the spring 237 an energizing circuit is established, said circuit extending from ground G^8 through the springs 237 and 113, through the relay winding 49 of the differential relay 50, through the line relay 47 to conductor 111, thence through substation A to conductor 110, through the line relay 46, winding 48 of the relay 50 to the battery lead 63, thence through battery B to ground G. This circuit provides talking battery current for that portion of the line to the left of the condensers 53 and 54, while the circuit previously traced through the relay 51 provides talking battery current for that portion of the line between the condensers 53 and 54 of the repeater F and condensers 238 and 239 of the repeater M. Now, when the calling subscriber operates his calling device for the third digit 2, the repeater M is operated by impulses from the repeater F to operate the line relays of the selector H (Fig. 3). The energizing circuit just traced through the line and differential relays of the repeater F is broken at substation A when the subscriber turns his dial. At the same time the grounding of the ver-

tical line operates the line relay 46 and the differential relay 50, since the winding 48 alone carries current. The operation of these relays have been hereinbefore described. The energizing of the relay 50 carries the spring 240 into contact with the spring 241, and breaks the contact between the springs 235 and 236. The separation of the latter springs breaks the energizing circuit through the relay 51, thus leaving the trunk lines leading to the repeater M free to transmit impulses. The deenergizing of the relay 51 allows the spring 115 to again engage the spring 114, enabling the impulse springs 125 and 137 to obtain ground when operated by the line relays 46 and 47. When the line relays 46 and 47 energize, impulses are sent to the line relays of the repeater M in the same manner that they were formerly transmitted to the line relays of the selector H'. When the relay 217 energizes, the springs 223, 224 and 225 are pressed into contact, thereby energizing the slow-acting relay 226 from ground G^{18} . This relay, when energized, in turn separates the springs 218 and 219, 227 and 228, and carries the springs 229 and 230, and 219 and 231, into contact. The separation of the springs 227 and 228 disconnects the condenser 239 from the trunk conductor 221, thereby opening one side of the circuit through the repeater, the engagement of the springs 229 and 230 connects the rotary impulse spring with the conductor 222, and the shifting of the spring 219 shifts the connection of the rotary relay 214 from the grounded to the non-grounded side of the battery. The relay 226, being slow-acting, remains in its energized position until all the impulses are delivered for the third digit, after which it returns to normal position, and the energizing circuit is no longer maintained until the impulses are sent for the next digit. The vertical line relay, upon energizing, presses the springs 232 and 233 into contact, thereby grounding the vertical trunk line conductor 221 from ground G^{18} through the springs 225, 224 and 223, springs 232 and 233 to the conductor 221, thence through the side switch wiper 126 and vertical line relay 127 to the battery lead 128, thence through battery B to ground G. The vertical line relay operates to press the springs 129 and 130 into contact, which closes a circuit through the vertical magnet 133 extending from ground G^{20} through the springs 129 and 130, private magnet springs 131 and 132 to the vertical magnet 133, thence to the battery lead 128, and through battery B to ground G. The vertical magnet operates to carry the shaft and shaft wipers 134, 135 and 136 two steps to a point opposite the second bank level. After the vertical impulses the rotary line relay then operates to press the springs 140 and 129 into contact,

thereby closing an energizing circuit for the private magnet 141 which, upon energizing and deenergizing, permits the side switch to pass from first to second position. When the side switch wiper 142 engages its second contact point an energizing circuit is established through the rotary magnet 143 from ground G^{10} through the side switch wiper 142, interrupter springs 144, through the windings of the rotary magnet 143 to the battery lead 128, thence through battery B to ground G. The rotary magnet operates in the manner explained in connection with the selector E to rotate the shaft wipers 134, 135, and 136 into engagement with bank contacts of an idle trunk line leading to the connector switch I. The side switch wiper 145, upon engaging its third-position contact point, establishes a positive guarding potential at the private bank contact of the trunk line engaged. This potential extends from ground G^{11} to the side switch wiper 145, through the winding of the back-release relay 146 to the private wiper 136. When the side switch wipers 126 and 139 engage their respective third-position contact points, the subscribers' line conductors 29 and 30 are extended to the trunk conductors 147 and 148, and to the connector switch I. The calling subscriber now operates the dial for the fourth digit 2, and in turn the repeaters F and M are operated (in the manner previously explained) to repeat the impulses for operating the vertical and rotary line relays 149 and 150 of the connector. When the vertical line relay 149 energizes, the relay springs 151 and 152 are pressed into contact, thereby closing the circuit through the vertical magnet 153, said circuit extending from ground G^{12} through the springs 151 and 152, private magnet springs 154 and 155, side switch wiper 156, vertical magnet 153 to the battery lead 128, thence through battery B to ground G. The vertical magnet operates and carries the shaft wipers 157, 158 and 159 two steps in a vertical direction, opposite the bank level in which are located the terminals of the line No 22220. Following the vertical impulses the rotary line relay energizes to place the springs 160 and 151 in contact to close a circuit through the private magnet 161, which latter operates to place the side switch wipers in second position. When the side switch wiper 156 engages its second-position contact point the rotary magnet 162 is placed under the control of the vertical line relay, so that when the dial is operated for the last digit 0, and the vertical relay 149 presses the springs 151 and 152 into contact ten times, then an energizing circuit is closed through the rotary magnet 162 ten times, instead of through the vertical magnet 153. The rotary magnet operates, in response to the operation of the dial for the last digit, to carry the shaft wipers 157, 158 and 159 into engagement with the tenth contact of the second level of the connector bank. Following the vertical impulses for the digit 0, the usual rotary impulse energizes the rotary line relay 150, and again the private magnet 161 is energized to permit the side switch wipers 156, 163, 164 and 165 to pass to third position. The engagement of the third-position contact point by the side switch wiper 156 places the vertical line relay 149 in control of the ringer relay 166 in the same manner in which the rotary magnet 162 came under the control of the vertical line relay when the wiper 156 passed from first to second position. When the side switch wiper 165 passes to third position a positive guarding potential is established at the private bank contact of the called line. Also, this guarding potential provides an energizing circuit for the bridge-cut-off relay 167 of the line switch C' of the called line. This energizing circuit extends from ground G^{13} through the side switch wiper 165 to the shaft wiper 159, thence over the normal conductor 168, through the winding of the bridge-cut-off relay 167 to the battery lead 128, thence through battery B to ground G. This relay, upon energizing, operates to separate the springs 169, 170 and 171 and to carry the springs 169 and 172 into contact. The side switch wipers 163 and 164, upon passing to third position, extend the calling subscribers' line conductors 29 and 30 to the normal conductors 173 and 174 of the called line. The calling subscriber at substation A, therefore, presses the signaling button 33, whereby an energizing circuit is established through the vertical line relay 149 of the connector. The connector line relay operates to close a circuit through the ringer relay 166, said circuit extending from ground G^{12} through the springs 151 and 152, private magnet springs 154 and 155, side switch wiper 156, through the winding of the ringer relay 166 to the battery lead 128, thence through battery B to ground G. The ringer relay, upon energizing, operates to separate the calling and called lines and to bridge across the latter the terminals of the ringer generator J, thereby transmitting signaling current to the ringer 44 of the called substation No. 22220. The path of the ringing current extends from the generator J through the ringer springs 175 and 176, side switch wiper 163, shaft wiper 157 to the normal conductor 173, bridge-cut-off springs 172 and 169 to the line conductor 177, to the switch hook 42 and spring 43, through the ringer 44, condenser 45 to the rotary line conductor 178, normal conductor 174, shaft wiper 158, side switch wiper 164, ringer relay springs 179 and 180 back to the generator J. In response to the signal

the subscriber at substation No. 22220 removes the receiver from the switch hook. The substation A' receives talking battery current from the local battery 39. The two
5 are now connected and communication may be carried on over the circuit shown by the heavy line conductors in Figs. 1, 2 and 3.

The release of the central office switching apparatus is brought about when the call-
10 ing subscriber restores his receiver to the switch hook, thereby momentarily pressing the release springs 7, 8 and 9 into contact, which grounds both line conductors 29 and 30 simultaneously. Grounding the rotary
15 line conductor 30 places a short-circuit upon the rotary line relay 47 and the relay winding 49, said circuit extending from ground G' through the springs 7, 8 and 9 to the rotary line conductor 30, trunk con-
20 ductors 90 and 111, through the line relay 47 and the winding 49, and springs 113 and 237 to ground G^s. The relay 50 then operatively energizes and separates the springs, 235 and 236 and closes the springs 240 and
25 241, since the winding 48 alone carries current. The separation of springs 235 and 236 removes the energizing circuit through the relay 51 and thereby removes the short-circuit upon the line relay and winding 49.
30 The relay 51, deenergizing, allows the spring 113 to return into contact with the spring 121, thus restoring main battery (the non-grounded pole) to one side of the winding 49, and completing an energizing circuit
35 through this winding and the relay 47 to ground G'. The springs 114 and 115 likewise make contact and restore ground to the spring 124. Since the line relays 46 and 47 are now energized, ground is thrown on
40 both sides of the line conductors 122 and 123 from ground G^s through the spring 125 on the vertical side, and the spring 137 on the rotary side. Grounding the rotary line conductor 123 places a short-circuit upon the
45 rotary line relay 214 and the relay winding 216, said circuit extending from ground G^s through the springs 114 and 115, 124 and 137, 119 and 120, rotary line conductor 123, trunk conductor 212, through the line relay
50 214 and winding 216, springs 219 and 218 to ground G¹⁹. The relay 217 then operatively energizes and places the springs 223, 224 and 225 into contact, since the winding 215 alone carries current. The engagement
55 of the above springs closes an energizing circuit through the slow-acting relay 226, as previously stated. This relay now operates to shift the spring 219 from the spring 218 and into contact with the spring
60 231, whereby the rotary line relay 214 in series with the winding 216 is disconnected from the ground connection G¹⁹ and placed in contact with the battery lead 220, thereby removing the short-circuit and establishing
65 an energizing circuit instead. The vertical

and rotary line relays 213 and 214 energize simultaneously and press the springs they control into contact. This grounds the trunk line conductors 221 and 222 simultaneously and energizes the vertical and rotary line
70 relays 149 and 150 of the connector. The line relays of the connector, upon energizing simultaneously, place the trunk-release springs 181 and 182 in contact, which closes
75 an energizing circuit through the connector release magnet 183 in series with the release relay 146 of the selector H. This circuit extends from ground G¹¹ through the side switch wiper 145, winding of the back-re-
80 lease relay 146 to the shaft wiper 136, then to the trunk-release springs 181 and 182, through the release magnet 183 to the battery lead 128, thence through battery B to ground G. The release magnet 183, upon
85 energizing, operates to restore the switch shaft and side switch to normal position. The release relay 146, upon energizing, operates to close the springs 184 and 185 in contact, which establishes an energizing cir-
90 cuit from ground G¹⁴ through the release magnet 186 of the selector. The engagement of the trunk-release springs 242 and 243 of the repeater, upon the simultaneous energizing of the line relays, closes an en-
95 ergizing circuit through the release relay 210 of the first selector. This circuit extends from ground G¹⁷ through the side switch wiper 209 and back-release relay 210 to the shaft wiper 201, through the trunk-re-
100 lease springs 242 and 243, resistance winding 244, springs 219 and 231 to the battery lead 220, thence through battery B to ground G. The back-release relay thereupon en-
105 ergizes and places the springs 245 and 246 into engagement, and closes an energizing circuit for the release magnet 247. The engagement of the trunk-release springs 187 and 188 of the repeater F, upon the simul-
110 taneous energizing of the line relays, closes an energizing circuit through the release relay 109 of the first selector. This circuit extends from ground G⁷ through the side switch wiper 106 and back-release relay to the shaft wiper 100, through the trunk-re-
115 lease springs 187 and 188, resistance winding 52, springs 240 and 241 to the battery lead 63, thence through battery B to ground G. The back-release relay thereupon en-
120 ergizes and places the springs 189 and 190 in engagement, and closes an energizing circuit for the release magnet 191; and the release magnet in turn, upon energizing, operates to close the springs 192 and 193 in contact, thereby closing the circuit through the re-
125 lease magnet 73 of the line switch C. All of the release relays and the magnet thus energized attract their respective armatures and remain in readiness to release their re-
130 spective switches when the ground connection to the line conductors 29 and 30 is re-

moved by the disengagement of the release springs 7, 8 and 9.

From the foregoing it will be seen that the repeater not only repeats impulses originating in a telephone of the common battery section, to operate the switches of the local battery section, but also that, after the connection is established, the repeater enables the calling substation to receive talking battery current from the main central battery. The repeaters M and F form a simple and efficient means for enabling a subscriber of a common battery automatic exchange to call and communicate with a subscriber of a local battery automatic exchange.

From the foregoing it will be seen that I provide an arrangement whereby a subscriber of one exchange may automatically trunk from one exchange to the other for either one of two purposes. First, for the purpose of obtaining connection with the line of a common battery subscriber at the second exchange, and, second, for the purpose of obtaining connection with a repeater at the second exchange, whereby the call may be extended to the line of a local battery subscriber at the third exchange. The repeaters at the second exchange are adapted for extending connection to local battery subscribers, and are also, as explained, adapted for supplying sufficient current in the other direction to operate the pole-changing relays of the repeaters at the first exchange. For this purpose more current is required than would be necessary in a case where the current obtained through the repeater M is necessary simply for enabling the calling subscriber to use his transmitter. In other words, the current sent back over the line circuit from the repeater M must be stronger when it is to be employed for operating the relay 51 than would be the case were the said current to be used simply for operating the transmitter 17 at the calling substation. Hence, the relay 51 receives all of such current, and during conversation there is nothing in multiple with this relay—that is to say, there is nothing in bridge of the circuit between it and the battery B of Fig. 2. It is desirable that the repeater F be suitable for extending connection to a common battery subscriber, and such being the case it must be capable of responding when the called common battery subscriber answers, so as to supply talking current to the calling line in the usual and well-known manner. Suppose, for example, that subscriber A desires to call a common battery subscriber of the second exchange, as indicated in Fig. 2. In such case the repeater F will be used in extending connection through the selector H' to the common battery connector shown in Fig. 2, which connector will then seize the line of the called common battery subscriber. It will be understood that certain levels of

the selectors H' may have access to repeaters M, and certain other levels may have access to common battery connectors. The common battery connector in Fig. 2 is shown only diagrammatically to illustrate the talking circuit through it and the circuits over which talking battery current is furnished to the calling and called lines. The operations of the common battery connector by means of which it finds the called line are substantially the same as those of the connector I. When the called subscriber answers, a battery is bridged across the talking circuit by the relay 260 in the connector by shifting the connection of the rotary line relay 261 from the non-grounded to the grounded terminal of the battery, and current from this battery then energizes the relay 51, which relay in turn bridges another battery across the circuit to supply talking current to the calling subscriber. Thus the repeater F is capable of responding to either a common battery connector or another repeater for the purpose of establishing a flow of talking current in the calling line. It is because this repeater F is desirably of a character to extend connection to a called common battery subscriber that the necessity arises for a repeater M of a character to extend connection to a local battery subscriber's line, and furnish current back over the circuit to the first exchange. The relay 51 of the repeater F must be energized in order to supply current to the calling subscriber. When connection is made to a common battery subscriber the common battery connector completes the circuit for the relay 51. A local battery connector, however, does not supply current to the trunk leading to it, but current for energizing the relay 51 is supplied from the repeater M. In a repeater required to do the work of the repeater F both sides of the circuit are preferably normally connected with the same side of the battery; but in a repeater required to do the work of the repeater M the battery is normally in bridge of the circuit. The repeaters M are, therefore, adapted for use in extending connection to a local battery subscriber, in a system employing repeaters F that are adapted for use in extending connection to common battery subscribers. The repeaters M are, therefore, in the nature of means for enabling the common battery subscribers to use the repeaters F for extending connection to local battery subscribers.

It will be seen that my invention relates more especially to that type of automatic system in which the subscribers are divided into groups, and in which connectors are provided having vertical motion to select groups, and then rotary motion to find the called subscriber in any selected group. As shown, each group is composed of ten sub-

scribers, there being ten of these groups for each connector—that is to say, there are ten levels in each connector and in each level there are the terminals of ten subscribers' lines. It will be understood, of course, that the subscribers' lines are provided with multiple terminals, so that each subscriber is represented in several connectors. The selectors also have vertical motion to select groups or divisions of the exchange, and then rotary motion to find an idle trunk line in any selected group.

What I claim as my invention is:—

1. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays, and means whereby said repeater is operative for extending connection to either a common battery or a local battery subscriber's line.

2. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays at the common battery exchange operative for extending connection to a common battery subscriber's line, and means at another exchange whereby the said repeater is also operative for extending connection to a local battery subscriber's line.

3. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, means including a repeater for extending connection from one common battery line to another, adapted to establish talking current in the calling line when the called subscriber answers, and means whereby said repeater is also operative for extending connection to a local battery subscriber's line, adapted to cause the repeater to establish a flow of talking current in the calling line before the called subscriber answers.

4. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, a repeater for use in extending connection from one common battery line to another, and another repeater for enabling a calling common battery subscriber to use said first-mentioned repeater in extending a call to a local battery subscriber's line.

5. In a telephone system, a first exchange, a second exchange, a third exchange, repeaters at the first exchange for enabling the subscribers thereof to call subscribers of the second exchange, and means at the second exchange for enabling the subscribers of the first exchange to use said repeaters in calling subscribers of the third exchange.

6. In a telephone system, a first common battery exchange, a second common battery exchange, a local battery exchange, repeaters at the first exchange for enabling the subscribers thereof to call subscribers of the second exchange, and repeaters at the second exchange for enabling the subscribers of the first exchange to use said first-mentioned re-

peaters in calling subscribers of the local battery exchange.

7. A telephone exchange system, a line circuit, a repeater connected thereto and having one side of the line circuit normally grounded, a battery normally in bridge of the line circuit, and a relay for shifting one side of the line circuit to the other pole of the battery, preliminary to the use of the repeater for transmitting impulses.

8. A telephone exchange system repeater having a battery bridge normally across the talking circuit thereof, a relay for shifting one side of the circuit to the other pole of the battery, and a double-wound relay controlling said first-mentioned relay.

9. A telephone exchange system repeater having an impulse spring, a trunk conductor normally disconnected therefrom, and a relay for closing and holding closed the connection between said trunk conductor and said spring while the series of impulses are being transmitted by the repeater, said relay deenergized during talking.

10. A telephone exchange system, trunk conductors, a repeater having the trunk conductors transposed therein, a condenser in each of said conductors, and a relay for disconnecting one of said condensers from a part of one of said conductors during transmission of impulses over that part of said conductor.

11. A telephone exchange system, trunk conductors, a repeater having said conductors transposed therein, a condenser in each of said conductors, and a relay for disconnecting one of said condensers from a part of its conductor during transmission of impulses over that part of said conductor, said relay deenergized during talking.

12. A telephone exchange system repeater having an impulse spring, a trunk conductor normally disconnected therefrom, another trunk conductor, a line relay and a differential relay, a relay adapted to connect the impulse spring to its trunk conductor and open the other conductor, and adapted also to place said line relay and differential relay in condition to be energized responsive to the calling subscriber.

13. In a telephone system, a trunk circuit including two trunk conductors, a condenser, an impulse spring, and a relay operative by deenergizing to connect one trunk conductor with the condenser and disconnect the other conductor from said spring, and to connect one side of the trunk circuit to ground.

14. In a telephone system, a repeater for use in extending connection from a calling common battery subscriber to a called local battery subscriber, a battery therefor, another repeater, and circuit connections whereby current is supplied from the battery through the first repeater to the other

repeater during talking, said first repeater being free from local circuits during talking.

15. In an automatic telephone exchange system in which the subscribers are divided into groups, common battery subscribers' lines, local battery subscribers' lines, a repeater, and electrically controlled means whereby said repeater is operative for extending connection to either a common battery or a local battery subscriber's line, said means having vertical motion to select groups and rotary motion to find the called subscriber in any selected group.

16. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays, and electrically controlled means whereby said repeater is operative for extending connection to either a common battery or a local battery subscriber's line, said means having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

17. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays at the common battery exchange operative for extending connection to a common battery subscriber's line, and switches at another exchange controlled by said repeater whereby the said repeater is also operative for extending connection to a local battery subscriber's line, said switches having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

18. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, common battery subscribers' lines, local battery subscribers' lines, means including a repeater for extending connection from one common battery line to another, adapted to establish talking current in the calling line when the called subscriber answers, and electrically controlled means whereby said repeater is also operative for controlling a connection to a local battery subscriber's line, adapted to cause the repeater to establish a flow of talking current in the calling line before the called subscriber answers, said means having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

19. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, common battery subscribers' lines, local battery subscribers' lines, a repeater for use in extending connection from one common battery line to another, and another repeater for enabling

a calling common battery subscriber to use said first-mentioned repeater in extending a call to a local battery subscriber's line, said system provided with automatic means controlled by the repeaters having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

20. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a first exchange, a second exchange, a third exchange, repeaters at the first exchange for enabling the subscribers thereof to call subscribers of the second exchange, and electrically controlled means at the second exchange for enabling the subscribers of the first exchange to use said repeaters in calling subscribers of the third exchange, said system provided with automatic means controlled by the repeaters having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

21. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a first common battery exchange, a second common battery exchange, a local battery exchange, repeaters at the first exchange for enabling the subscribers thereof to call subscribers of the second exchange, and repeaters at the second exchange for enabling the subscribers of the first exchange to use said first-mentioned repeaters in calling subscribers of the local battery exchange, said system provided with means controlled by the repeaters having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

22. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a line circuit therefor, a repeater connected thereto and having one side of the line circuit normally grounded, a battery normally in bridge of the line circuit, and a relay for shifting one side of the line circuit to the other pole of the battery, preliminary to the use of the repeater for transmitting impulses, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

23. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a repeater therefor having a battery bridge normally across the talking circuit thereof, a relay for shifting one side of the circuit to the other pole of the battery, and a double-wound relay controlling said first-mentioned relay, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

24. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a repeater therefor having an impulse spring, a trunk conductor normally disconnected therefrom, and a relay for closing and holding closed the connection between said trunk conductor and said spring while the series of impulses are being transmitted by the repeater, said relay deenergized during talking, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

25. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, trunk conductors, a repeater having the trunk conductors transposed therein, a condenser in each of said conductors, and a relay for disconnecting one of said condensers from a part of one of said conductors during transmission of impulses over that part of said conductor, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

26. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, trunk conductors, a repeater having said conductors transposed therein, a condenser in each of said conductors, and a relay for disconnecting one of said condensers from a part of its conductor during transmission of impulses over that part of said conductor, said relay deenergized during talking, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

27. In an automatic telephone exchange trunking system in which the trunks thereof are divided into groups, a repeater therefor having an impulse spring, a trunk conductor normally disconnected therefrom, another trunk conductor, a line relay and a differential relay, a relay adapted to connect the impulse spring to its trunk conductor and open the other conductor, and adapted also to place said line relay and differential relay in condition to be energized responsive to the calling subscriber, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

28. In an automatic telephone exchange

trunking system in which the trunks thereof are divided into groups, a repeater therefor for use in extending connection from a calling common battery subscriber to a called local battery subscriber, a battery therefor, another repeater, and circuit connections whereby current is supplied from the battery through the first repeater to the other repeater during talking, said first repeater being free from local circuits during talking, said system provided with automatic means controlled by the repeater having vertical motion to select groups and rotary motion to find an idle trunk in any selected group.

29. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays, and electrically controlled means whereby said repeater is operative for extending connection to either a common battery or a local battery subscriber's line.

30. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, a repeater including relays at the common battery exchange operative for extending connection to a common battery subscriber's line, and electrically controlled means at another exchange whereby the said repeater is also operative for extending connection to a local battery subscriber's line.

31. In a telephone system, common battery subscribers' lines, local battery subscribers' lines, means including a repeater for extending connection from one common battery line to another, adapted to establish talking current in the calling line when the called subscriber answers, and electrically controlled means whereby said repeater is also operative for extending connection to a local battery subscriber's line, adapted to cause the repeater to establish a flow of talking current in the calling line before the called subscriber answers.

32. In a telephone system, a first exchange, a second exchange, a third exchange, repeaters at the first exchange for enabling the subscribers thereof to call subscribers of the second exchange, and electrically controlled means at the second exchange for enabling the subscribers of the first exchange to use said repeaters in calling subscribers of the third exchange.

Signed by me at Chicago, Cook county, Illinois, this third day of June, 1909.

FRITZ LUBBERGER.

Witnesses:

EDWARD D. FALES,
ARTHUR J. RAY.