T. G. MARTIN.

TELEPHONE EXCHANGE SYSTEM.

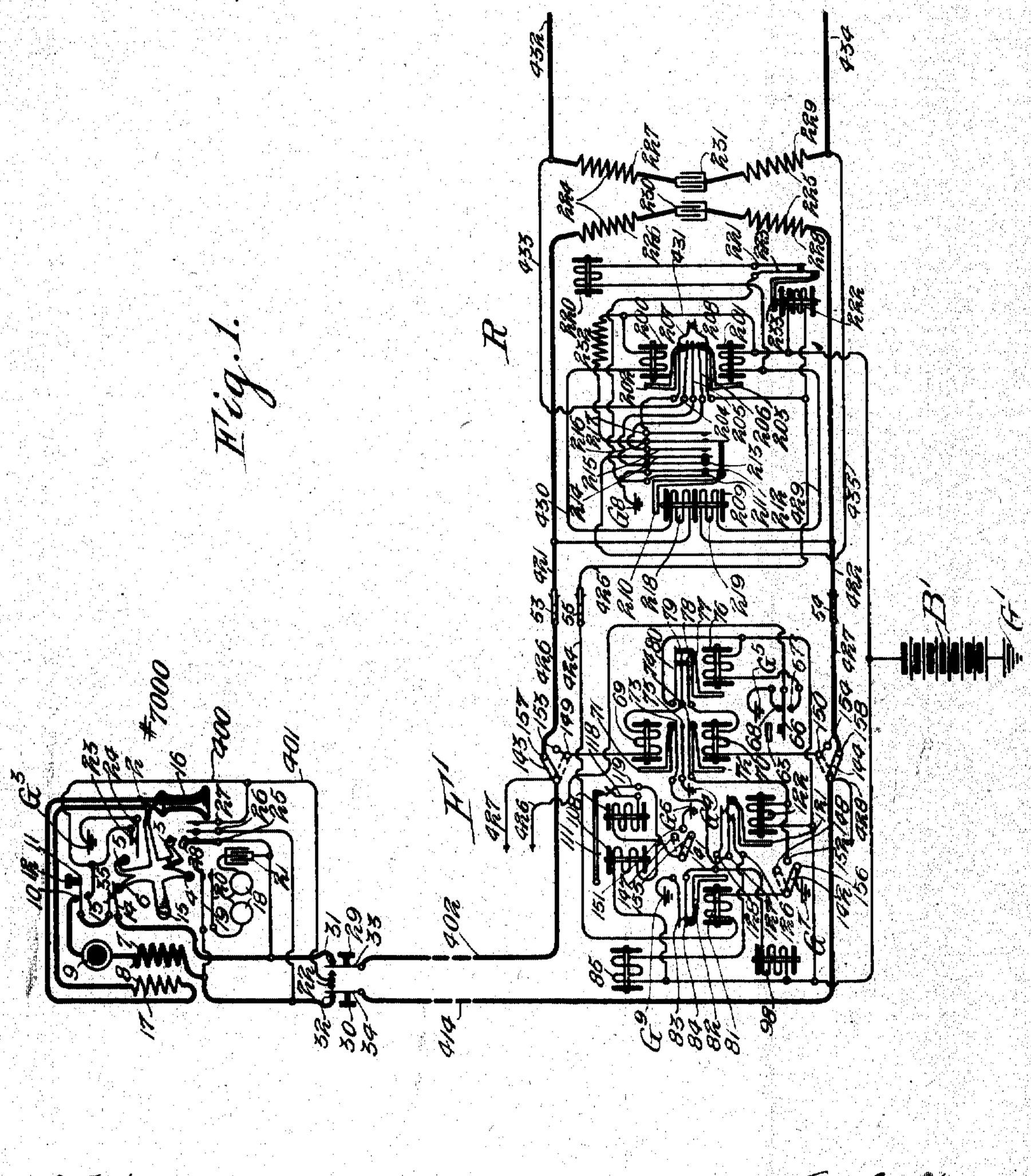
APPLICATION FILED JAN. 12, 1906. RENEWED FEB. 25, 1918.

1,282,257.

Patented Oct. 22, 1918.

4 SHEETS—SHEET 1.

Fig. 1.



Witnesses.
R. L. Burpind
A. Andersen.

Inventor:
Talbot G. Martin
By Buckley & Dunand
Attorneys.

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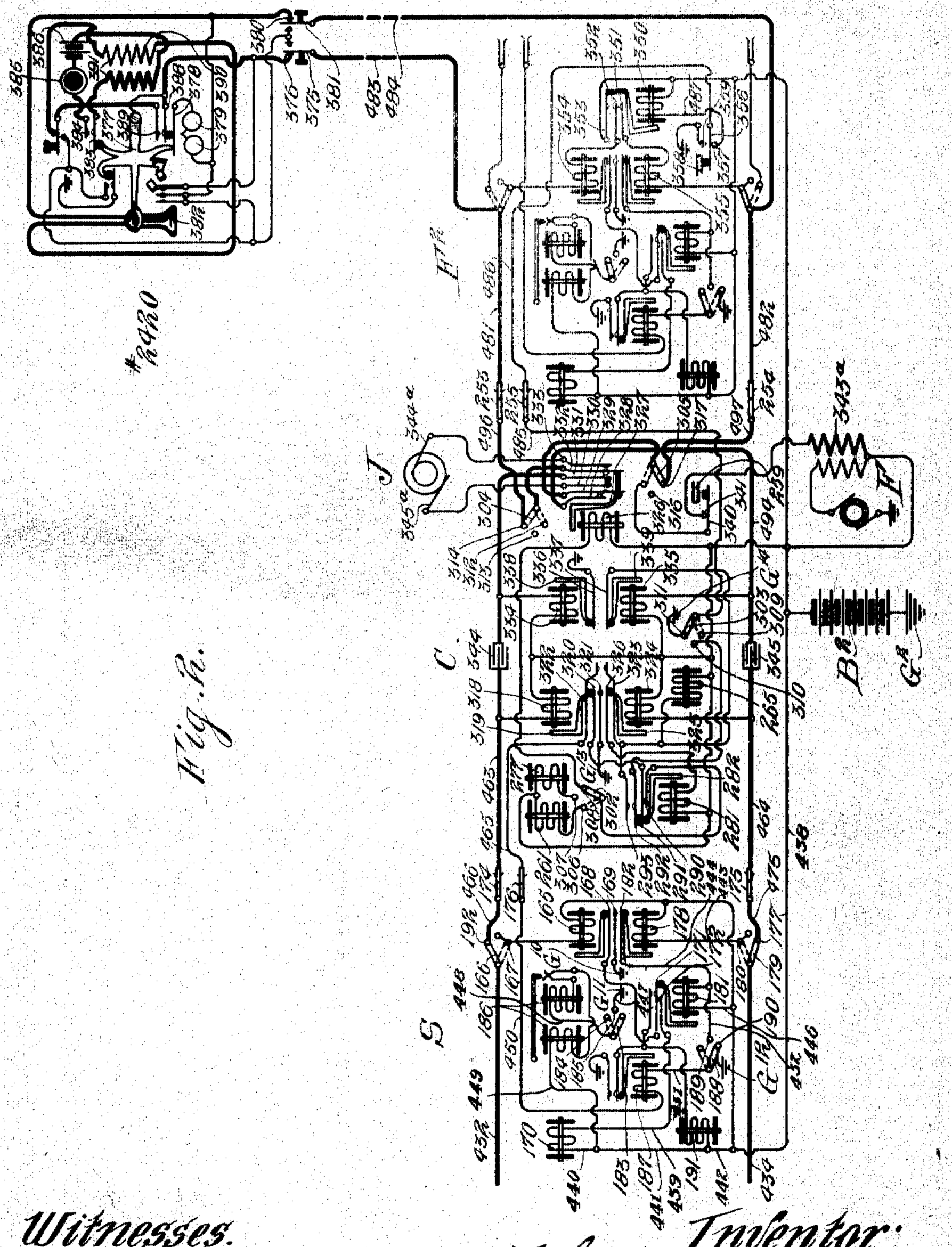

Fig. 2.

Witnesses.

R. H. Burfoind

A. Andersen.

Inventor.

Talbot G. Martin

By Bulkley & Durand

Attorneys

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4 SHEETS—SHEET 3.

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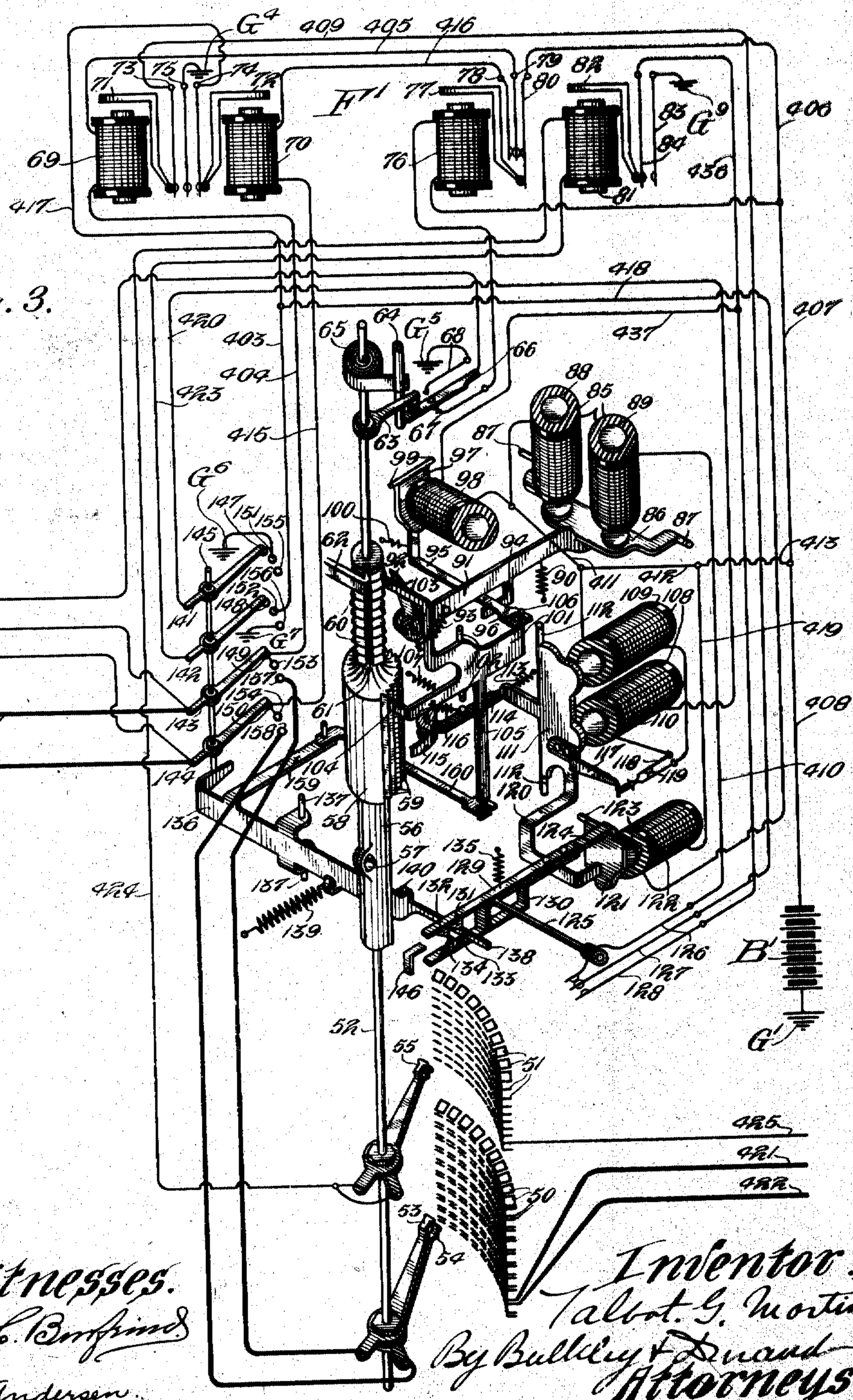
Fig. 3.



Witnesses.

R. H. Brafford

A. Andersen.

Inventor:

Talbot G. Martin

By Bulkley & Dinard

Attorneys.

T. G. MARTIN.

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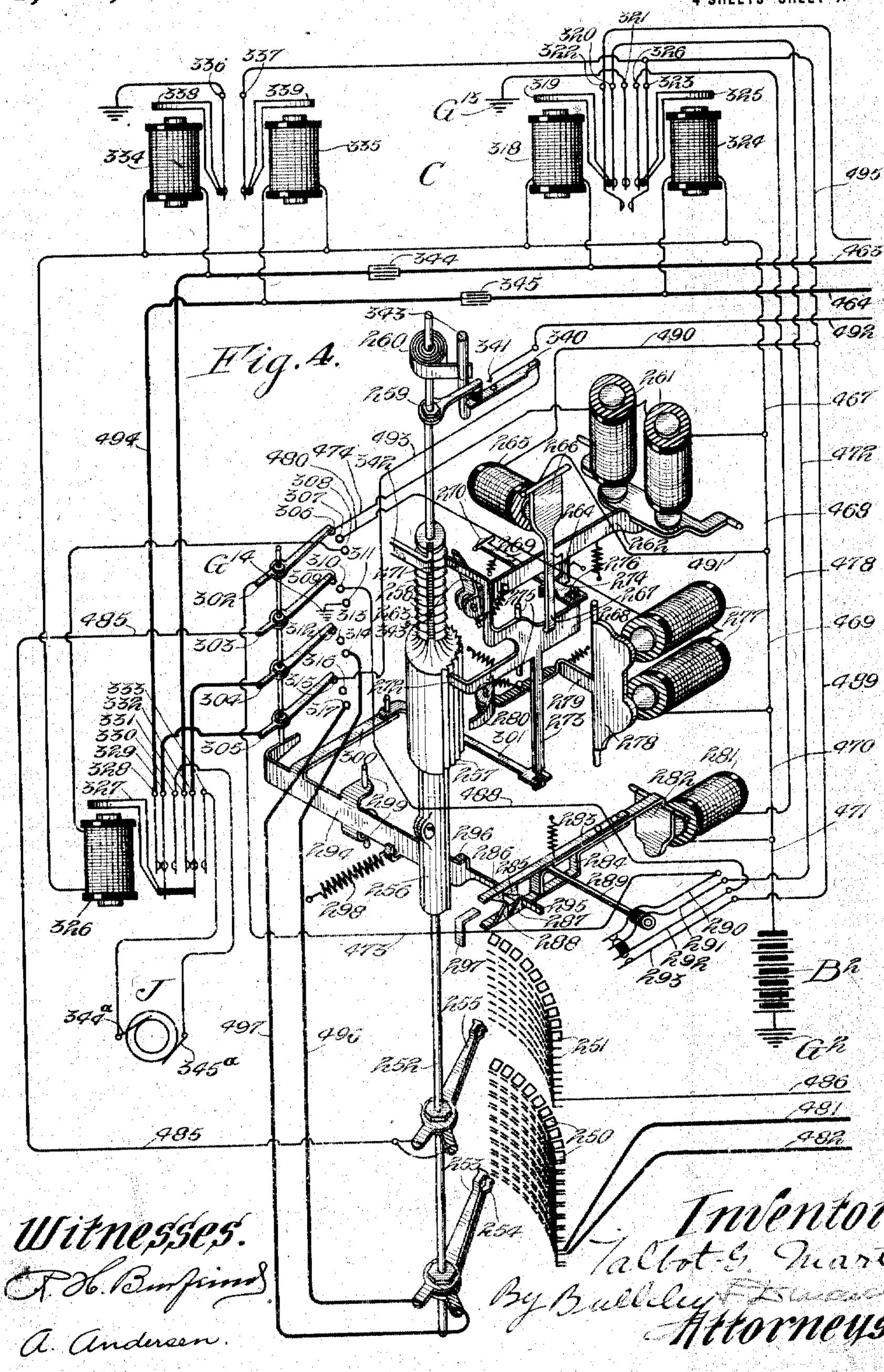
4 SHEETS—SHEET 4.

Fig. 4.



Witnesses.

A. H. Burpins

A. Andersen.

Inventor:

Talbot G. Martin

By Bulkley & Bulkley

Attorneys.

UNITED STATES PATENT OFFICE.

TALBOT G. MARTIN, OF CHICAGO, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC COMPANY, A CORPORATION OF ILLINOIS.

TELEPHONE EXCHANGE SYSTEM.

1,282,257. Specification of Letters Patent. Patented Oct. 22, 1918.

Application filed January 12, 1906, Serial No. 295,753. Renewed February 25, 1918. Serial No. 219,158.

To all whom it may concern:

Be it known that I, TALBOT G. MARTIN, a citizen of the United States of America, and resident of Chicago, Cook county, Illinois, have invented a certain new and useful Improvement in Telephone-Exchange Systems, of which the following is a specification.

My invention relates to telephone systems in general, but more particularly to automatic or semi-automatic telephone systems, and especially to automatic telephone exchange apparatus of that particular character in which subscriber-controlled trunk-selecting and line-connecting switching machinery is employed, the expedient for enabling the subscribers to control the said machinery consisting of subscribers' impulse transmitters or calling devices so constructed that any calling subscriber can transmit the electrical impulses necessary for calling the number of any other subscriber's line.

Generally stated, the object of my invention is the provision of an improved and highly efficient telephone system.

Special objects of my invention are the provision of an improved repeater for use in establishing a talking circuit between a subscriber of one exchange and the subscriber of another exchange; the provision of means for establishing a trunk-line connection between a subscriber of a common battery automatic telephone exchange and a subscriber of a local battery automatic telephone exchange; the provision of an improved construction and arrangement whereby the calling subscriber of the common battery automatic exchange will receive current for talking purposes as soon as connection is established between his line and the repeater through the medium of which connection is then to be established with the line of the subscriber of the second or local battery automatic exchange; and the provision of certain details and features of improvement tending to increase the general efficiency and serviceability of telephone apparatus of this particular character.

In certain respects my present invention is in the nature of an improvement on the telephone exchange system disclosed in my copending applications Serial Nos. 262,728 and 294,663.

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

Figures 1 and 2 illustrate diagrammatically the means employed by a subscriber of an automatic common battery exchange in calling a subscriber of an automatic local battery exchange. The two exchanges are connected by trunk-lines one of which is shown terminating at one end in the repeater R at the calling central station and at the other end in the second-selector S at the called central station.

Fig. 1 shows the common battery sub-station #7000 and first-selector F^1 allotted to said sub-station and the repeater R.

Fig. 2 shows the second-selector S and a connector C connected with the line leading to the sub-station #2420, bridged across which line a first-selector F^2 will be recognized, which belongs exclusively to the line #2420.

Fig. 3 is a diagram of a first-selector.

Fig. 4 is a diagram of a connector.

The sub-stations employed in connection with the common battery exchange in question are all of a well-known and suitable type. Sub-station #7000, for instance, is at once recognized by the peculiar switch-hook 2 which is made with a number of cam-like arms 3, 4, 5 and 6. The primary circuit at said station when in use is bridged across the main line and comprises in series the primary winding 7 of the induction-coil 8, a transmitter 9, a couple of springs 10 and 11 identified with the signaling-button 12, and two springs 13 and 14 by means of which the said circuit is maintained closed or opened depending upon whether the hook is up or down. Said hook is held pivoted by one end to the screw 15, and is forced to rise whenever the weight of the receiver 16 is removed from it, by a suitable switch-hook-spring not shown. The secondary circuit, auxiliary to the primary, comprises the said receiver in series with the secondary winding 17 of the induction-coil 8, in a permanently closed local circuit. The ringer circuit at said sub-station includes the ringer 18, the ringer-circuit-springs 19 and 20 and the condenser 21. Said circuit while the switch hook is down is closed by the cam-arm 4 that presses the said ringing-circuit-springs into contact, and is normally bridged across the main line. While the hook is up, however, the said bridge is open

because the said springs 19 and 20 spring apart after the cam-arm 4 is removed from the spring 19. The cam-arm 5 controls the continuity of a ground circuit between the so-called ground-post 22 and the ground terminal G^3, by means of two springs 23 and 24 that are included in said circuit. The sub-station has three other springs 25, 26 and 27 which are known as the release-springs and by means of which the main line-conductors may be grounded simultaneously for the purpose of restoring the exchange apparatus in a manner that will be fully explained. When the hook is depressed, as it descends, the said release-springs are forced together by the cam-arm 3, which latter then engages the laterally projecting extremity 28 of the spring 25. The engaging portions of the cam 3 and spring 25 are constructed with their surfaces at an angle with each other, so that as the hook goes down one surface of the projection 28 is engaged by the cam-arm, and when it rises the opposite surface is met. In this way, when the hook goes down the spring 25 is forced into electric connection with the springs 26 and 27, and when the hook rises it is shoved in the opposite direction. It should be clear that at the limit of each stroke of the hook the cam-arm 3 clears or disengages the spring 25. The electrical impulse transmitter or calling device employed by the subscriber may be of any suitable design. The type illustrated, however, comprises two push-buttons 29 and 30, two contact-points 31 and 32, two springs 33 and 34 and the ground-post 22. The spring 33 and contact 31 are normally in contact, as well as the spring 34 and contact 32. But when the button 29 is pressed, the spring 33 is separated from the contact-point 31 and connected with the ground-post 22, and when the button 30 is pressed the second spring 34 is pressed onto the same ground-post after said spring leaves the contact-point 32. The signaling-button 12 has a grounded contact-point 35 associated with it, onto which the spring 11 is forced whenever the said button is pressed.

In Fig. 3 the first-selector F^1 is shown with the bank 50 of trunk-line-terminals beneath it, while the private-bank 51 is located just above the latter. The switch-shaft 52 is vertically disposed on the front of the switch-frame and is retained connected therewith by bearings which are not shown. The shaft may be moved vertically or endwise in said bearings and then rotatively by electro-magnetically-operated ratchet and pawl mechanisms, the vertical or endwise step-by-step movements occurring first. Among the functions of the shaft is that of a holder for the line-wipers 53 and 54, and for the private-wiper 55. The former two comprise a set distinct from the latter, but both sets are located within range of the contacts of their respective banks 50 and 51. Said wipers are not only insulated from the shaft, but from each other as well. Among the details that are associated with the shaft is a cam-piece 56 which is of a split sleeve design and secured to the shaft by a screw 57. The general shape of said cam, in cross-section, is that of an elongated oval with the sharper end on the side farthest away from the said screw. Said cam abuts on a hub 58 that is shrunk to the shaft near the middle of the latter. This hub carries a set of longitudinal teeth 59 that serve, as will be disclosed, to enable the forward rotation of the shaft, and as a locking means against backward rotation of the same. On the neck portion of said hub there is found a set of circular teeth 60 that serve in turn as a means by which the raising of the shaft is accomplished, and for locking it when raised. These circular teeth are traversed by a groove or channel 61 into which the end of a so-called shaft-rest 62 normally projects; but when the shaft is rotated, any one of the said circular teeth which may be at the proper height slides onto the end of the said rest. The end of the rest is, of course, adapted to fit the circular grooves between said circular ratchet-teeth. The upper surface of the engaging end is level, but the under side is chamfered to correspond with the upper slope of the circular teeth. Above the hub 58 the shaft carries an arm 63 known as the normal-post-arm and which is, while the switch-shaft is at rest, and while the shaft-rest occupies the slot 61, retained against the normal-post 64 by the coiled spring 65. The said normal-post-arm normally retains a shaft-controlled spring 66 in contact with a contact-point 67 located beneath it, but when the shaft is raised said spring then flexes into contact with a grounded contact-point 68. Among the magnets allotted to the first-selector some are used as relays and others as operating magnets. The magnets 69 and 70 are among the former kind and are known as the vertical and rotary line-relays. By means of their respective armatures 71 and 72 the springs 73 and 74 are controlled with respect to the ground-spring 75. Said springs are comprised in energizing circuits of operating magnets that raise and rotate the shaft. The magnet 76, armature 77 and springs 78, 79 and 80 constitute the bridge-opening relay, or bridge-cut-off-relay as it is called, and the magnet 81 with its armature 82 and springs 83 and 84 constitute the back-release-relay which is used for restoring the switch after it has seized a trunk-line. Of the operating magnets, the magnet 85 is known as the vertical-magnet and has a so-called vertical-armature 86 that is supported by pivots 87. Whenever the coils 88 and 89 of said ver-

tical-magnet become energized the armature 86 is attracted, and when the magnetization ceases the retracting-spring 90 restores said armature to its normal position. The upward movement of the armature is limited by the pole-pieces of the magnet-coils 88 and 89, and the lower limit is marked by a section of the switch-frame that passes under the arm 91. Said arm is known as the vertical-arm and extends forwardly from the vertical-armature 86, of which latter it is a part. The vertical-arm carries on its end a so-called vertical-pawl 92 which, when the vertical-armature is attracted, engages with some one of the circular teeth 60 to raise the shaft. Normally the under surface of the upper section of said pawl rests against a piece that is secured to the switch-frame, and that retains the pawl away from the circular teeth. When the vertical-armature is attracted, as the said pawl rises, a retracting-spring 93 thrusts the upward side of the pawl toward the circular teeth 60. As soon as said pawl clears or disengages its normal-rest, and by the time that the vertical-armature strikes the pole-pieces, the vertical-pawl strikes with the rear surface of its upper section a bumper piece or stop which constitutes a part of the switch-frame. Therefore, the shaft is thus prevented from being thrown up more than one notch at a time by its own momentum. It is clear, then, that the pawl 92 not only raises the shaft, but that it also acts as a lock at the end of each stroke. The vertical-arm has also an L-shaped piece 94 on its under edge that forks over a so-called release-link 95 of flexible spring material. Said link carries an aperture 96 on its front end, and is secured to the armature 97 of one of the operating magnets 98 known a. the release-magnet. Said armature is suspended from the frame by the supports 99, and is normally retained by the spring 100 away from the pole-piece of the release-magnet. A stop is suitably provided behind said armature to limit its movement when retracted. The first-selector is provided with a peculiarly shaped mechanism 101 known as the double-dog. It is pivoted so that it may swivel about a vertical axis that passes through the pivots 102. On its front side said double-dog develops into two dogs 103 and 104 which are so situated and constructed that the former may coöperate with the circular teeth 60, while the switch-shaft is raised and in normal rotary position, and the latter with the longitudinal teeth 59 when the shaft is rotated. To the right of the pivots 102 the body of the double-dog extends rearwardly, and projecting down therefrom is an arm 105 that comes into use very prominently during the releasing of the switch. Near the extremity of and on the upper side of said body a pin or lug 106 projects upwardly. Said lug is normally caught in the aperture 96 of the release-link 95, and because of the action of the spring 100 through said link the dogs 103 and 104 are retained away from the shaft. Always, at the first stroke of the vertical-armature, the link 95 is drawn away from the lug 106 by the piece 94, and then the double-dog is rotated by the retracting-spring 107, so that the dog 103 falls under the first circular tooth, and so that when the vertical-armature returns to its normal position the said shaft is retained by said dog in its new position. The release-link 95, while the double-dog is free, rests with its free end upon the lug 106, and out of locking engagement therewith. When the vertical-magnet is energized a second time the shaft is raised a second step and the dog 103 at the second stroke passes from under the first tooth to below the second tooth, holding the shaft again as above. The release-magnet 98 is composed of two coils like the vertical-magnet 85, but as a matter of convenience of illustration only one coil is shown. If, while the shaft is raised, the said release-magnet should be energized, the release-armature 97 is, of course, attracted and the release-link 95 is thrust forward to catch the lug 106 in the aperture 96. Upon the deënergization of the release-magnet the retracting-spring 100 then withdraws the dogs 103 and 104 from the shaft, which latter being deprived of its only support then falls to normal position by its own weight. After the shaft is once raised it may be rotated by a second operating magnet 108, known as the rotary-magnet. Said magnet has two coils 109 and 110, and unlike the vertical-magnet has its armature 111 pivoted in a vertical plane. Said armature may be moved about a vertical axis that passes through the pivots 112. The limit of the movement of said armature toward the rotary-magnet is determined by the pole-pieces of said magnet, which movement is produced by the rotary-magnet itself. The motion of the armature in the opposite direction is produced by the retracting-spring 113, and is limited by a switch-stop behind the so-called rotary-arm 114. This arm, like the vertical-arm, carries a so-called rotary-pawl 115. Similarly to the vertical-pawl, said rotary-pawl normally rests against a stop that retains it away from the longitudinal teeth, and when the rotary-armature is attracted it is drawn into engagement with the longitudinal teeth by a spring 116 that is attached between the rotary-arm and the rear of said pawl. By the time that the rotary-armature strikes the pole-pieces of the rotary-magnet, the rotary-pawl also strikes a bumping post, as does the vertical-pawl, and locks the shaft against further advance by the force of its own momentum. At the end of the first rotary step the dog 104 falls behind the first longitudi-

nal tooth, so that when the rotary-pawl falls back the shaft is retained. It should be evident that as the shaft is rotated the vertical-dog 103 is extricated from the groove below the circular tooth with which it has been in resting engagement, by the passage of the rotary-dog 104 over the longitudinal tooth over which it has to slide at the time; but at the beginning of the rotation it will be evident that the tooth which has been caught by the vertical-dog slides onto the shaft-rest 62, and in this way the shaft is still held raised after the rotation begins. The rotary armature is provided with a so-called interrupter-finger 117 that separates the interrupter-springs 118 and 119 whenever the rotary-armature is attracted, also with a rotary-armature-finger 120 that exercises certain controlling influences over the armature 121 of the last of the operating magnets—the private-magnet 122. The said private-armature 121 works in a vibratory manner about a horizontal axis that passes through the supporting-points 123. This armature is formed with a forwardly-projecting arm 124, the latter having two flat surfaces in an approximately horizontal plane. Furthermore, the end of the said arm is bent at a right angle downwardly and carries certain mechanical details, namely a lateral arm 125 which is designed to control circuits comprising the private-springs 126, 127 and 128, and a tooth-escapement which includes two flexible springs 129 and 130 each of which springs is riveted by one end to the arm 124, one on the upper side and the other on the lower. The upper spring is straight and has formed on its end two tooth-projections 131 and 132 which extend downwardly, while the lower one is bent down and at a right angle again to the front. This double angle on the lower spring is so designed that the latter may clear or disengage the bent portion of the private-arm, against which portion said spring rests with a requisite degree of tension, and so that there may be space in front of said bent portion to receive two other tooth-shaped upward projecting pieces 133 and 134 that are formed on the forward end of said escapement-spring 129, and which are sustained in juxtaposition to the upper teeth, but slightly to the rear thereof. A retracting-spring 135, suitably located, holds said armature normally away from the private-magnet pole-piece. A well-known auxiliary switching mechanism common to such switches is the so-called side-switch. It is shown in connection with the first-selector F and comprises an arm 136 which is secured to the switch-frame in such a manner that it may be made to swing about a vertical axis through the pivots 137. The right extremity of said arm is drawn out into a finger 138 that works in conjunction with the escapement-teeth previously described. Said teeth, in a manner to be demonstrated, reduce the outward movement of the side-switch by means of said finger to a step-by-step motion, which movement is produced by a retracting-spring 139. At the base of the finger 138 a lug 140 that is bent to the front is adapted to strike the cam 56 at a suitable time. Whenever the shaft is rotated, however, said cam is carried beyond the reach of said lug, and the finger falls against the tooth 134. Near its left extremity the arm 136 carries a number of wipers 141, 142, 143 and 144 suitably mounted upon a pin 145 and insulated therefrom and from each other. Said wipers are known as the side-switch-wipers and are adapted to be operated by the private-magnet and escapement device previously explained. If the private-magnet is energized once the private-armature is drawn down once and restored to its normal position. The escapement-finger 138 then passes from behind the tooth 133 to the rear of the tooth 131 at the downward stroke of the private-armature 121, and from behind the latter tooth at the return stroke. As soon as the escapement-finger clears or disengages the latter tooth the retracting-spring 139 draws the side-switch to the second position where it is stopped by the lug 140 when it strikes the cam 56. Immediately, then, when the rotary-magnet energizes, the shaft is rotated and the cam passes out of reach of the lug 140. Then the finger 138 of necessity falls against the tooth 134, because of the tension in the spring 139. The rotation of the shaft results when the rotary-armature 111 is attracted by the rotary-magnet, and at the same time the rotary-armature-finger 120 depresses the private-armature 121 and causes the finger 138 to disengage from the tooth 134 and advance against the tooth 132. Then, as the rotary-armature returns to normal position, when the rotary-magnet deenergizes the private-armature, on following the finger 120, permits the escapement-finger 138 to escape from the last tooth 132, thus permitting the side-switch to pass to the third position with the said finger 138 resting against the side-switch-stop 146. In their normal positions the side-switch-wipers 141, 142, 143 and 144 engage with the contact-points 147, 148, 149 and 150, respectively. This position is known as the first position of the side-switch, at which time, it will be clear, the finger 138 is held behind the escapement-tooth 133. In the second position, while the said finger is between the teeth 133 and 134, the said side-switch-wipers engage instead with the contact-points 151, 152, 153 and 154, respectively; and when the said finger 138 falls against the stop 146 the wipers shift their positions and move into contact with contact-points 155, 156, 157 and 158, respectively. Between the

pivots 137 and the wiper-supporting pin 145 a rearwardly-extending arm 159 on the side-switch-arm 136 supports on its end, pivotally, one end of a link 160, the other end of which latter, being bifurcated, engages with the lower end of a double-dog-arm 105 which is constructed somewhat in the shape of an inverted T. Should the release-magnet be energized while the side-switch is in third position, and, of course, while the shaft is rotated, the release-link 95, being attached to the release-armature 97, is then thrust forward when the release-armature is attracted, and catches the lug 106 in the aperture 96. Then, when said release-armature is restored, the spring 100, as before described, withdraws the dog 103 from the circular teeth 60. At the same time the arm 105 drives the link 160 back, which latter then rotates the side-switch-arm 136 about the pivots 137, against the tension of the side-switch retracting-spring 139, and thus drives the finger 138 outwardly between the springs 129 and 130 and into a position behind the tooth 133, locking the side-switch in the first or normal position. The switch-shaft being unlocked by the removal of the dog-support 104, and being thus left free, is then rotated by the coil-spring 65 until the instant that the end of the shaft-rest enters the slot 61, at which time the shaft then drops to its normal position. Therefore, after the switch has been operated, the energization and deënergization of the release-magnet is sufficient to restore the switch completely to its normal position. The line and private banks are each provided with ten rows of contact-terminals, each row consisting of two sets of contacts. Therefore, the shaft is so constructed that it may be raised to any one of ten levels, and at each level it may be rotated ten successive steps in order that the wipers which it carries may be placed in connection with any one of the terminals of the ten sets of contact-terminals in each level.

The repeater R is made up of a number of relays and auxiliary parts which may be assembled upon any suitable base. It comprises two line-relays 200 and 201 which, through their respective armatures 202 and 203, operate between them the line-relay-springs 204, 205, and 206 and two so-called trunk-release-springs 207 and 208. The differential-relay 209 has the power, through its armature 210, to operate the differential-relay-springs 211, 212, 213, 214, 215, 216 and 217. Said differential-relay has two windings 218 and 219, the former of which is connected with one end of the vertical-line-relay 200, the other end of the latter being permanently connected with the non-grounded terminal of battery B'. The second differential-winding 219 is connected with the rotary side of the main talking line by one end, while the other end is connected with one side of the rotary-line-relay 201, and through said line-relay with the non-grounded terminal of battery B'. The said second end or terminal of the differential-winding 219 is also connected through a preferably 350 ohm dead-resistance-coil 220 with the spring 221 of an auxiliary-relay 222. The other spring 223 of the said auxiliary-relay is permanently connected with one of the differential-relay-springs 211, which latter normally engages a second differential-relay-spring 212 that is normally connected with ground. With such construction, it would be evident that the differential-relay-coil 218 may be energized only when the vertical side of the main line connected with it is grounded; but the other coil 219 may be energized when the rotary side of said line is grounded, or at times when the auxiliary-relay 222 forces the auxiliary-springs 221 and 223 into contact, which latter operation then connects to ground the end of the coil 219 that ends to the rotary-line-relay 201. In such a case, and if the line-conductors are connected through the sub-station, it is evident that the current will flow from the grounded differential-relay-spring 212 through the coil 219, then by way of the sub-station to the coil 218, and thence to the non-grounded terminal of the battery. In this last case, of course, the current through the coil 219 flows in a different direction from that in which it flows when the rotary side of the main line is grounded. In one case the coils 218 and 219 will counteract the magnetic forces developed in each, while in the other case they will be reinforced. Furthermore, it is evident that if the main line terminal of the coil 219 is grounded at the same time that the terminal connected with the rotary-line-relay is grounded, the said coil will then be short-circuited or shunted. The differential-relay-springs are so adjusted that when the armature 210 is attracted the spring 212 is separated from the spring 211 and forced onto the spring 213, while the springs 214 and 215 are driven into contact, as well as the springs 216 and 217. Normally, however, all the differential-relay-springs are out of contact with each other save the springs 211 and 212. In addition, the repeater is provided with two repeating-coils 224 and 225, the former of which has two windings 226 and 227, and the latter two windings 228 and 229. The coils 226 and 228 are connected through a condenser 230, while the coils 227 and 229 are connected with a second condenser 231. Of the trunk-release-springs 207 and 208, the latter constitutes the terminal of the trunk-release-conductor that leads to the first-selector, while the former is connected with one of the differential-relay-springs 217; and when the differential-relay 209 is energized, the said spring 217, being then connected with the

spring 216, places the said trunk-release-spring 207 in connection with the non-grounded terminal of the battery B through a dead-resistance-coil 232, the resistance of which is usually about 50 ohms. With the relays of the repeater, good results have been obtained by winding the coils 218 and 219 to about 250 ohms resistance each. The line-relays 200 and 201 are 125 ohms resistance each, and the auxiliary-relay 222 is about 1000 ohms resistance.

The second-selectors of the type employed in connection with my system, one of which is illustrated at S, Fig. 2, are identical with the first-selector F. However, parts like the shaft-springs 66, 67 and 68 and like the bridge-cut-off-relay 76 are eliminated from the second-selector. Furthermore, conductors like those that terminate in the bridge-cut-off-relay-springs 78, 79 and 80 are permanently united and the springs discarded.

Fig. 4 shows the connector C which has many parts and circuits very similar to those of the first-selector. The line and private banks 250 and 251 will be recognized. The switch-shaft 252 is identical with the first-selector-shafft and is, therefore, provided with the line-wipers 253 and 254, the private-wiper 255, the cam 256, longitudinal and circular teeth 257 and 258, respectively, the normal-post-arm 259, and the coil-spring 260. The vertical movement of the shaft is, of course, produced by means of the vertical-magnet 261, vertical-arm 262, and vertical-pawl 263, the said vertical-arm 262 being supplied with the L-shaped piece 264, as usual. The release-magnet 265, however, has its armature 266 on the right side instead of on the left side, which armature is constructed with an elongated front extremity 267 that reaches as far as the middle section of the body of the double-dog 268. The release-link 269 is under the control of the L-shaped piece 264, but it is also permanently secured to the switch-frame at the pin 270. The double-dog has the usual vertical and rotary locking-dogs 271 and 272, respectively and the side-switch releasing-arm 273; while on the upper side of the body of the double-dog the lug 274 that is caught by the release-link 269 is in its usual position. When the release-magnet of the connector is energized the release-link 269 instead of being thrust forward to catch the said lug 274 remains where it is, and, instead, the double-dog 268 is moved by the armature 266 to a point at the right of the bearing 275, so that the lug 274 is driven under the aperture 276 in which it is caught by the release-link 269. The double-dog 268 is thus prevented from returning to its operative position when the release-magnet becomes deënergized. The rotary magnet 277 has a rotary-armature 278 that is quite simple. This latter is provided with only a vertical-arm 279 upon the extremity of which the rotary-pawl 280 is located. The rotation of the shaft is produced in the same step-by-step manner described in connection with the first-selector each time that the rotary-magnet is energized. The private-magnet 281, the private-armature 282, springs 283 and 284, escapement-teeth 285, 286, 287 and 288 and the arm 289 are identical with the similar parts of the first-selector. The said arm 289, however, controls the private-springs 290, 291, 292 and 293, so that when the private-armature 282 is down the first two of said springs are separated and the last two brought into contact: and when the said armature is up the reverse takes place—that is, the springs 290 and 291 close together, and the springs 292 and 293 separate. In the side-switch of the connector the side-switch-arm 294, escapement-finger 295, cam-lug 296, side-switch-stop 297, and retracting-spring 298 on one side of the pivots 299 conform to like parts of the first-selector-side-switch; while the member 300, link 301, side-switch-wipers 302, 303, 304 and 305, together with their corresponding contact-points 306, 307 and 308; 309, 310 and 311; 312, 313 and 314; and 315, 316 and 317 are on the other side of said pivots. Among the relays of the connector the vertical-line-relay 318 can by its armature 319 flex the spring 320 against the ground-spring 321, and the spring 322 toward the spring 323, when said relay is magnetized. The rotary-line-relay 324, in the same manner, and by its armature 325, when the former is magnetized, forces the spring 326 against the same ground-spring 321, and permits the spring 323 in turn to bend toward the former spring 322. Said two springs 322 and 323 are so adjusted that they come together whenever the two armatures 319 and 325 are attracted at the same time. The ringer-relay 326 is a feature common to all connectors of the type under consideration and has power when magnetized to open the connection between the called and the calling line and place across the former the terminals of the ringer-generator J. This operation is accomplished by means of the armature 327 and the ringer-relay-springs 328, 329, 330, 331, 332 and 333. It will be more clearly pointed out in the description to follow that when one subscriber calls another subscriber the called subscriber's individual apparatus is rendered inactive and is, therefore, withdrawn from his direct control for purposes that will be made clear. Evidently, then, when one subscriber has called another, the called subscriber is unable to make a call unless he is furnished with means by which he may control the connection that has been established with his line. With the end in view of attaining this object, the connector is provided, in addition, with a so-called back-release-relay compris-

ing two coils 334 and 335. These two coils have under their control two springs 336 and 337, and when the armature 338 of the coil 334 is attracted by said coil, when it is magnetized, the spring 336 is forced in the direction of the spring 337, while the armature 339, when the other coil 335 is magnetized, forces the spring 337 toward the spring 336. The adjustment is such, however, that only when the two coils become magnetized simultaneously do the said springs 336 and 337 come into engagement with each other. The back-release-relay is designed to control circuits that comprise the release-magnet of the connector, by means of which any established connection may be destroyed. The release of the first-selector, it has been pointed out, does not occur until the de-energization of the release-magnet, but the release of the connector occurs immediately upon the energization of the release-magnet of the latter. Should the connector-shaft 252 be raised at the time when the release-magnet is energized, the release-armature 266, as above stated, moves the double-dog 268 under the release-link, which latter then catches the lug 274, and holds the said double-dog out of engagement with the shaft. The shaft being free, in the same manner described in connection with the first-selector, returns to its normal released condition. The normal-post-arm 259, as usual, has control of the shaft-spring 340 with respect to the contact-point 341. The said contact and spring are normally out of engagement, but as the shaft rises the connection is closed to be separated again when the shaft-rest 342 enters the slot 343 and the shaft falls. As will be shown, the said spring and contact are comprised in a busy-signaling circuit which becomes established through the calling sub-station to notify the said subscriber when the called line is busy. The sub-stations of the local battery system are mechanically constructed exactly as the sub-stations of the common-battery system, but the circuits of the former are changed to suit the different conditions. For instance, the primary circuit is made local and subject to be opened or closed by a switch-hook, and comprises the usual transmitter and primary winding of an induction-coil and a local battery. The secondary circuit comprises the receiver and secondary winding of the induction-coil, and is bridged across the main line during talking, subject also to be opened or closed by the switch-hook. The ringer is bridged directly across the main line normally and the circuit in which it is comprised is also controlled by the switch-hook.

In Fig. 2 the first-selector F^2 that is associated with the called line is identical with the first-selector F^1 of the calling line, and needs no explanation, since like parts are likewise represented. When reference is made to the parts of said called first-selector it will be understood that their functions and constructions are the same as those already described for the first-selector F^1. In the system under consideration, of course, it is clear that there may be a multiplicity of sub-stations common to each central station, each of which stations is connected with the central station by a line of two conductors, each of which lines has permanently allotted to it a first-selector. The first-selectors may be sub-divided into groups of one hundred each with all corresponding line-bank terminals of a given group connected in multiple, a similar arrangement being followed in connection with the private-bank-terminals. For each level of first-selector-line-bank-terminals one set of ten trunk-lines is provided that terminate in suitable switches arranged in groups. Therefore, for each step a first-selector-shaft is raised its line-wipers are placed on a level with a different set of trunk lines which terminate in switches one of which may be selected for the purpose of reaching subscribers in different numerical groups. Each first-selector is connected with a given set of bank-contact-points in the banks of the connectors of the particular hundred group to which said first-selector belongs, and when the first-selector comes into use, a guarding potential is placed at the connector-private-bank-contacts of the line of the calling first-selector to prevent any other calling subscriber from calling-in on said line over so-called normal-trunk-conductors that extend between the connector-banks and the first-selector.

To more fully understand the operations and circuits in connection with my invention, a description will now be given of the apparatus and circuits brought into use in the system when one subscriber calls another subscriber as illustrated in Figs. 1 and 2. For instance, when the subscriber at sub-station #200 calls the subscriber at sub-station #300 the subscriber at the calling sub-station #200 removes the receiver from the switch-hook 2, causing the ground-springs 23 and 24 to come into contact and complete a circuit between the ground terminal 13 and the ground-post 22 by way of the conductors 400 and 401. Then the vertical-push-button 29 is pressed twice and the rotary-button 30 once, again the first button 29 four times and the second button 30 once, then the button 29 twice and the button 30 once, and for the last time the first button ten times and the last button once. When the spring 33 is forced onto the ground-post 22 twice in succession for the first time, the vertical-line-conductor 402 is grounded twice, causing the vertical-line-relay 69 of the first-selector to become magnetized, and to thereby twice momentarily attract its armature

71. The energizing current that passes through said vertical-line-relay at this time enters the line at the ground terminal G^2, then passes to the ground-post 22 and through the spring 33 to the vertical-line-conductor 402, thence through the vertical-side-switch-wiper 143, conductor 404, vertical-line-relay 69, conductor 405, bridge-cut-off-relay-springs 79 and 80, conductors 406, 407 and 408 to the non-grounded terminal of battery B^1 to ground G^1. As a result, the line-relay-spring 73 is forced onto the ground-spring 75 twice, which operation closes a second magnetizing circuit through the vertical-magnet 85. The current in this second circuit enters the line at the ground terminal G^4 and then passes through the springs 75 and 73 to conductor 409 and through the private-springs 127 and 126 and conductor 410 to the vertical-magnet 85, passing thence through the conductors 411, 412, 413 and 408 to the non-grounded terminal of battery B^1 and to ground G^1. The vertical-magnet 85 then attracts the vertical-armature 86 twice and raises the switch-shaft two steps. At the first step, of course, the release-link 95 is withdrawn from the double-dog 101, at which time the dog 103 engages with the circular teeth 60 and prevents the shaft from falling to its original position. So soon as the switch-shaft rises, the off-normal-spring 66 closes with the grounded contact-point 68, at which instant and by which act the connector-private-bank-contacts that correspond to the line-conductors of the sub-station #7000 are connected with ground G^5, which connection establishes a guarding potential over the line #7000 in order that no subscriber may be able to connect with it after once the first-selector F^1 of said line has been operated. After the vertical-line-conductor is grounded twice the rotary-line-conductor 414 is grounded once through the spring 34. An electric current then flows through the rotary-line-relay 70 for a moment, which magnetizes the said rotary-line-relay, causing the latter to attract its armature 72 once and force the spring 74 once against the ground-spring 75. The magnetizing current passes from ground G^3 to the ground-post 22, thence through the spring 34 to the rotary-line-conductor 414, side-switch-wiper 144, contact-point 150, conductor 415, rotary-line-relay 70, conductor 416, springs 78, 79 and 80 to the non-grounded terminal of battery B^1 and to ground G^1. When the springs 74 and 75 close together a second magnetizing circuit is completed through the private-magnet 122. The electric current in this latter case flows from the grounded terminal G^4 through the line-relay-springs 75 and 74, conductors 417 and 418 to the private-magnet 122, after passing through which it passes through the conductors 419, 413 and 408 to the non-grounded terminal of battery B^1 and to ground G^1. The private-armature 121 being attracted once and restored immediately, the escapement-tooth 133 first clears or disengages the escapement-finger 138, which latter then falls against the second tooth 131, and when the armature returns to its normal position this latter tooth also clears in turn the said escapement-finger. At that instant the side-switch is drawn into the second position by the retracting-spring 139, with the cam-lug 140 resting against the cam 56. It will be understood that the prongs of the bifurcated end of the link 160 that rests upon the T-shaped extremity of the double-dog releasing-arm 105 are of sufficient length to permit the said releasing-arm 105 to move from the position that it occupies when the double-dog is held normally locked by the release-link 95, to the position it assumes when the said double-dog is released, without disengaging from said prongs. At the moment that the side-switch passes from the first to second position a circuit is completed through the rotary-magnet 108 when the side-switch-wiper 141 closes with the contact-point 151. The current then flows from the ground terminal G^6 to the contact-point 151, through the side-switch-wiper 141 and conductor 420 to the rotary-magnet-coil 110, thence through the interrupter-springs 118 and 119 and through the second rotary-magnet-coil 109 to the conductors 412, 413 and 408 to the non-grounded terminal of battery B^1 and to ground G^1. The rotary-magnet 108 then attracts the rotary-armature 111 and forces the rotary-pawl 115 into engagement with one of the longitudinal teeth 59, causing the shaft to rotate one step. Just at the time, or at the instant before the rotary-armature strikes the rotary-magnet pole-pieces the rotary-dog 104 falls behind the first of the longitudinal teeth, in the manner already described, to prevent the shaft from returning to its normal position when the rotary-magnet becomes deenergized at the instant that the interrupter-finger forces the interrupter-springs apart and destroys the energizing circuit through the said magnet. This interruption occurs just at the time or just after the rotary-armature strikes the pole-pieces. When the rotary-pawl 115 advances to engage the longitudinal teeth, as described, the rotary-armature-finger comes into contact with the private-armature 124, producing a depression of the latter at the same time that the rotary-pawl produces a rotation of the shaft. As the shaft begins to rotate, the cam-56 very soon passes out of reach of the cam-lug 140 and permits the escapement-finger 138 to fall against the tooth 131 before the rotary-armature-finger 120 has depressed the private-armature 124 too far. Very soon, however, the said tooth 131 is carried below the finger 138, which latter then falls against

the upper tooth 132 at about the time that the shaft-wipers are rotated onto the first contact of the second level of their respective banks. As soon as the energizing circuit through the rotary-magnet is interrupted the rotary-armature then begins to return to its normal position, and the private-armature 121 as well, following up the receding movement of the rotary-armature-finger 120. Very soon the tooth 132 clears or disengages the escapement-finger 138 also, and the side-switch springs into its third position with the escapement-finger 138 against the side-switch-stop 146. The shifting of the side-switch takes place just before the interrupter-finger permits the interrupter-springs 118 and 119 to reëngage, so that by the time that they do reëngage the energizing circuit that has been described through the rotary-magnet has been opened between the side-switch-wiper 141 and the contact-point 151. When the motion of the rotary-armature ceases permanently, the operation of the first-selector then comes to an end, the line-wipers 53 and 54 having seized upon an idle trunk-line similar to the trunk-line whose conductors 421 and 422 terminate at the tenth set of contacts of the second level of the same line-bank. The seized line is protected from further seizure by a guarding potential temporarily established at the private-wiper, and, therefore, at the first contact of the second level of the private-bank 51, and to all other private-contacts in multiple. Said guarding potential is established by reason of the connection between the grounded terminal of battery B^1 and said private-contacts, through the ground terminal G^7, side-switch-wiper 142, conductor 423, back-release-relay 81, conductor 424 and the private-wiper 55. Similarly, should any first-selector appropriate to its use the second trunk-line of the same level, a guarding potential will then appear at the second private-contact of the second level of the private-bank 51, as well as at all other private-banks in multiple. And should a third first-selector seize the third trunk on the same level a guarding potential will appear also at the third private-contact of the second level, and should the fourth, fifth, etc., and ninth trunks be occupied guarding potentials would be found at the fourth, fifth, etc., as well as at the ninth private-contact-terminals of the second level of the private-bank. Therefore, if the first nine trunk-lines of the second level are busy a guarding potential is found at each one of the first nine private-contacts of the second level of the private-bank 51. If this condition exists at the time that the calling subscriber grounds his rotary-line-conductor by pressing button 30, the rotation of the shaft will not terminate as soon as the wipers have cut onto the first terminal of the level to which they have been raised. The first nine private-contacts being grounded, then when the calling subscriber grounds the rotary side of the line the side-switch trips into second position in the manner described; but then the rotation of the shaft will begin not to cease until the wipers have been carried beyond the last of the busy trunk-lines, in this case onto the tenth terminal of the second level of the banks in question. This operation takes place in the following manner: The energizing circuit through the rotary-magnet being closed, as was pointed out, at the juncture when the side-switch-wiper 141 engages with the contact-point 151, the rotary-armature is attracted by the rotary-magnet 108, and the shaft is rotated one step, in the manner described, so that the line and private wipers are rotated into engagement with the first terminal of the second level of their respective banks. At the same time the private-armature is depressed by the rotary-armature-finger and the interrupter-springs 118 and 119 at the end of the stroke are separated by the interrupter-finger 117. There being a guarding potential at the first contact which the private-wiper meets, a circuit is completed through the private-magnet 122, which extends from the grounded terminal G^1 of the battery B^1 through the private-wiper of whatever first-selector is occupying the first trunk of the second level in question, through the bank-multiplying conductors to the contact-point with which the private-wiper 55 has engaged, thence through said private-wiper 55, conductor 424, winding of the back-release-relay 81, conductor 423, side-switch-wiper 142, contact-point 152, conductors 403 and 418 and private-magnet 122, to the non-grounded terminal of the battery B^1 and to ground G^1. The private-armature is thereby retained in its attracted position even after the energizing circuit is broken at the interrupter-springs, and while the rotary-armature-finger 120 returns to its normal position in response to the retracting tension of the rotary-armature retracting-spring 113, since the escapement-finger 138 is held prisoner by the upper foremost escapement-tooth 132. The side-switch-wiper 141 being, therefore, retained in engagement with the grounded contact-point 151, as soon as the interrupter-springs reëngage the energizing circuit through the rotary-magnet 108 is completed once more. As a result the rotary-armature is attracted again, the shaft is rotated one more step, and the private-wiper 55 is moved onto the second terminal of the second level of the private-bank 51. Said second contact also being grounded the energizing circuit through the private-magnet is still maintained, so that the side-switch is not liberated when the rotary-armature again returns to its normal position. Clearly, then, the shaft

will be rotated in a step-by-step manner as long as the private-wiper continues to meet with grounded-private-contacts. After having rotated onto the ninth contact, the private-wiper is rotated one more step and brought into engagement with the tenth contact of the second level of the private-bank; but, this last contact being devoid of guarding potential, as soon as the said wiper leaves the ninth contact the magnetizing circuit that has up to this time maintained the private-magnet energized is broken. This occurs at just about the time when the rotary-armature is at the end of its attractive or forward stroke, so that the private-armature that has up to this time held the side-switch in its second position, by the magnetizing force that has now disappeared from the private-magnet, falls back upon the rotary-armature-finger and follows said finger as the rotary-armature returns to its normal position. Between the time that the private-armature is released by the private-magnet and the time that the rotary-armature fully regains its normal position, the escapement-finger 138 which, during the rotation of the shaft, has been resting against the foremost tooth of the upper escapement-spring, disengages from said tooth and permits the side-switch to pass into the third position. It is then that the side-switch-wiper 141 leaves the contact-point 151 and passes onto the contact-point 155, and that the wiper 142 passes onto the contact-point 156. The disengagement of the wiper 141 and the contact-point 151 occurs just before the interrupter-springs 118 and 119 reengage, so that the circuit through the rotary-magnet is permanently broken in order that no further rotation of the shaft may take place during its operation; and the engagement of the wiper 142 with contact-point 156 provides the private-wiper 55 with guarding potential. The side-switch-wipers 143 and 144 having engaged with the contact-points 157 and 158, the subscriber's line-conductors 402 and 414 are extended through the respective wipers to the vertical and rotary line-wipers 53 and 54, respectively. Said wipers being at the time in engagement with the tenth contact of the second level of the line-bank, the calling subscriber is thus placed in connection with the repeater R. It may be stated at this point that if, after the subscriber has begun to call, and before the first-selector has trunked to the repeater, he should desire to discontinue his call he may interrupt the operation of the first-selector and restore it by simply hanging up his receiver on the switch-hook 2. This may occur while the side-switch is either in the first or second position, it matters not. As a result of restoring the receiver both sides of the main line will be grounded simultaneously. The vertical and rotary line-relays 69 and 70 will be magnetized at the same time, and, as a result following, the release-magnet 98 of the first-selector will be energized and the first-selector will be restored. It has been described that in its action the release-cam-arm 3, as it passes down when the receiver is restored, flexes the release-springs 25, 26 and 27 into contact for a moment. Of these springs the release-springs 25 and 26 are connected, respectively, with the vertical and rotary line-conductors, while the third release-spring 27 is connected to ground G^3. Therefore, as a natural result, the temporary engagement of these three springs sends a ground impulse over each side of the main line, with the effect upon the first-selector-line-relays already described. The current through the vertical-line-relay, during the release, passes from ground G^3 through the ground-springs 24 and 23, conductor 400, release-springs 27, 26 and 25 to the vertical-line-conductor 402, and thence through said relay to the non-grounded terminal of the battery B^1 and to ground G^1. Through the rotary-line-relay 70 the current flows from the same ground G^3 to the release-spring 27, thence through the release-spring 26 and to the rotary-line-conductor 414, thence through the line-relay in question to the non-grounded terminal of battery B^1 and to ground G^1. Since the contact-points 149 and 153 associated with the vertical-side-switch-wiper 143 are connected together, and since the contact-points 150 and 154 of the rotary-side-switch-wiper 144 are connected together, it will be evident that it makes no difference whether the side-switch is in first or second position, as the energizing circuits during the release, as pointed out in the conditions under consideration, will still be the same. The fact is already familiar that when the rotary-line-relay is energized the private-magnet 122 is energized as a result, which latter during its energization maintains the private-springs 127 and 128 in contact. It is also well understood that when the vertical-line-relay is magnetized the private-spring 127 is connected with ground G^4 at the line-relay-springs. It was shown that when said private-spring 127 was grounded, and while in contact with the spring 126 the vertical-magnet 85 was energized; but in this case, since said springs 127 and 126 are not in contact, but instead the springs 127 and 128, a different circuit is established that comprises the release-magnet 98. The energizing current in this circuit passes from the ground G^4 to the private-springs 127 and 128, thence through the release-magnet 98, conductors 411, 412, 413 and 408 to the non-grounded terminal of battery B^1 and to ground G^1. When the cam-arm 3 clears or disengages the release-springs, the line-relays 69 and 70 then be-

come deënergized. As a result, the release-magnet 98 becomes deënergized and the armature of the latter in regaining its normal position restores the first-selector-switch in the well-known manner. It should be made clear that when the first-selector-shaft is first operated, and when the off-normal-spring 66 closes into electrical contact with the contact-point 68, a guarding potential is then established at the connector-private-bank-contacts, through the so-called private-normal-conductor 426, to correspond with the number at the sub-station #7000. The establishment of this guarding potential is for the purpose of preventing any calling subscriber from establishing connection with the line #7000 over the normal-line-conductors 427 and 428 that terminate in the connector-banks, while the said line is making the call. But when the shaft falls to its normal position, when the switch is released, this guarding potential is then destroyed at the instant that the normal-post-arm 63 forces apart the springs 68 and 66. However, since the calling subscriber continues to make his call, he continues to operate his calling device to obtain the desired connection. Attention will be called to the fact that the guarding potential established at the private-wiper 55 and, therefore, at the tenth contact of the second level of the private-bank 51, forces a current through the auxiliary-relay 222 of the repeater R, which relay upon attracting its armature closes a circuit that provides the calling station with a current that energizes the primary-circuit of the talking apparatus. The current that energizes the relay 222 passes from ground G^7 to the side-switch-wiper 142 through the back-release-relay 81, conductor 424, private-wiper 55, release-trunk-conductor 425, auxiliary-relay 222 to the non-grounded terminal of battery B^1 and to ground G^1. The relay 222 upon attracting its armature 233 forces the auxiliary-relay-springs 221 and 223 into contact at which time, as it has been stated, the calling sub-station is provided with talking battery current. The current passes from ground G^8 and through the differential-relay-springs 212 and 211, through the auxiliary-springs 223 and 221, resistance-coil 220, differential-relay-coil 219, trunk-conductor 422, rotary-wiper 54 of the first-selector F^1, contact-point 158, rotary-line-conductor 414, spring 34, contact-point 32, primary winding 7 of the induction-coil 8, transmitter 9, contact-point 10, spring 11, primary-circuit-springs 13 and 14, contact-point 31, spring 33, vertical-line-conductor 402, side-switch-wiper 143, contact-point 157, line-wiper 53, vertical-trunk-conductor 421, winding 218 of the differential-relay 209, conductor 430, line-relay 200, conductor 431 to the non-grounded terminal of battery B^1 and to ground G^1. The current through the windings 218 and 219 of the differential-relay passes through said coils in such a direction that the said differential-relay does not become energized; but the vertical-line-relay 200 does, and the latter attracts its armature 202. The engagement of the springs 221 and 223 during the time that the differential-relay-springs 211 and 212 are in contact not only provides the calling sub-station with talking battery current, but also causes the rotary-line-relay 201 to become energized in series with the resistance-coil 220, by reason of part of the talking current being diverted through said rotary-line-relay after it leaves the conductor 429, which current then passes to the non-grounded terminal of battery B^1 and to ground G^1. But the energized condition of said vertical and rotary line-relays has no significance at present. The calling subscriber now, it will be evident, each time that he operates his calling device, destroys or opens the circuit that provides his station with talking current each time that either of the springs 33 or 34 is moved from the contact-point with which it normally engages. But the rotary-line-relay is not de-energized, as will be pointed out, until the vertical-line-conductor is grounded. The subscriber after having pressed the push-button 29 twice and the push-button 30 once, continues by pressing the push-button 29 again four times. Again the vertical-line-conductor 402 is momentarily grounded four times. The first-selector-line-relays 69 and 70 having been cut off from the line at the instant that its side-switch passed into third position, and the line being connected then with the repeater R, the grounding of the vertical-line conductor then energizes the line-relay 200 and the differential-relay 209 of the repeater R. The current in this case after reaching the vertical-line-conductor and the vertical-side-switch-wiper 143 of the first-selector passes through the contact-point 157, the vertical-line-wiper 53, trunk-conductor 421, differential-line-relay 218; conductor 430, vertical-line-relay 200, conductor 431 to the non-grounded terminal of battery B^1 and to ground G^1. Each time that the vertical-line-relay 200 is energized the spring 204 is forced onto the spring 205, and since the differential-relay forces at the same time the spring 212 onto the spring 213, each time that the vertical-line 402 is grounded, the inter-exchange-trunk-conductor 432 is grounded also. The effect of grounding the said trunk-conductor 432 will be explained hereinafter. The circuit through which the said trunk-conductor is connected to ground may be traced from ground G^8 to the differential-relay-springs 212 and 213, line-relay-springs 205 and 204, conductor 433 to the trunk-conductor 432. The effect of grounding the vertical-line-

conductor 402 produces, as was stated, a de-energization of the rotary-line-relay 201, indirectly. The energizing circuit through said relay when the auxiliary-relay-springs 223 and 221 are closed comprises the differential-relay-springs 211 and 212. Therefore, since the differential-relay is energized when the vertical-line-conductor is grounded, the springs 212 and 211 are separated, destroying the magnetizing current through the said rotary-line-relay 201. The subscriber, after operating the push-button 29, operates the push-button 30 once, grounding the rotary-line-conductor 414 once. The first effect of grounding the said line-conductor becomes manifest in the energization of the differential-relay 209, which latter produces a shifting of the energizing circuit that maintains the rotary-line-relay 201 energized. The current, instead of passing through the said rotary-line-relay from the ground G^8 now passes through said relay from the ground G^8 at the said sub-station, the latter ground being substituted for the former at the instant that the differential-line-relay-springs 211 and 212 disengage. The energizing current that passes through this differential-relay and through the rotary-line-relay 201 enters the circuit at ground G^3 and passes to the rotary-line-conductor 414, after reaching which it extends through the side-switch-wiper 144, wiper 54, rotary-trunk-conductor 422, differential-relay-winding 219, conductor 429, rotary-line-relay 201 to the non-grounded terminal of battery B^1 and to ground G^1. At the instant that the ground connection to the rotary-line-conductor 414 is interrupted, both the differential and rotary line-relays then become deënergized, but the rotary-line-relay becomes reënergized at once as soon as the differential-relay-armature 210 advances sufficiently to permit the differential-relay-springs 211 and 212 to reëngage. Since the line-relay-springs 205 and 206 are maintained in connection while the differential-relay-armature 210 is attracted, and, therefore, when the differential-relay-springs 212 and 213 and the differential-relay-springs 214 and 215 are forced into contact, the inter-exchange rotary-trunk-conductor 434 is grounded, but since the differential-relay is energized only once the said trunk-conductor is only grounded once. The path through which the ground impulse reaches the said conductor 434 extends from ground G^8 through the springs 212 and 213 and through the line-relay-springs 205 and 206, differential-relay-springs 215 and 214, conductor 435 to the rotary-trunk-conductor 434. The effect of grounding said conductor will be considered hereinafter. Of course, as long the vertical and rotary line-relays 200 and 201 are maintained energized together the line-relay-springs 204, 205 and 206 are kept in contact, as well as the trunk-release-springs 207 and 208. The engagement of these springs while talking battery current is being furnished to the sub-station #7000 is of no consequence at this time, but plays a very important part during the release, as will be made clear. The sub-station #7000 being connected directly with the repeater at this point, it follows that if the calling operator restores his receiver to its hook and grounds, simultaneously, the vertical and rotary line-conductors 402 and 414, he will thereby restore the central apparatus through the repeater. The grounding of the vertical-line-conductor 402 maintains the vertical-line-relay 200 energized, and causes a flow of current through the winding 218 of the differential-relay, but the grounding of the rotary-line-relay shunts the winding 219 of the differential-relay out of service, causing the current to cease flowing through said coil and producing at once, of course, as a result, the energization of the differential-relay, due to the magnetizing effect of the coil 218. The shunted circuit in which the coil 219 is cut out of service may be traced from ground G^3 to the rotary-line-conductor 414 through the winding 219 of the differential-relay to the conductor 429, resistance-coil 220 to the ground terminal G^8. As soon as the differential-relay becomes energized and the differential-relay-springs 211 and 212 are forced apart the shunt across the winding 219 is removed, at which instant a current then flows through said winding in series with the rotary-line-relay 201, the said rotary-line-relay remaining energized and the differential-relay being strengthened. The current through the winding 219 and the relay 201, of course, extends from ground G^3 through the said coils 219 and 201 to the non-grounded terminal of battery B^1 and to ground G^1. The trunk-release-springs 207 and 208 being connected, since both line-relays are magnetized, it follows that as soon as the differential-relay-springs 216 and 217 come into engagement the back-release-relay 81 of the first-selector F^1 becomes energized by current flowing from ground G^7 through the side-switch-wiper 142 of the first-selector F^1, through the said relay 81 to the private-wiper 55, trunk-release-conductor 425, trunk-release-springs 208 and 207, differential-relay-springs 217 and 216, resistance-coil 232, conductor 431 to the non-grounded terminal of battery B^1 and to ground G^1. As soon as the back-release-relay attracts its armature 82 the release-magnet 98 is energized. The current that energizes the release-magnet flows from ground G^9 through the back-release-relay-springs 83 and 84 to the conductors 436 and 437, and through the release-magnet 98, conductors 411, 412, 413 and 408 to the non-grounded

terminal of battery B^1 and to ground G^1. As soon as the release-springs at the substation #7000 disengage, the current flowing through the line-relays 200 and 201, and through the differential-relay 209, is interrupted, and as a result the back-release-relay 81 becomes deënergized. When the release-relay-armature 82 is restored the springs 83 and 84 are separated at the same time and the energizing circuit through the release-magnet 98 is interrupted. At once the release-armature 97 returns to its normal position, producing a restoration of the first-selector in the well-known manner. The restoration of the first-selector-shaft destroys the magnetizing circuit through the auxiliary-release-relay 222 of the repeater R, so that by the time that the first-selector is released the repeater is restored also. It should be noted that when the line-relays 200 and 201 are energized during the release that the vertical and rotary inter-exchange trunk-conductors 432 and 434 are simultaneously grounded, since the line-ground-spring 205 is connected to ground G^8 through the differential-relay-springs 212 and 213. If the subscriber does not wish to release he continues his call; but before proceeding with the description the effect of grounding the inter-exchange trunk-conductors 432 and 434 will be considered. Since the said trunk-conductors are directly connected with the second-selector S in the same manner that the line-conductors 402 and 414 of the sub-station #7000 are connected with the first-selector F^1, the grounding of the trunk-conductors 432 and 434, as previously traced, results in the operating of the second-selector in the identical manner in which the first-selector F^1 is operated when the buttons 29 and 30 are pressed and when the release-springs 25, 26 and 27 are connected together. The grounding of the vertical-trunk-conductor 432 energizes the vertical-line-relay 165, at which time the current flows from ground terminal G^8 over said conductor to the side-switch-wiper 166, contact-point 167, and through the vertical-line-relay 165, conductor 438 to the non-grounded terminal of battery B^2 and to ground G^2. The line-relay-springs 168 and 169 are forced together in the usual manner, and a circuit is established that permits the current to flow from ground G^{10} through the springs 169 and 168, private-springs 171 and 172, conductor 439, vertical-magnet 170, conductors 440, 441, 442 and 438 to the non-grounded terminal of battery B^2 and to ground G^2. The energization of the vertical-line-relay occurring four times, the vertical-magnet 170 is energized four times also, and as a result the switch-shaft is raised four steps in the manner that needs no description. At the end of this operation, of course, the switch-shaft-wipers 174, 175 and 176 will be found opposite the first contact of the fourth level of their respective banks. The grounding of the rotary-trunk-conductor 434, following the grounding of the vertical-trunk-conductor, produces an operation of the rotary-line-relay 178. The current through said relay after reaching the rotary-trunk-conductor 434 from the ground G^8 passes to the side-switch-wiper 179, contact-point 180, conductor 443, rotary-line-relay 178, conductor 438 to the non-grounded terminal of battery B^2 and to ground G^2. The relay being energized momentarily energizes in turn the private-magnet 181 once at the instant that the springs 182 and 169 are forced into contact. The current here flows from ground G^{10} through the springs 169 and 182 through the conductor 444, private-magnet 181, conductors 446 and 442 to the non-grounded terminal of battery B^2 and to ground G^2. The private-magnet, actuating its armature once, permits the side-switch to pass into second position, at which time the side-switch-wiper 183 passes from engagement with the contact-point 184 onto the grounded contact-point 185. The engagement of said side-switch-wiper with the said contact-point produces an actuation of the rotary-magnet 186, by reason of a current that flows from ground G^{11} through the conductor 447 to the contact-point 185, thence through the side-switch-wiper 183, conductor 448, rotary-magnet 186, conductors 449, 441 and 442 to the non-grounded terminal of battery B^2 and to ground G^2. Assuming that the first nine trunks of the fourth level of the second-selector-banks are busy, the rotation of the shaft, in the manner clearly described in connection with the first-selector F^1, continues until the shaft has been rotated ten steps, placing the switch-wipers in connection with the tenth terminal of the fourth level of the line-banks. Of course, the private-magnet during the rotation of the private-wiper over the busy contacts is maintained energized, as was described in connection with the first-selector. The current passes from the busy contacts to the private-wiper 176 through the conductor 450, through the back-release-relay 187, conductor 451 to the side-switch-wiper 188, which latter being in second position extends the circuit through the contact-point 189, conductors 452 through the private-magnet 181 to the non-grounded terminal of battery B^2 and to ground G^2. The line-wipers 174 and 175 are then, of course, in electric connection with the trunk-conductors 463 and 464, and the private-wiper 176 with the release-trunk-conductor 465. The side-switch-wiper 188, while in third position, being connected to ground G^{12} through the contact-point 190, the usual guarding potential is then supplied to the private-wiper 176 and, of course, to

the private-contact with which it is connected, in order that no other trunk-seeking second-selector may be able to seize upon the trunk-conductors 463 and 464. The second-selector S may be released like the first-selector, while its side-switch is in first or second position, if the inter-exchange trunk-conductors 432 and 434 are grounded simultaneously for a moment. The release will occur if the calling subscriber hangs up his receiver at any stage of the call that may find the second-selector-side-switch in its first or second position. It will be clear that if the vertical and rotary line-conductors 402 and 414 are grounded simultaneously for a moment, while the first-selector, repeater and the second-selector are connected, and while the second-selector-side-switch is in either the first or second position, the first-selector will be released as described—through the repeater—during which release the trunk-conductors 432 and 434 will be grounded simultaneously, producing the release of the second-selector also. The simultaneous grounding of the inter-exchange trunk-conductors produces the simultaneous magnetization of the second-selector vertical and rotary line-relays 165 and 178, by which operation the release-magnet 191 becomes magnetized. As soon as the line-relays are deënergized the restoration of the second-selector follows, as usual. After the subscriber's line-conductors are extended to the connector the operation of the calling device at the calling station will operate the connector. The grounding of the vertical-line-conductor will cause the vertical-line-relay 200 and the differential-relay 209 at the repeater R to be energized twice. As a result the vertical-trunk-conductor 432 becomes grounded twice and the vertical-line-relay 318 of the connector becomes energized twice by a current flowing from ground G^8 at the repeater R, to the vertical-trunk-conductor 432, thence through the side-switch-wiper 166 to the contact-point 192, conductor 466, vertical-line-wiper 174, vertical-trunk-conductor 463, vertical-line-relay 318 of the connector C, conductors 467, 468, 469, 470 and 471 to the non-grounded terminal of battery B^2 and to ground G^2. The vertical-line-relay then attracts its armature 319 and closes the springs 320 and 321 into contact, establishing an energizing circuit through the vertical-magnet 261. The energizing current passes from ground G^{18} through the springs 321 and 320, conductor 472, private-springs 291 and 290, conductor 473, side-switch-wiper 302, contact-point 306, conductor 474, vertical-magnet 261, conductor 468 to the non-grounded terminal of battery B^2 and to ground G^2. The vertical-magnet, upon attracting its armature twice, raises the shaft 252 two steps, in the same manner that the previous selectors have operated their shafts, and places the connector-wipers 253, 254 and 255 opposite the first contacts of the second level of their corresponding banks. The calling subscriber then presses the rotary-button 30 once, grounds the rotary-line-conductor 414 once, energizes the rotary-line-relay 201 and the differential-relay 209 of the repeater R once, which former in turn grounds the rotary-trunk-conductor 434 once. The said conductor extending to the connector causes the rotary-line-relay 324 to become energized, the current in this last circuit flowing from ground G^8 to the rotary-trunk-conductor 434 and through the second-selector-side-switch-wiper 179, contact-point 177, conductor 475, rotary-line-wiper 175, trunk-conductor 464, rotary-line-relay 324, conductor 467 to the non-grounded terminal of battery B^2 and to ground G^2. The connector-line-relay-springs 321 and 326 being brought together, the private-magnet 281 is then energized by a current flowing from ground G^{18} through said springs 321 and 326, conductor 478, private-magnet 281, conductor 471 to the non-grounded terminal of battery B^2 and to ground G^2. The connector-private-magnet, being energized once, attracts its armature once, which permits the connector-side-switch to pass to second position, the side-switch-wiper 302 passing from the contact-point 306 onto the contact-point 307, and the side-switch-wiper 303 from the contact-point 309 onto the contact-point 310. The shifting of the side-switch-wiper 302 produces a change in circuits in the connector, so that when the vertical-button 29 is pressed ten times for the last digit the rotary-magnet 277, instead of the vertical-magnet 261, is operated when the springs 320 and 321 are brought into contact. Each time the springs 320 and 321 close together a circuit is established from ground G^{18} through the springs 321 and 320 and through the private-springs 291 and 290 to the side-switch-wiper 302, passing through which latter it extends to the contact-point 307, the conductor 480, thence through the rotary-magnet 277 to the non-grounded terminal of battery B^2 and to ground G^2. At each electrical pulsation in this circuit the rotary-magnet attracts its armature 278, rotating the shaft 252 one step at a time, sliding the wipers 253 and 254 along the second level of the banks which they engage. At the end of the tenth pulsation the wipers are moved onto the tenth contact-terminal of the second level of their banks. Then for the last time the rotary-button 30 is pressed once, and as a result the rotary-trunk-conductor 434 is grounded at the repeater R once by the method described. Again the rotary-line-relay 324 of the connector is energized once, the said relay in turn producing an operation of the private-magnet 281

that permits the side-switch to pass to third position with the side-switch-wipers 302, 303, 304 and 305 in connection with the contact-points 308, 311, 314 and 317, respectively. The engagement of the side-switch-wiper 303 with the contact-point 311 places a guarding potential at the private-wiper 255, and at the tenth private-contact of the second level of the private-bank 251, so as to preclude any other connector from establishing connection with the called line #2420. It will be understood, of course, that the same guarding potential exists at all other private-bank-contacts in multiple with the private-bank-contacts mentioned. The closure of contact between the side-switch-wipers 304 and 305 and contact-points 314 and 317, respectively, connects the extended subscriber's line-conductors 463 and 464 through the condensers 344 and 345 with the vertical and rotary line-wipers 253 and 254, and, therefore, with the normal-conductors 481 and 482 that constitute the terminals of the called sub-station #2420. The calling first-selector, it will be remembered, places a guarding potential over its own line at the connector-private-bank-contacts that correspond to the sub-station #7000, at the instant that the off-normal-spring 66 comes into contact with the grounded spring 68. Later, and at the instant that the connector seizes on the called subscriber's normal-conductors 481 and 482, the calling connector places a guarding potential over the called line at the instant that the side-switch-wiper 303 engages with the contact-point 311. Evidently, then, a line is protected by a guarding potential either when calling or when called—in the former case by operations in the first-selector, and in the latter case by the connector. The establishment of the guarding potential over the called line #2420 not only protects it from further seizure, but also forces a current through the bridge-cut-off-relay 350 of the called first-selector F^2, in order that the latter through its armature may separate the bridge-cut-off-relay-springs 351, 352 and 353. The separation of the said springs from each other destroys a bridged circuit through the vertical and rotary line-relays 354 and 355, that normally extends across the line-conductors 483 and 484, and at the same time interrupts a connection between said relays 354 and 355 and the non-grounded terminal of the battery B^2, which terminal is directly connected with the spring 353. Since the conductors 483 and 484 are included, one on each side of the main talking circuit, as will be hereafter disclosed, it is desirable, for obvious reasons, to remove all unnecessary bridges from across said conductors, and at the same time to remove all possibility of the vertical and rotary-line-relays being energized when a ringing current is supplied to the called sub-station, in order that no undesirable interruptions may take place thereby. The energizing circuit through the bridge-cut-off-relay 350 extends from ground G^{14} to the connector-side-switch-contact-point 311, side-switch-wiper 303, conductor 485, private-wiper 255, private-normal-conductor 486, spring 356, contact-point 357, conductor 487, bridge-cut-off-relay 350 to the non-grounded terminal of battery B^2 and to ground G^2. The connection between the calling and called line having been established, the calling party is then in a position to signal the called station by means of his signaling-button 12. But before going further it will be explained that if for any reason the called line is busy at the time that the calling subscriber grounds the rotary-line-conductor 414 for the last time to transfer the connector-side-switch from second to third position, the connector is released. For instance, if the line #2420 has been called by another connector, there will be a guarding potential at the tenth private-contact of the second level of the private-bank 251, corresponding to the line of the sub-station #2420. Or, on the other hand, if the first-selector F^2 of the called line is being used, and the shaft of said first-selector is off-normal as a result, the same private-bank-contact will be connected to ground from the instant that the normal-post-arm 358 permits the off-normal-spring 356 to engage with the grounded contact-point 359. Said guarding potential will reach the private bank of the connector by way of the private-normal-conductor 486. At any rate, if the private-wiper 255 finds a guarding potential at the tenth contact of the second level of the private-bank 251, at the instant that the calling subscriber grounds his rotary-line-conductor 414 for the last time, instead of the side-switch being tripped to third position the connector will be released, because the energization of the private-magnet 281 as a final result of grounding the rotary-line-conductor 414 sets up an energizing circuit through the release-magnet of the connector when the armature of the said private-magnet forces the springs 292 and 293 into contact. The energizing circuit through the releasing-magnet allows the current to flow from the grounded terminal of the battery B^2 to the tenth contact of the second level of the connector-private-bank 251, through the private-wiper 255, conductor 485, side-switch-wiper 303, contact-point 310, conductor 488, private-springs 292 and 293 and conductors 489 and 490, release-magnet 265, conductor 491 to the non-grounded terminal of battery B^2 and to ground G^2. The connector-release-magnet being energized, the release-armature 266 moves the double-dog 268 so that the lug 274 is caught and held in the aperture 276 on the end of the release-

link. Of course, when the double-dog is thus rotated, the locking-arm 272 is then withdrawn from the longitudinal teeth 257. Then the shaft is free to rotate back to its normal rotary position, by reason of the tension of the coiled spring 260, until the normal-post-arm 259 strikes the normal-post 343. At that instant the shaft-support 342 enters the slot 343b, and the said shaft of necessity falls to its normal position. The release-armature, when it rotates the double-dog 268, at the same time drives the side-switch to its first position, about the pivots of the latter, by means of the side-switch-link 301 and the release-arm 273. The latter, by pressing the former back forces the escapement-finger 295 back between the escapement-springs 283 and 284, which finger 295 is then caught behind the rearmost lower tooth 287 where it remains until the connector comes into use again. The restoration of the connector-shaft begins while the release-magnet 265 is in an energized state; but since the energizing circuit through said magnet comprises the private-wiper 255 and the side-switch-wiper 303, it will be evident that as soon as the shaft begins to rotate to its normal position the energizing circuit through the release-magnet 265 will be broken as soon as the said private-wiper 255 leaves the private-contact-point with which it has been engaged; and the same energizing circuit is also interrupted at the side-switch-wiper 303 when the latter is forced into its first position. The subscriber then thinking he has established connection, presses the signaling-button 12 at his sub-station, with the result that the spring 11 is separated from the contact point 10 and closed in connection with the grounded contact-point 35. The said spring 11 being in direct communication with the vertical-line-conductor 402, through the primary-springs 13 and 14, through the contact-point 31 and spring 33, it follows that the pressing of the button 12 grounds the vertical side of the line. The grounding of the vertical line causes the energizing of the connector-vertical-line-relay 318 in the usual manner, and since the connector-side-switch is in first position, the connector-vertical-magnet 261 is energized when the line-relay-springs 320 and 321 are pressed into contact through a circuit that is already familiar. As a result, and for reasons previously described, the shaft of the connector is raised and the springs 341 and 340 which it controls are brought into contact. The engagement of these two parts completes a busy circuit through which the busy signaling current is transmitted to the calling sub-station, which current may originate in any suitable apparatus, such, for example, as that represented at F, Fig. 2, which comprises a coil 343a in which the said busy current is induced. The subscriber, having been instructed, will understand from this signal that the line he desires is busy. This busy current passes from the coil 343a to the conductor 492, through the springs 341 and 340, conductor 493, contact-point 315, side-switch-wiper 305, springs 329 and 328, conductor 494, condenser 345, conductor 464, wiper 175, conductor 475, side-switch-wiper 179, trunk-conductor 434, winding 229 of the repeating-coil 225, condenser 231, winding 227 of the repeating-coil 224, trunk-conductor 432, wiper 166, conductor 466, wiper 174, trunk-conductor 463, vertical-line-relay 318, back to the coil 343a. This current is then induced in turn in the repeater-coils 228 and 226 whence it passes to the line-conductors 414 and 402, and through the primary winding 7, from which latter it passes to the secondary coil 17 and to the receiver 16. The subscriber will then restore his receiver to its switch-hook, thereby grounding both the line-conductors 402 and 414, as before described. The grounding of these two conductors causes a simultaneous energizing of the rotary and vertical line-relays 324 and 318 of the connector, which relays, attracting their armatures 325 and 319 simultaneously, permit the connector-trunk-release-springs 322 and 323 to come into contact. The engagement of said release-springs establishes an energizing circuit through the connector-release-magnet 265, and through the second-selector-back-release-relay 187, in which circuit the current flows from the ground terminal G^{12} to the second-selector-side-switch-contact-point 190, side-switch-wiper 188, second-selector back-release-relay 187, private-wiper 176, release-trunk-conductor 465, connector-release-springs 322 and 323, conductors 495 and 490, connector-release-magnet 265, conductor 491 to the non-grounded terminal of battery B^2 and to ground G^2. The release-magnet of the connector and back-release-relay of the second-selector S becoming energized, it will be evident that both the connector and the second-selector will be released in a familiar manner. Furthermore, the first-selector F^1 will also be released in a way that has also been pointed out. But it has been described that the calling subscriber did not find the line #2420 busy, and that he did complete his connection with said line. After so doing he presses his signaling-button 12 in the manner already stated, and thereby grounds the vertical-line-conductor 402. The grounding of said conductor energizes the vertical-line-relay 318 by means and circuits already familiar. Since the side-switch of the connector is in third position, and since the connector-side-switch-wiper 302 is in engagement with the contact-point 308, the engagement of the line-relay-springs 320 and 321 energizes the connector-ringer-relay 326. The

energizing current passes from ground G^{18} through the springs 321 and 320, private-springs 291 and 290, side-switch-wiper 302, contact-point 308, ringer-relay 326 to the non-grounded terminal of battery B^2 and to ground G^2. The ringer-relay-armature 327 then forces the ringer-relay-springs 329 and 332 onto the ringer-relay-generator-springs 330 and 333. A signaling current then passes out to the called subscriber's line from the ringer-generator J to the brush 344^a, springs 333 and 332, side-switch-wiper 304, contact-point 314, conductor 496, vertical-wiper 253, vertical-normal-conductor 481, vertical-line-conductor 483, spring 375, contact-point 376, switch-hook 377, spring 378, ringer 379, contact-point 380, spring 381, rotary-line-conductor 484, rotary-normal-conductor 482, rotary-wiper 254, conductor 497, contact-point 317, wiper 305, ringer-relay-springs 329 and 330 and brush 345^a to the ringer-generator J. The bell at the sub-station will be rung as long as the calling subscriber presses his button, but as soon as he releases said button the ringer-relay 326 will then be deënergized and the ringer-relay-springs will return to their normal positions. Then, if the subscriber at the called sub-station removes his receiver 382 from the hook 377, the primary-circuit-springs 383 and 384 will be brought into contact, and the ringer circuit will be opened as the switch-hook rises. At the instant that the primary-circuit-springs 383 and 384 close together, the transmitter 385 is energized by current from the local battery 386 through a circuit comprising said springs. The transmitters 9 and 385 of the sub-stations #7000 and #2420 being energized, and the receivers 16 and 382 being connected inductively, the subscribers are then in position to speak to each other. The voice of the talking individual at station #7000 striking the transmitter 9 produces very rapid fluctuations of the energizing current through said transmitter. Since the coils 218 and 200 are located between the vertical-line-conductor and the battery B^1, and the coils 219 and 201 between the rotary-line-conductor and the said battery, and since the repeating-coils 226 and 228 are bridged across the said line with the condenser 230 in series with them, it follows that the fluctuation of the current mentioned in the main circuit will produce disturbances in the electric circuit that will extend through the said repeater-coils and condenser. Such disturbances will be induced in the repeater-coils 227 and 229 in the well-known manner. These induced currents will pass through the receiver 382 and the connector-condensers 344 and 345. On the other hand the induced currents sent to the line-circuit from the sub-station #2420 from the secondary winding 390, because of the vibrations of the transmitter 385 when the called subscriber speaks, will reach the repeater-coils 227 and 229 through the same connector-condensers 344 and 345. These vibrations reproduced, then, in the coils 226 and 228 will be transmitted through the winding 7 of the induction-coil 8 at the sub-station #7000, and the coil 17 and receiver 16 will be affected in the usual manner. The circuit comprising the said primary winding 7 and the repeater-coils 226 and 228 extend as follows: From the winding 7 through the transmitter 9 to the vertical-line-conductor 402 through the side-switch-wiper 143 of the first-selector F^1, contact-point 157, vertical-line-wiper 53, trunk-conductor 421, repeater-coil 226, condenser 230, repeater-coil 228, trunk-conductor 422, rotary-line-wiper 54 of the first-selector, contact-point 158, side-switch-wiper 144, rotary-line-conductor 414, back to the coil 7. The circuit comprising the repeater-coils 227 and 229 and the receiver 382 may be traced from the condenser 231, through the repeater-coil 227, inter-exchange trunk-conductor 432, side-switch-wiper 166, contact-point 192, vertical-wiper 174, trunk-conductor 463, condenser 344, ringer-relay-springs 331 and 332, side-switch-wiper 304, contact-point 314, conductor 496, vertical-line-wiper 253, normal-conductor 481, line-conductor 483, secondary-circuit-springs 388 and 389, secondary winding 390 of the induction-coil 391, receiver 382, rotary-line-conductor 484, normal-conductor 482, wiper 254, contact-point 317, side-switch-wiper 305, ringer-relay-springs 329 and 328, condenser 345, rotary-trunk-conductor 464, rotary-line-wiper 175, contact-point 177, side-switch-wiper 179, trunk-conductor 434, repeating-coil 229 back to the condenser 231. After the two subscribers have communicated the exchange apparatus may be released if the calling subscriber restores his receiver to the switch-hook. The restoration occurs in the following manner: The calling subscriber upon restoring his receiver grounds both of his line-conductors and as a result, the winding 219 of the differential-relay 209 becomes short-circuited through ground, which short-circuit has been described. Of course, at once the current that has been flowing through said coil is cut off, and as a result the differential-relay 209 becomes energized. The repeater vertical and rotary line-relays being in an energized state at the same time, the trunk-release-springs 207 and 208 are forced into contact, while the differential-relay-springs 216 and 217 are in engagement. There, of course, immediately follows an energizing of the back-release-relay 81 of the first-selector, and as a result the energization of the release-magnet of the first-selector, also. It will be clear that the energizing of the repeater-differential-relay while the line-relays 200 and 201 are energized will momentarily and simultaneously put a ground

on both sides of the inter-exchange trunk-line. As soon as the vertical inter-exchange trunk-conductor 432 is grounded, the connector-vertical-line-relay 318 becomes energized. The rotary-trunk-conductor 434 being grounded the rotary-line-relay 324 also becomes energized. The trunk-release-springs 322 and 323 of the connector are thus held in contact, and the releasing energizing circuit through the connector-release-magnet 265 and through the back-release-relay 187 of the second-selector S is established with the result that the connector-release-magnet becomes energized, restoring the connector-side-switch and shaft. As soon as the connector-shaft is released the energizing circuit through the bridge-cut-off-relay 350 of the first-selector F^2 is destroyed and said first-selector is thus rendered operative at the hands of the subscriber at the sub-station #2420. Of course, at the same time that the connector-release-magnet 265 is energized the back-release-relay 187 of the second-selector also becomes energized, as already described, with the result that the release-magnet of the second-selector also becomes magnetized. All this occurs while the switch-hook of the calling subscriber is descending and while the release-springs 25, 26 and 27 are maintained in contact. But as soon as the release-cam clears the release-springs the ground to the vertical and rotary line-conductors 402 and 414 is destroyed. There follows immediately a restoration of the repeater-line-relays, and the repeater-differential-relay, which destroys the continuity of the energizing circuit through the first-selector-back-release-relay, which latter re-energizes and breaks the energizing circuit through the first-selector-release-magnet. It is clear, then, that the restoration of the first-selector follows. When the repeater-line-relays are restored the ground connections to the inter-exchange trunk-conductors are interrupted, the connector-line relays are deënergized, and as a result the release energizing circuit through the connector-release-magnet and the second-selector-back-release-relay is broken. Therefore, the second-selector is restored, as well as all of the magnets of the connector that have remained energized even after the side-switch and shaft have assumed their normal positions.

A practical arrangement of the exchanges with respect to each other which may be adhered to, but to which I do not confine myself is as follows: The sub-stations at central #1 are numbered from 6000 to 10,000, inclusive, and the subscribers of the exchange #2 from 1000 to 5999, inclusive. The first-selector-banks are provided with ten trunks from each level, as is customary, said trunks being common to all first-selectors of the same group. The trunks of each of the last five levels at exchange #1 terminate each in a second-selector; those of the sixth level in second-selectors of one group; those of the seventh level in second-selectors of a second group; those of the eighth in a third group, and so on through the tenth level. The second-selector-banks, of course, will have trunks from their levels arranged to correspond with suitable groups of connectors. The first five levels of the said first-selector-banks are given trunks similar to those of the last five levels, each of which trunks terminates in a repeater of the type described, and each repeater having permanently connected to it an inter-exchange trunk-line, as described. Each of said inter-exchange trunk lines terminates in the second-selector at exchange #2. The said repeater-trunks of each of the first five levels terminate in a different group of repeaters, one group to each level, and, therefore, with corresponding groups of second-selectors at exchange #2, which latter, it will be understood, are suitably arranged with respect to connector groups like the second-selectors of exchange #1. For calling from exchange #2 to exchange #1 a similar arrangement is followed in exchange #2, with the exception that in the said exchange #2 the last five levels are devoted to repeaters through which trunk-line connections are established to trunk-second-selectors at exchange #1. The first five levels, however, are devoted solely to local second-selectors.

It has been found in practice that good results are obtained when the repeater-line-relay-coils 200 and 201 are wound to a resistance of about 125 ohms, each the differential-relay-windings 218 and 219 to 250 ohms each, the auxiliary-relay 222 to 1000 ohms and the resistance-coil 220 to 350 ohms. It is evident that with a back-release-relay 81 of 1/2 ohm the resistance-coil 232 in the repeater of 60 ohms is essential in order to avoid an excessive rush of current through the said back-release-relay when a circuit is completed. Obviously, however, the resistance of the various relays and magnets and other coils can be varied or adjusted to suit the requirements of different cases.

Thus it will be seen that I provide a simple and highly efficient arrangement for establishing a trunk-line connection between a subscriber of a common battery automatic telephone exchange and a subscriber of a local battery automatic telephone exchange. The repeater R is capable not only of repeating the voice-currents from one circuit to another, but also of repeating from one circuit to the other the electrical impulses which are necessary for calling the number of the called subscriber, and which necessarily precede the establishment of the desired talking circuit and the propagation of the so-called voice-currents therein, caused

by the articulation of the two subscribers into their respective transmitters. During conversation between the two subscribers the so-called vertical and rotary line-relays of the repeater remain energized, but in this case only the vertical-line-relay is energized over a line-circuit, the so-called rotary-line-relay being simply energized through a local circuit. This is a trunk-release system, and in the absence of a release-magnet at the repeater the so-called dead-resistance-coil 232 is included in series with the release-relay 81 of the first-selector when the calling subscriber hangs up his receiver, and when the differential-relay 209 is energized in the manner previously described. The repeating-coils of the repeater efficiently repeat the voice-currents from one section of the talking circuit to the other, and the condensers interposed between these coils prevent the flow therethrough of battery current.

The different features and combinations constituting my invention may, however, as will be readily understood by those skilled in the art, be changed or modified more or less without in any way departing from the spirit of my invention.

It will be understood that the selectors herein described and illustrated can be of the general type disclosed in Patent No. 815,321, granted March 13, 1906, to Keith, Erickson & Erickson. It will also be understood that the connectors herein referred to can be of the general type disclosed in Patent No. 815,176, granted March 13, 1906, to Keith, Erickson & Erickson.

It will be seen that the energizing of the trunk-release-circuit through the release-relay 81 is dependent upon the simultaneous energizing of the differential and line relays of the repeater R. Consequently, it is necessary to preclude the energizing of the rotary-line-relay 201 when the differential-relay 209 and the vertical-line-relay 200 are necessarily energized by the pressure of the button 29 and the grounding of the vertical-line-conductor 402. In other words, these two relays must be thus energized in order to repeat the vertical-line impulses from one section of the circuit to the other, but at the same time the energizing of the rotary-line-relay 201 must be avoided in order to prevent a premature release of the first-selector. It will be seen that the circuit of this rotary-line-relay is purely local, except when the rotary-line-conductor is grounded in front of the differential-relay-winding 219, at the calling sub-station for instance, and it will also be seen that these two line-relays and the differential-relay conjointly control a normally-open low-resistance shunt extending around the high-resistance auxiliary-relay 222.

Thus it will be seen that the line-contacts of the first-selector are structurally and inductively connected with the line-contacts of the second-selector, through the medium of the repeating-coils. In other words, said repeating-coils are interposed between the two selectors, and constitute an inductive and structural connection between the two trunk-selecting switch mechanisms.

Broadly considered, it will be seen that I provide automatic means for use in uniting common battery lines of any suitable character with local battery lines of any suitable character. As illustrated, the common battery lines are automatic lines and the local battery lines are of the same character. Also, as shown, both the common battery and the local battery subscribers are provided with calling mechanisms for controlling the automatic switches. Obviously, however, this may be changed or modified, if desired, without departing from the spirit of my invention.

What I claim as my invention is:—

1. A telephone exchange system comprising a common battery automatic telephone exchange calling subscriber's line-circuit, a local battery automatic telephone exchange called subscriber's line-circuit, a trunk-line connection between the two line-circuits, and a repeater included in the said trunk-line connection, said repeater being provided with means for repeating voice-currents from the calling line to the called line, and also with means for repeating switch-operating impulses from the calling line to the trunk-line connection.

2. A telephone exchange system comprising a common battery automatic telephone exchange calling subscriber's line-circuit, a local battery automatic telephone exchange called subscriber's line-circuit, a trunk-line connection between the two line-circuits, and a repeater included in the said trunk-line connection, said repeater being provided with repeating-coils for repeating voice-currents from the calling line to the called line, and also with relays for repeating switch-operating impulses from the calling line to the trunk-line connection.

3. A telephone exchange system comprising a common battery automatic telephone exchange calling subscriber's line-circuit, a local battery automatic telephone exchange called subscriber's line-circuit, a trunk-line connection between the two line-circuits, and a repeater included in the said trunk-line connection, said repeater being provided with repeating-coils for repeating voice-currents from the calling line to the called line, and also with relays for repeating switch-operating impulses from the calling line to the trunk-line, together with condensers for stopping the flow of battery current through said repeating-coils.

4. A telephone system comprising a calling subscriber's line, a centralized source of

current for supplying current to the said line for both talking and switching purposes, a trunk-line, and a repeater in said trunk-line, said repeater being provided with relay means for establishing a flow of talking current in the said line as soon as connection is established with said trunk-line.

5. A telephone system comprising a calling subscriber's line, a trunk-line, and a repeater in said trunk-line, said repeater being provided with a normally-bridged differentially-wound relay for supplying talking current through its coils to the said line as soon as connection is established with the said trunk-line, and a centralized source of current for supplying electric current to the line for both talking and switching purposes.

6. A telephone system comprising a common battery automatic telephone exchange calling subscriber's line, a local battery automatic telephone exchange called subscriber's line, a centralized source of talking and switching current for the calling subscriber's line, a trunk-line connection between the two lines, and a repeater included in said trunk-line connection and provided with means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers.

7. A telephone system comprising a calling subscriber's line, a called subscriber's line, a centralized source of talking and switching current, subscriber-operated switching machinery for establishing a trunk-line connection between the two lines, and a repeater provided with means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers.

8. A telephone system comprising a calling subscriber's line, a called subscriber's line, and subscriber-operated apparatus including a connector provided with line contacts having vertical motion to select groups and rotary motion to find the called line in any selected group for establishing connection between the two lines, said apparatus also including a centralized talking battery for one subscriber only and relay means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers.

9. A telephone system comprising calling and called subscribers' lines, trunk-line connection between the two lines, and a repeater included in the trunk-line connection, said repeater being provided with a pair of line-relays, and an energizing circuit for each relay, the energizing circuit of one relay including the line of the calling subscriber, and the energizing circuit of the other relay being local.

10. A telephone system comprising calling and called subscribers' lines, trunk-line connection between the two lines, a repeater in the trunk-line connection, and a centralized source of talking and switching current, said repeater being provided with a pair of line-relays, and an energizing circuit for each relay, the energizing circuit of one relay including said source of current and the line of said calling subscriber, and the other energizing circuit being local.

11. A telephone system comprising a temporarily established talking circuit, a repeater provided with means for repeating voice-currents from one division of the talking circuit to another, and with means for repeating switch-operating impulses from one division of the circuit to another, together with means for establishing a flow of talking current in one end of the circuit before the other end of the circuit is closed.

12. A telephone system comprising two divisions of a talking circuit, repeating-coils inductively connecting one division of the circuit with the other, whereby voice-currents are repeated from one division to the other, subscriber-operated switches, a centralized source of current for operating said switches, and means for repeating switch-operating electric impulses from one division of the circuit to the other, together with means for establishing a flow of talking current in one division of the circuit before the other division is closed.

13. A telephone system comprising a repeater provided with a differential-relay, a pair of line-relays, a direct ground connection for supplying talking current to a calling line controlled by said differential-relay, a normally-open connection controlled by the three relays conjointly, each relay having permanent connection with the non-grounded pole of the said battery.

14. A telephone system comprising a line-circuit, a differential-relay provided with a pair of windings, a pair of line-relays, a permanently closed bridge across said line-circuit, said bridge including the coils of said line-relays connected in series between the said windings of the said differential-relay, a battery having one pole grounded, and a permanent connection between all of said relay-coils and the non-grounded pole of said battery.

15. A telephone system comprising a trunk-line, a repeater at the end of said trunk-line, and a centralized source of talking and switching current, said repeater being provided with a bridged differentially-wound relay, a pair of bridged line-relays, a dead resistance, an impedance-coil, and an auxiliary-relay, the windings of said resistance and relays being all permanently connected with the non-grounded pole of said source of current.

16. A telephone system comprising a

trunk-selecting switch mechanism provided with a release-relay, a repeater provided with an auxiliary-relay, a battery, a temporarily closed circuit including said release-relay and auxiliary-relay, the said auxiliary-relay being of sufficiently high resistance to prevent the release-relay from energizing, a normally-open low-resistance shunt extending around said auxiliary relay, and subscriber operated differential and line relays controlling the continuity of said shunt.

17. A telephone system comprising a trunk-selecting switch mechanism provided with a release-relay, a trunk-release energizing circuit for said relay, a source of current, a high resistance relay in said circuit, a normally-open low-resistance shunt extending around said high-resistance relay, and subscriber controlled means for closing said shunt and thereby sufficiently reducing the resistance of said circuit to permit the said release-relay to become energized.

18. A telephone system comprising a trunk-release circuit, two normally-open switch-points in said circuit, a differential-relay for controlling one of said switch-points, so-called vertical and rotary line-relays for controlling the other switch-point, a vertical-line-conductor, subscriber-operated means for grounding said conductor, a battery for energizing the differential-relay and the said vertical-line-relay when the said vertical-line-conductor is grounded, a local circuit for the said rotary-line-relay, and connections whereby the said local circuit is opened when the said differential-relay and vertical-line-relay are energized by the grounding of the vertical-line-conductor.

19. A telephone system comprising a trunk-selecting switch mechanism provided with a release-relay, a repeater provided with an auxiliary-relay, a battery, a temporarily closed circuit including said release-relay and auxiliary-relay, the said auxiliary-relay being of sufficiently high resistance to prevent the release-relay from energizing, a normally-open low-resistance shunt extending around said auxiliary-relay, and subscriber-controlled relays for closing said shunt and thereby sufficiently decreasing the resistance of said circuit to energize said release-relay, the said system also comprising subscriber-operated electric-impulse-transmitters for sending the impulses representing any called subscriber's number.

20. A telephone exchange system comprising a common battery automatic telephone exchange calling subscriber's line-circuit, a local battery automatic telephone exchange called subscriber's line-circuit, a trunk-line connection between the two line-circuits, and a repeater included in the said trunk-line connection, said repeater being provided with repeating-coils for repeating voice-currents from the calling line to the called line, and also with relays for repeating switch-operating impulses from the calling line to the trunk-line connection, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

21. A telephone exchange system comprising a common battery automatic telephone exchange calling subscriber's line-circuit, a local battery automatic telephone exchange called subscriber's line-circuit, a trunk-line connection between the two line-circuits, and a repeater included in the said trunk-line connection, said repeater being provided with repeating-coils for repeating voice-currents from the calling line to the called line, and also with relays for repeating switch-operating impulses from the calling line to the trunk-line, together with condensers for stopping the flow of battery current through said repeating-coils, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

22. A telephone system comprising a calling subscriber's line, a centralized source of current for supplying current to the said line for both talking and switching purposes, a trunk-line, and a repeater at the end of said trunk-line, said repeater being provided with relay means for establishing a flow of talking current in the said line as soon as connection is established with the other end of said trunk-line, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

23. A telephone system comprising a calling subscriber's line, a trunk-line, and a repeater at the end of said trunk-line, said repeater being provided with a normally bridged differentially-wound relay for supplying talking current through its coils to the said line as soon as connection is established with the other end of said trunk-line, and a centralized source of current for supplying electric current to the line for both talking and switching purposes, the said system also comprising common-battery

transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

24. A telephone system comprising a common battery automatic telephone exchange calling subscriber's line, a local battery automatic telephone exchange called subscriber's line, a centralized source of talking and switching current for the calling subscriber's line, a trunk-line connection between the two lines, and a repeater included in said trunk-line connection and provided with means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

25. A telephone system comprising a calling subscriber's line, a called subscriber's line, a centralized source of talking and switching current, subscriber-operated switching machinery for establishing a trunk-line connection between the two lines, and a repeater provided with means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

26. A telephone system comprising a calling subscriber's line, a called subscriber's line, and subscriber-operated apparatus for establishing connection between the two lines, said apparatus including suitable relay means for establishing a flow of talking current in the calling subscriber's line before the called subscriber answers, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

27. A telephone system comprising calling and called subscribers' lines, trunk-line connection between the two lines, and a repeater included in the trunk-line connection, said repeater being provided with a pair of line-relays, and an energizing circuit for each relay, the energizing circuit of one relay including the line of the calling subscriber, and the energizing circuit of the other relay being local, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

28. A telephone system comprising calling and called subscribers' lines, trunk-line connection between the two lines, a repeater in the trunk-line connection, and a centralized source of talking and switching current, said repeater being provided with a pair of line-relays, and an energizing circuit for each relay, the energizing circuit of one relay including said source of current and the line of said calling subscriber, and the other energizing circuit being local, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

29. A telephone system comprising a temporarily established talking circuit, a repeater provided with means for repeating voice-currents from one division of the talking circuit to another, and with means for repeating switch-operating impulses from one division of the circuit to another, together with means for establishing a flow of talking current in one end of the circuit before the other end of the circuit is closed, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

30. A telephone system comprising two divisions of a talking circuit, repeating-coils inductively connecting one division of the circuit with the other, whereby voice-currents are repeated from one division to the other, subscriber-operated switches, a centralized source of current for operating said switches, and means for repeating switch-operating electric impulses from one division of the circuit to the other, together with means for establishing a flow of talking current in one division of the circuit before the other division is closed, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling

the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

31. A telephone system comprising a calling first-selector provided with a release-relay, a repeater provided with a dead resistance and a normally-open connection, a battery connected with said normally-open connection, and a release-circuit for said selector, said release-circuit including said dead resistance and normally-open connection and release-relay and battery in series, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

32. A telephone system comprising a calling first-selector provided with a release-relay temporarily connected to ground, a battery, a repeater provided with a normally-open connection at one pole of said battery, the other pole of the battery being grounded, the repeater having also a dead resistance, a trunk-line-conductor between the selector and repeater, and a release-circuit for the selector, said circuit including the release-relay and trunk-line-conductor and normally-open connection and dead resistance and battery in series, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

33. A telephone system comprising a repeater provided with a differential-relay, a pair of line-relays, a ground connection controlled by said differential-relay, a normally-open connection controlled by the three relays conjointly, each relay having permanent connection with the non-grounded pole of the said battery, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

34. A telephone system comprising a line-circuit, a differential-relay provided with a pair of windings, a pair of line-relays, a permanently closed bridge across said line-circuit, said bridge including the coils of said line-relays connected in series between the said windings of the said differential-relay, a battery having one pole grounded, and a permanent connection between all of said relay-coils and the non-grounded pole of said battery, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

35. A telephone system comprising a trunk-line, a repeater at the end of said trunk-line, and a centralized source of talking and switching current, said repeater being provided with a bridged differentially-wound relay, a pair of bridged line-relays, a dead resistance, an impedance-coil, and an auxiliary-relay, the windings of said resistance and relays being all permanently connected with the non-grounded pole of said source of current, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

36. A telephone system comprising calling and called subscribers' lines, a trunk-line connection between the lines, a repeater in the trunk-line connection, and means for supplying all necessary current, said repeater having repeating-coils for inductively transmitting voice-currents, relays for repeating switch-operating electric impulses, and a differentially-wound relay for use by the calling subscriber in releasing, said differentially-wound relay having two windings permanently connected with the non-grounded pole of said source of current, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

37. A telephone system comprising a selector provided with a release-relay, an energizing circuit for said relay, and a repeater operative by itself to control said circuit for releasing purposes, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

38. A telephone system comprising a subscriber-operated trunk-selecting switch

mechanism provided with a release-relay, an energizing circuit for said relay, and a repeater, together with a source of operating current, said circuit having two normally-open switch-points controlled by said trunk-selecting switch mechanism, and having also two other normally-open switch-points controlled by said repeater, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

39. A telephone system comprising a trunk-selecting switch mechanism provided with a release-relay, a repeater provided with an auxiliary-relay, a battery, a temporarily closed circuit including said release-relay and auxiliary-relay, the said auxiliary-relay being of sufficiently high resistance to prevent the release-relay from energizing, a normally-open low-resistance shunt extending around said auxiliary-relay, and subscriber-controlled relays for closing said shunt and thereby sufficiently decreasing the resistance of said circuit to energize said release-relay, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

40. A telephone system comprising a trunk-selecting switch mechanism provided with a release-relay, a repeater provided with an auxiliary-relay, a battery, a temporarily closed circuit including said release-relay and auxiliary-relay, the said auxiliary-relay, being of sufficiently high resistance to prevent the release-relay from energizing, a normally-open low-resistance shunt extending around said auxiliary-relay, and subscriber-operated differential and line relays controlling the continuity of said shunt, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

41. A telephone system comprising a trunk-selecting switch mechanism provided with a release-relay, a trunk-release energizing circuit for said relay, a source of current, a high-resistance relay in said circuit, a normally-open low-resistance shunt extending around said high-resistance relay, and subscriber-controlled means for closing said shunt and thereby sufficiently reducing the resistance of said circuit to permit the said release-relay to become energized, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

42. A telephone system comprising a trunk-release circuit, two normally-open switch-points in said circuit, a differential-relay for controlling one of said switch-points, so-called vertical and rotary line-relays for controlling the other switch-point, a vertical-line-conductor, subscriber-operated means for grounding said conductor, a battery for energizing the differential-relay and the said vertical-line-relay when the said vertical-line-conductor is grounded, a local circuit for the said rotary-line-relay, and connections whereby the said local circuit is opened when the said differential-relay and vertical-line-relay are energized by the grounding of the vertical-line-conductor, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

43. A telephone system comprising a trunk-release circuit, three relays conjointly controlling said circuit the energizing of said circuit for release purposes being dependent upon the simultaneous energizing of said relays, line-circuits also controlled by said relays, and means precluding the energization of one of said relays when the other two are necessarily energized for the purpose of closing one of said line-circuits, the said system also comprising common-battery transmitters, subscriber-operated ringing keys controlling the flow of talking current through said transmitters, local-battery transmitters, and circuits therefor, and subscriber-operated ringing keys excluded from the local circuits of said last-mentioned transmitters.

44. A telephone system comprising a line-circuit, a repeater in said circuit dividing the latter into two inductively connected sections, each section having a vertical and a rotary side, said repeater having also a circuit connection between the vertical side of one of the said circuit sections and ground comprising two normally-open contact-points, and another circuit connection between the rotary side of the same circuit section and ground and also comprising two normally-open contact-points, two line-relays and a differential-relay controlling said

normally-open switch-points, means whereby when the differential-relay is energized together with one of said relays one of the normally-open circuit connections to ground is closed, and means whereby when said differential-relay is energized with the other of said relays the other of said circuit connections is closed.

45. A telephone system comprising a line-circuit including a trunk-line, a repeater located in said line-circuit at the terminal of the trunk-line, the latter having a vertical and a rotary side, ground connections, said repeater being provided with a differential-relay and two line-relays controlling said ground connections through the medium of two normally open contacts, means whereby when the differential-relay and one of the line-relays are energized simultaneously a ground connection is established between the vertical side of the said trunk-line to ground, and means whereby when the said differential-relay and the other of the said line-relays are energized simultaneously a ground connection is established between the rotary side of the trunk-line and ground.

46. A telephone system comprising a subscriber's line having vertical and rotary line-conductors, a repeater, a trunk-line at the terminal of said repeater, said trunk-line being similar to the subscriber's line, said repeater having a differential-relay, a vertical-line-relay and a rotary-line-relay, a subscriber's calling apparatus for sending ground electric pulsations over the vertical or rotary line-conductors, means whereby each time that the vertical-line-conductor is grounded the said vertical-line-relay is energized with the differential-relay to reproduce the ground impulses in the vertical-trunk-line-conductor, means for deënergizing the rotary-line-relay at the same time, and means whereby when the rotary-line-conductor is grounded the differential-relay is energized to reproduce the ground impulses in the rotary-trunk-line-conductor.

47. A telephone system comprising a central battery, a subscriber's line and means for grounding the same at the subscriber's telephone, a repeater having a differential-relay and a line-relay one end of which is permanently connected to the non-grounded terminal of the battery and which is provided with two energizing circuits one controlled by the differential-relay and the other directly by the subscriber.

48. A telephone system comprising a line-circuit, a line-relay, a line energizing circuit for said relay, a local energizing circuit for said relay, means whereby the relay is energized over the local circuit for calling purposes, and means whereby the relay is energized over the line-circuit for release purposes.

49. A telephone system comprising a subscriber-controlled switch mechanism provided with a rotatable and vertically-movable switch-shaft, means including a line-relay for accomplishing the rotary motion of said switch-shaft, switch-releasing means controlled by said relay, a line-circuit for said relay, a local circuit for said relay, means whereby the relay is energized over the local circuit to accomplish the rotation of the switch-shaft, and means whereby the said relay is energized over the line-circuit for releasing purposes.

50. A telephone system comprising a line-circuit, a differential-relay bridged across the line-circuit, and means including said differential-relay and contingent upon the energization thereof for grounding first one side and then the other of said line-circuit to transmit electrical impulses thereover, together with automatic switching machinery connected to receive and be operated by said impulses.

51. A telephone system comprising automatic trunk-selecting switch mechanism, a line-circuit leading to said mechanism, a differential-relay bridged across the line-circuit, and subscriber-controlled means contingent on the energization of said relay for grounding first one side of said circuit and then the other to transmit the electrical impulses for operating said mechanism.

52. A telephone system comprising a trunk-selecting switch mechanism provided with a rotatable switching means, a rotary-line-relay controlling the rotary motion of said switching means, and a subscriber-controlled local circuit for energizing said relay, said rotary line relay included in a repeater associated with said switch mechanism, and a differential relay for said repeater for transmitting impulses to operate said switch mechanism.

53. In a telephone exchange system, the combination of telephone lines, automatic means for trunking a calling line into connection with a called line, relays for repeating the switch-operated electrical impulses, repeating coils for transmitting the voice-currents, a common battery for supplying talking current to the line of the calling subscriber, and a local battery for the called line.

54. In a telephone exchange system, the combination of telephone lines, a common battery for the calling subscribers, local batteries for the called subscribers, means for repeating electrical impulses for operating the automatic switches, and repeating coils for transmitting the voice-currents.

55. In a telephone system, local and common battery subscribers' lines divided into groups, trunk lines divided into groups, automatic switches having one motion to select groups and a second motion to connect with a line in the selected group for extending a

connection from a calling to a called line, and means for establishing a flow of talking current in the calling line before the called line is found.

56. In a telephone system, the combination of switches having vertical and rotary motion for extending connection from a calling line to a called line, and means acting subsequent to the calling of the first digit of the called number to establish a flow of talking current in the calling line before the called line is found.

57. In a telephone system, including local and common battery subscribers, the combination of switches having vertical and rotary motion for extending connection from a calling line to a called line, the vertical motion to select groups and the rotary motion to connect with a line in any selected group, and means controlled only by the calling subscriber for supplying talking current to the calling line.

58. In a telephone system, the combination of switches having vertical and rotary motion for finding the called line, a repeater for controlling the supply of talking current to the calling line, and means by which the called subscriber answers without disturbing the current conditions in the calling line.

59. In a telephone system, including local, and common battery subscribers, the combination of automatic trunking apparatus having vertical motion to select groups and rotary motion to connect with a line in any selected group, and central means controlled only by the calling subscriber for supplying talking current to the calling line.

60. In a telephone system, subscribers' lines and trunk lines divided into groups, automatic switches having one motion to select groups and a second motion to connect with a line in the selected group for extending a connection from a calling line to a called line, bridges across the conductors of the talking circuit, said bridges including operating elements for said switches, means for automatically reducing the number of said bridges between the calling and called subscribers' lines, and means for establishing a flow of talking current in the calling line before the called line is found.

61. In a telephone system, subscribers' lines and trunk lines divided into groups, automatic switches having one motion to select groups and a second motion to connect with a line in the selected group for extending a connection from a calling line to a called line, a plurality of bridges across the conductors of the talking circuit, said bridges including operating elements for said automatic switches, means for automatically reducing the number of said bridges, and means controlled only by the calling subscriber for supplying talking current to the calling line.

62. In an automatic telephone system, the combination of common battery lines; stations thereon; a central source of current; each of said common battery stations having a receiver and transmitter; said transmitters being in series with said central source of current; and local battery lines; local battery stations thereon; each local battery station having a receiver and transmitter, each of said transmitters being in series with a local source of current; and automatic means for uniting said common battery lines and said local battery lines for conversational purposes.

63. In an automatic telephone system, the combination of common battery lines; stations thereon; a central source of current; each of said common battery stations having a receiver and transmitter; said transmitters being in series with said central source of current; and local battery lines; local battery stations thereon; each local battery station having a receiver and transmitter, each of said transmitters being in series with a local source of current; automatic means for uniting said common battery lines and said local battery lines for conversational purposes; and subscribers' calling mechanisms by which said automatic means are controlled over the common battery lines.

64. In an automatic telephone system, the combination of common battery lines; stations thereon; a central source of current; each of said common battery stations having a receiver and transmitter; said transmitters being in series with said central source of current; and local battery lines; local battery stations thereon; each local battery station having a receiver and transmitter, each of said transmitters being in series with a local source of current; automatic means for uniting said common battery lines and said local battery lines for conversational purposes; and subscribers' calling mechanisms by which said automatic means are controlled over the local battery lines.

65. In an automatic telephone system, the combination of common battery lines; stations thereon; a central source of current; each of said common battery stations having a receiver and transmitter; said transmitters being in series with said central source of current; and local battery lines; local battery stations thereon; each local battery station having a receiver and transmitter, each of said transmitters being in series with a local source of current; and automatic means for uniting said common battery lines and said local battery lines for conversational purposes; the said automatic means comprising a repeater having provisions for feeding talking current to calling common battery lines.

66. In an automatic telephone system, the combination of common battery lines; sta-

tions thereon; a central source of current; each of said common battery stations having a receiver and transmitter; said transmitters being in series with said central source of current; and local battery lines; local battery stations thereon; each local battery station having a receiver and transmitter, each of said transmitters being in series with a local source of current; and automatic means for uniting said common battery lines and said local battery lines for conversational purposes; said automatic means comprising a set of repeating coils for use between common battery and local battery lines.

67. In a telephone system including local and common battery subscribers' lines, automatic switches for establishing connection between two of said lines, and means for establishing a flow of current in the calling line before the called line is found.

68. In a telephone system, a centralized source of current for operating and talking purposes, a trunk, a repeater in said trunk for supplying talking current to a calling line as soon as connection is established with said trunk.

Signed by me at Chicago, Cook county, Illinois, this 8th day of January, 1906.

TALBOT G. MARTIN.

Witnesses:
EDW. D. FALES,
BERNARD D. WILLIS.