B. D. WILLIS.

AUTOMATIC TELEPHONE SYSTEM.

APPLICATION FILED SEPT. 19, 1917.

1,318,004.

Patented Oct. 7, 1919.

4 SHEETS—SHEET 1.

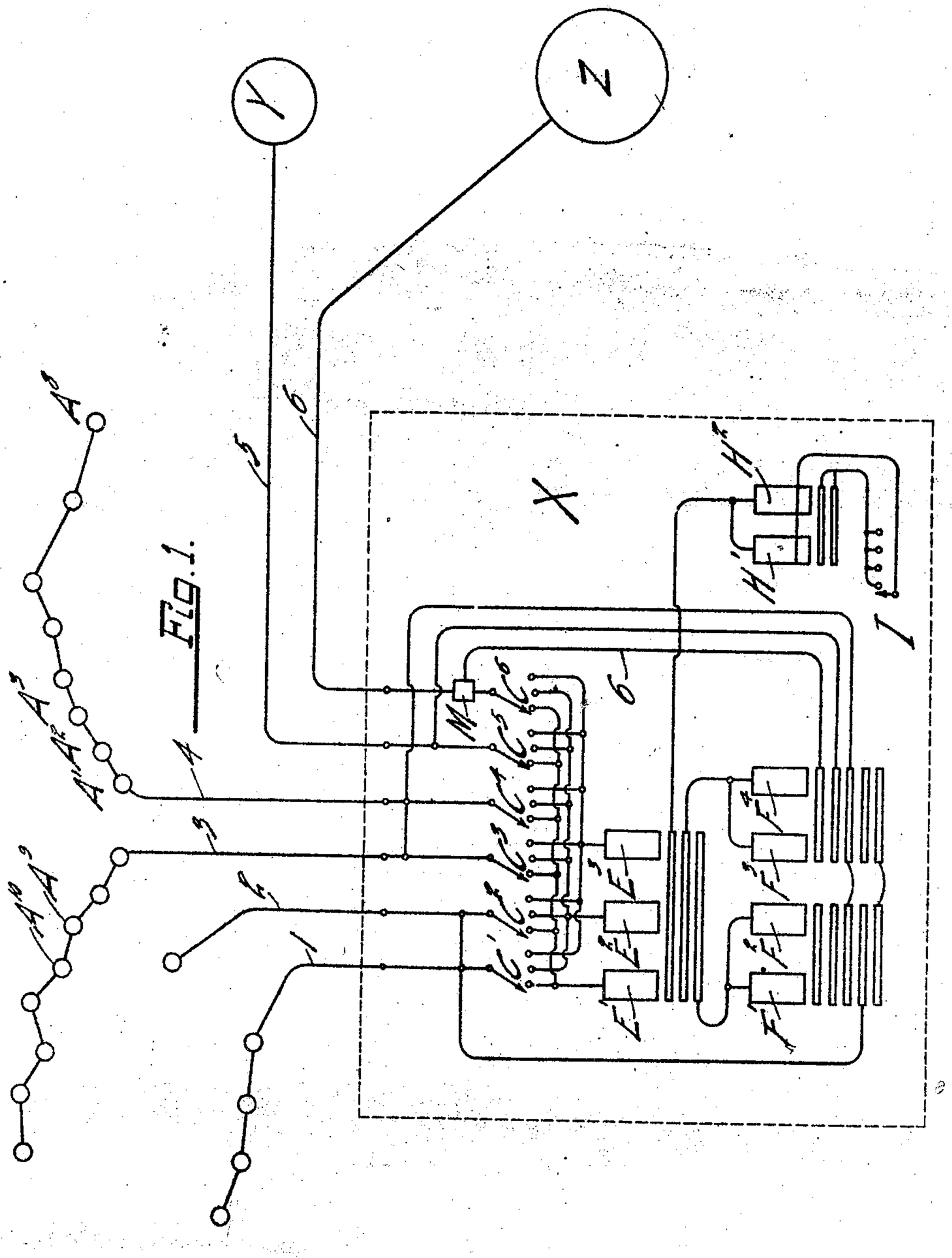

Fig. 1.

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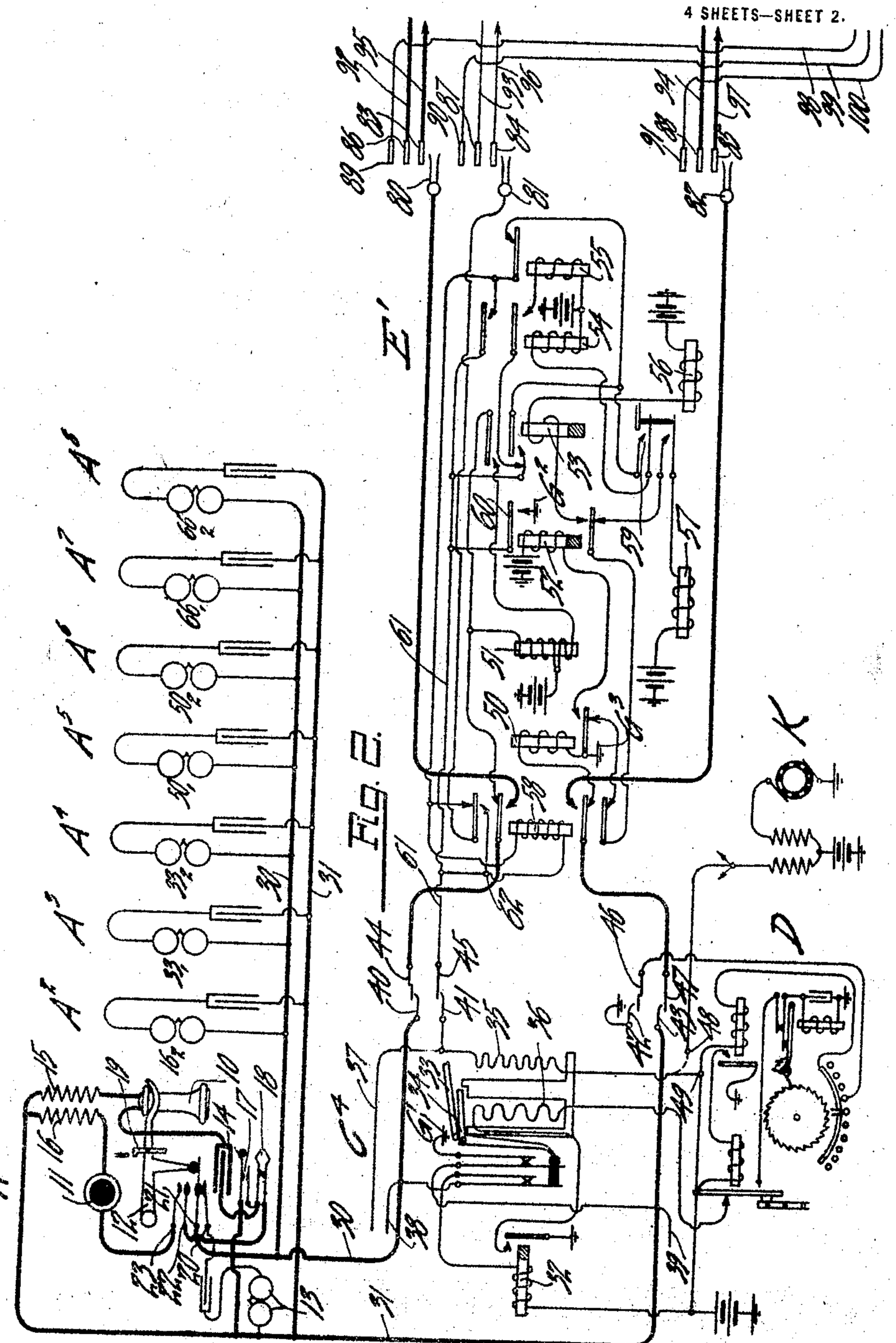

FIG. 2.

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4 SHEETS—SHEET 3.

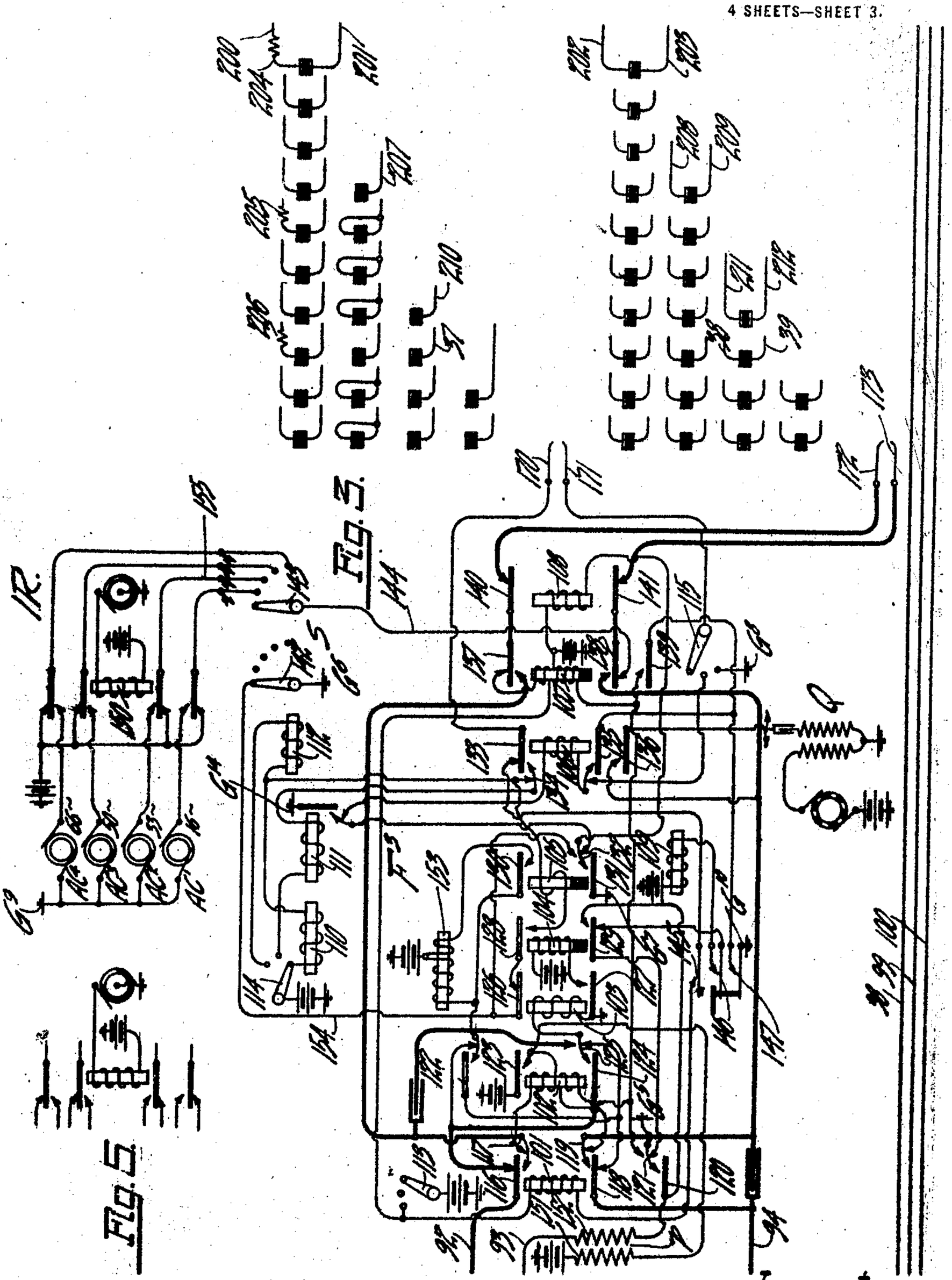

Fig. 5.

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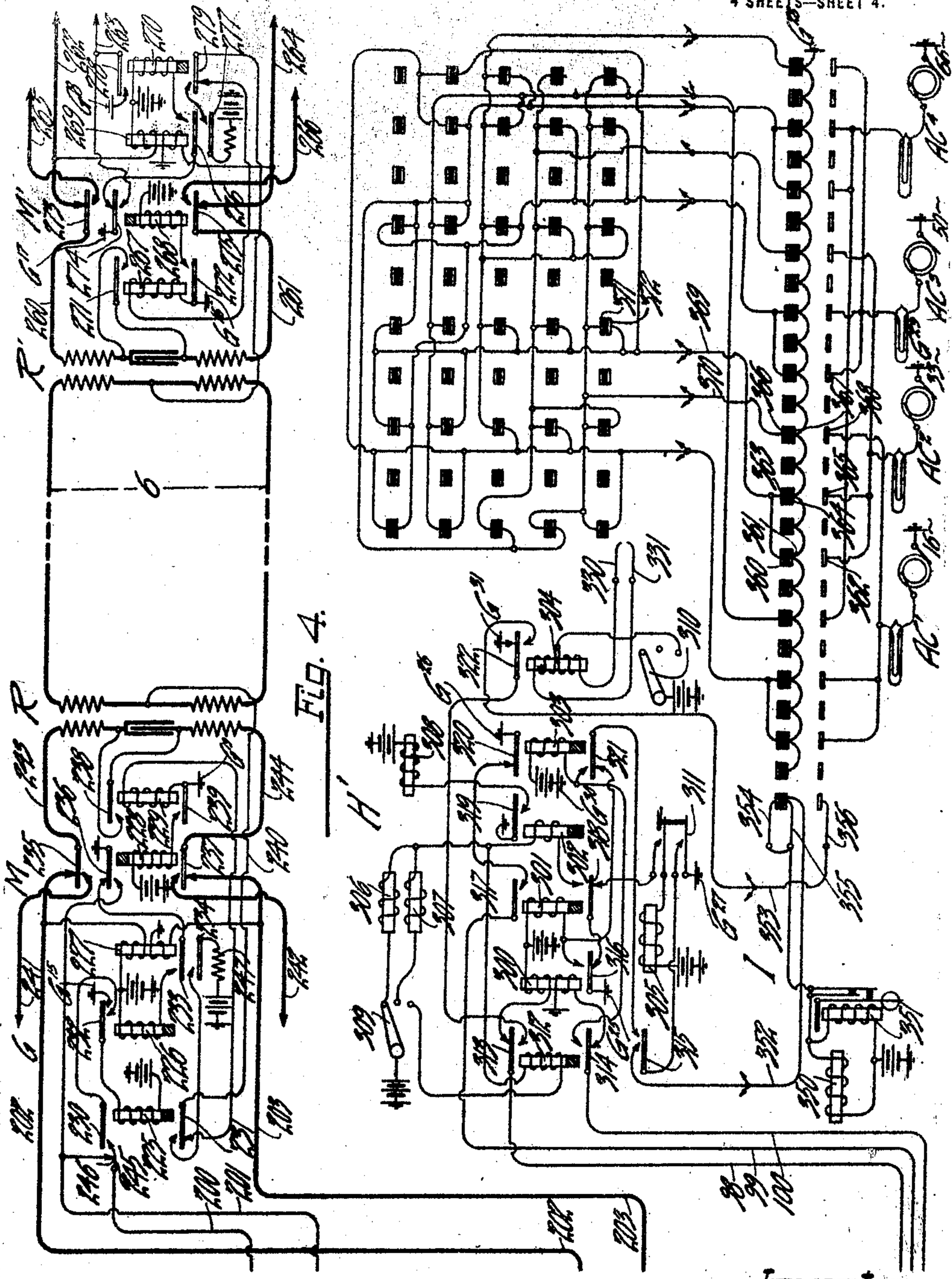

Fig. 4.

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UNITED STATES PATENT OFFICE.

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AUTOMATIC TELEPHONE SYSTEM.

1,318,004. Specification of Letters Patent. Patented Oct. 7, 1919.

Application filed September 19, 1917. Serial No. 192,135.

To all whom it may concern.

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

My invention relates to automatic telephone systems, and involves a number of separate features, many of which are applicable to automatic systems in general, but which are especially valuable in a particular type of system which I term a "mixed service system." The distinguishing characteristics of such systems together with the improvements provided by my invention, their fuctions and operation, will be described fully hereinafter, reference being had to the accompanying drawings.

In the drawings, Figure 1 is a schematic diagram or trunking layout of a typical mixed service system; Figs. 2, 3 and 4 are circuit drawings of the essential features of the system shown in Fig. 1; while Fig. 5 is a detail of a portion of the ringing equipment.

Referring to Fig. 1, an automatic exchange such as the one shown within the rectangle and indicated by the reference character X is suitable for a small town of perhaps a thousand inhabitants, which may be the center of a well populated rural community. Within the town and within a limited radius outside there may be a number of private or individual lines, such as the line 2, and a number of four party lines, such as the line 1. Persons living at remoter points are not usually given such a high quality of service, being generally connected in larger numbers on so called farmer lines or rural lines. Two such lines as this are the eight party lines 3 and 4. While only a few lines are shown it will be understood that there will be many more radiating in all directions from the exchange X as a common center.

At still greater distances there may be other small centers of population, each with its system of telephone lines diverging from a central exchange; and there will inevitably also be larger centers of population or cities within range of telephonic communication. The smaller towns may be supplied with telephone service by mixed service automatic systems such as the one disclosed herein, or they may have small manual exchanges. Either large multiple manual switch boards, or modern full automatic systems may be used in the cities, depending upon the stage of development that has been reached by the company operating in the particular community. Whatever the character of the equipment used, these other exchanges may be connected with the exchange X by means of trunk lines, two of which, extending to two different exchanges, are shown in the drawing. There may be many more exchanges than the two shown, and a plurality of trunk lines extending to each, but since the trunks may all be included in two classes, manual and automatic, the two shown will be sufficient for purposes of illustration. Thus the trunk line 5 is one of a group of trunks connecting the exchange X with the small manual exchange Y, while the trunk line 6 is one of a group which extends to the large automatic exchange Z.

All lines entering the exchange X, whether individual lines, party lines, or trunk lines, terminate in individual line switches or trunk selectors. These switches are indicated in the drawing by reference characters C^1 to C^6, inclusive. The line switches have common access to a group of trunk lines extending to first selector switches, three of which are the selectors E', E^2, and E^3, and have the well known function of extending calling lines to idle ones of these selectors. The banks of the selectors are all multipled together and form terminals of trunk lines extending to connector switches which have access to called lines. The connectors are divided into two groups, whether the number of lines in the system exceeds the capacity of a single group of connectors or not. Thus the connectors F^1 and F^2 are included in one group, while connectors F^3 and F^4 are included in the second group. The trunk lines terminating in one group of connectors preferably extend from the first level of the selectors while the second level may be assigned to the trunks terminating in the other group. It will be understood, of course, that the "levels" referred to are the bank levels of the well known Strowger type of switches. Only the three lower selector levels are shown in the drawing and the five upper connector levels. The arrangement of these latter is as follows: The

upper or tenth level in one or both groups of connectors is reserved for the groups of trunk lines extending to other automatic exchanges. These trunk line groups must all terminate in a particular level or levels on account of a switching operation necessary to be performed at the connectors on calls to other automatic exchanges, and this switching operation is most convenient at the tenth level. The groups of trunk lines extending to manual exchanges may terminate indiscriminately in any of the connector levels not otherwise occupied; they may be assigned to particular levels separate from the other lines, or a group of trunk lines may occupy the same level with individual or party lines. However, for convenience it will be assumed that the manual trunk lines terminate in the ninth level of the second group of connectors.

In order to take care of the eight party lines, certain corresponding levels in both groups of connectors, designated in the drawing as the sixth and eighth levels, are multipled together. This is necessary on account of the selective ringing and it may be mentioned that the necessity of providing for selectively ringing the substations on the eight party lines is the prime reason for dividing the connectors into two groups. The connectors of each group are provided with means for selecting any one of the four standard frequencies of ringing current as used in well known harmonic signaling systems. This arrangement would of course provide for only four stations on each line and in order to increase the number to eight per line, each line is multipled in the banks of both groups of connectors as above mentioned. The ringing equipment associated with one of the connector groups is adapted to give the bell at a selected substation a single ring repeated at regular intervals; while the ringing equipment associated with the other group of connectors is adapted to give two rings separated by a short interval and repeated at longer intervals. This is the well known one and two bell selective ringing system. It will be seen that by a combination of the two methods eight stations on a line may be selectively signaled.

It will be understood that only those levels which are reserved for eight party lines are multipled between the two connector groups. In the remaining levels in each group are terminated all the other lines entering the exchange, including the individual lines such as the line 2 and the four party lines such as the line 1.

In any automatic system which contains party lines, means must ordinarily be provided to enable subscribers to signal other subscribers on the same line. For this purpose I provide ring back switches, two of which are indicated by reference characters H^1 and H^2, and a common single motion ringing switch, indicated by reference character I. The ring back switches may be accessible to subscribers' lines via the third level of the first selectors as shown.

It is believed that the foregoing description will be sufficient to enable the general layout of the system to be understood. A brief description of the apparatus indicated in the circuit drawings will now be given, after which the operation will be explained in detail.

The line shown in Fig. 2 comprising conductors 30 and 31 is an eight party line and the substations A^1 to A^8, inclusive, are connected in bridge thereof in the usual manner. Of these eight substations only substation A^1 is shown complete, the other seven being indicated simply by a ringer and condenser bridge across the line. The substation A^1 is similar to the substation shown in the application of John Erickson, Serial No. 130,528, filed November 10, 1916, except that the circuits are modified for use in a common battery system. It comprises essentially the receiver 10, transmitter 11, switch hook 12, ringer 13, condenser 14 and induction coil having the windings 15 and 16. The switch hook 12 is provided with a locking lever 19 which is adapted to hold the switch hook in an intermediate position when the receiver is removed. In the intermediate position of the switch-hook contact springs 20 and 21 are separated to open the signaling bridge while contact springs 21 and 22 are closed, whereby the receiver 10 is bridged across the line to enable the subscriber to listen and determine whether or not the line is in use. If the line is idle the locking lever 19 is released by hand and the switch hook is permitted to rise to its final position, thus connecting the transmitter 11 across the line also. This feature of the substation is fully disclosed in the application of Erickson above referred to. Being an automatic substation there is also provided a calling device of which only the impulse springs 18 and shunt springs 17 are shown herein. This calling device may be similar to the one disclosed in the patent to Dicker No. 29,654 of 1910. The ringers at the different substations are tuned to respond to different frequencies of ringing current, there being two ringers which are adapted to respond to each frequency. Thus the ringers at substations A^1 and A^2 respond to the 16 cycle ringing current while the ringers at substations A^3 and A^4 respond to 33 cycle ringing current, etc. The subscribers at substation A^1 and A^3, however, only respond when a "one bell" signal is received, while the subscribers at substations A^2 and A^4 respond only to "two bell" signals.

At the exchange the line conductors 30 and 31 terminate in the individual line

switch C^4. This line switch may be of the general type disclosed in the British patent to James No. 26,301 of 1906; being, however, of the particular type shown in U. S. Letters Patent No. 1,078,690, granted January 19, 1912, to Frank Newforth. Through the medium of line switch C^4 the party line shown is given access to a plurality of selector switches as has already been explained.

The line switch C^4 and a plurality of similar line switches are controlled in their trunk selecting operations by means of a master switch D. The master switch D is of the general type of master switch disclosed in the above mentioned British patent to James No. 26,301 of 1906, being, however, more nearly of the particular type disclosed in the British patent to Martin #1419 of 1910. As is well known the function of the master switch is to maintain the plungers of all the idle line switches which it controls in position before the terminals of an idle trunk line.

One of the trunk lines to which the line switch C^4 has access is shown in the drawing extended to the first selector E′ which may be of the general type of selector switch disclosed in U. S. Letters Patent No. 815,321, granted March 31, 1906, to Keith, Erickson and Erickson. The side switch and private magnet are omitted, however, and the circuits are modified in accordance with the two wire system of control. The operation of the line switch C^4 and the selector switch E′ will be described during the process of explaining the establishment of connections.

At the right of Fig. 2 three sets of bank contacts, one in each of three levels, are shown as being accessible to the wipers of the selector E′. From the first level contact set comprising bank contacts 83, 84 and 85, conductors 95, 96 and 97 extend to a connector (not shown) in the first connector group of the exchange. The second level contact set comprising bank contacts 86, 87 and 88 is the terminal of a trunk line comprising conductors 92, 93 and 94 which extends to the connector F^3 (Fig. 3) in the second connector group. A third trunk line comprising the conductors 98, 99 and 100 extends from the third level contact set comprising bank contacts 89, 90 and 91, to the ring back switch H′ (Fig. 4).

The connector F^3 may be described briefly as being of the general type of connector switch disclosed in the patent to Keith, Erickson and Erickson, No. 815,176, granted March 31, 1906. The circuits are modified to a large extent, however, both to enable the switch to operate in accordance with the two-wire system of control and in order to carry out the various objects of my invention as will be explained fully hereinafter.

Associated with the connector F^3 I have shown a busy signaling machine Q, a frequency selecting switch S, and intermittent ringing equipment IR. The busy signaling machine Q may be common to the exchange and is of the usual type found in other well known automatic telephone systems. The frequency selecting switch S is individual to the connector F^3 and comprises a stepping magnet 112 and wipers 142 and 143 which are adapted to be operated for the purpose of selecting the ringing current generator required to signal a desired subscriber. The ringing equipment IR is common to the second group of connectors. As shown herein it consists essentially of a relay 150, controlled by a two segment interrupter, which is adapted when energized to connect the generators AC′ to AC^4, inclusive, simultaneously to the four generator leads extending to the frequency selecting switches associated with connectors of the second group. In the deënergized position of the relay 150 these four generator leads are connected to the positive terminal of a booster battery.

In Fig. 5 there is shown a modification of the ringing equipment IR which is to be used in connection with the first group of connectors. It will be seen that the only difference between the two sets of ringing equipment is in the construction of the interrupters employed. The interrupter shown in Fig. 5 has but a single live segment while the other interrupter has two live segments, thus providing evidently for the one and two bell ringing.

At the right of Fig. 3 there is shown a fragmentary portion of the bank of connector F^3. The lower sets of banks are line contacts in the seventh, eighth, ninth and tenth levels while the upper sets of contacts are private or test contacts in the corresponding levels. There is nothing new in the bank wiring except the wiring of the private bank contacts on the trunking levels. Considering first the tenth level in which the groups of automatic trunks are terminated it has been assumed arbitrarily that there are three groups of trunks with three trunks in each of the first two groups and four trunks in the last. Each group of trunks extends to a different automatic exchange, the last group including the trunk comprising normal conductors 200 to 203, inclusive, being the group which extends to the automatic exchange Z. There are four conductors for each of these trunk lines, two line conductors and two private or test conductors. The division of the trunk lines into groups is determined by the inclusion of a resistance in the second test conductor of the last trunk of each group. This is clearly shown in the drawing and the function of the resistance will be explained fully hereafter. The wiring of the ninth level in which terminate the groups of trunk line extending to manual exchanges is somewhat

different. Each of these trunk lines has only the usual three conductors, two line conductors and a test conductor. Grouping of trunks is determined by tying together both test contacts of each trunk in a group except the last. The wiring of the remaining levels is standard, the second test contact of each contact set being left dead.

The normal conductors 200 to 203, inclusive, extend to and terminate in a repeater M. This repeater comprises essentially a repeating coil R and the relays 225 to 229, inclusive, whose functions and operation will be described. The two conductor trunk line 6 extends to the distant automatic exchange Z where it terminates in the repeating coil R' associated with the repeater M'. The repeater M' except for a slight circuit change necessary on account of the fact that it is adapted to be seized by a different type of switch in the main exchange may be similar in all respects to the repeater M. The main exchange may be of the general type disclosed in the patent to Newforth #13,901, reissued April 13, 1915. Calls from the mixed service exchange to the main exchange are extended by way of conductors 265 and 266 which terminate in an individual line switch. Calls in the reverse direction which originate at the main exchange are extended to the trunk line shown by way of conductors 262, 263 and 264 which may terminate in a selector level or in some level of a group of rotary connectors. These calls are completed at the mixed service exchange by way of conductors 241 and 242 which terminate in the line switch C^6 (Fig. 1).

The ring back switch H' is a vertical and rotary directively controlled switch similar in mechanical construction to the switch shown in the patent to Keith, Erickson and Erickson, No. 815,176, the circuits being modified, however, in order to adapt the switch to the two wire system of control and being further modified to enable the switch to perform its function of a ring back apparatus. The switch H' has but two wipers indicated by reference characters 330 and 331 and only the five lower levels of line contacts are used. The private or test contacts are omitted entirely.

The ringing switch I is a single motion rotary switch and may be of any suitable construction; it being necessary only to provide connections for the wipers which permit their continuous forward movement as shown in the patent to Lamb No. 1,193,160, granted August 1, 1916. In its preferred form and as shown diagrammatically herein it comprises essentially a stepping magnet 350, an interrupter relay 351, the three wipers 354, 355 and 356 and 25 sets of bank contacts arranged in the arc of a circle. The wipers of the switch are of the usual double or triple construction and are continuously in engagement with some contact set in the bank. The generators AC^1 to AC^4, inclusive, may be the same generators which are shown in Fig. 3. The wiring of so much of the bank of the ring back switch H' as is in use and the wiring of the bank of ringing switch I is shown complete and will be explained in the description of the operation.

It has not been thought necessary to show any of the trunk lines which extend to manual exchanges on account of the fact that the equipment associated with these trunk lines is old and is in part shown in Fig. 2 of the drawings. Considering for example the trunk line which is accessible to connector F^3 by way of the seventh set of contacts in the ninth level, the normal conductors 207, 208 and 209 extend to and terminate in an individual line switch indicated in Fig. 1 by the reference character C^5. This line switch is similar in all respects to the line switch C^4, the circuits of which are shown in detail in Fig. 2. It will be seen then that in so far as the exchange equipment is concerned these trunk lines are similar to the party line shown in Fig. 2 and comprises the conductors 30 and 31. At the manual exchange each trunk line terminates in the usual drop, jack, and cut off relay. Manual equipment of this kind is old and well known and need not be illustrated.

Having described briefly the apparatus involved in the system its operation will now be considered. The operation of the connector F^3 on local connections will first be explained and for this purpose it will be assumed that the subscriber at substation A^1 desires to obtain connection with the subscriber at substation A^{10} (Fig. 1), the telephone number of the latter substation being 2842. When the calling subscriber at substation A' removes his receiver to initiate the call the switch hook 12 is permitted to rise about half way where it is held by the locking lever 19. In this position of the switch hook contact springs 20 and 21 are separated while contact springs 21 and 22 are brought into engagement with each other, thereby bridging the condenser 14, receiver 10 and secondary winding 15 across the two conductors of the line. The calling subscriber will now place the receiver to his ear in order to determine whether or not the line is in use. No conversation being heard the locking lever 19 is now released by hand, whereupon the switch hook 12 is permitted to rise to its final position. Contact springs 21, 22 and 23 are now in engagement and the transmitter 11 and primary winding 16 of the induction coil are bridged across the line in parallel with the receiver. By the closure of the transmitter bridge a

flow of current is established in the winding of the line relay 32 of line switch C^4 as follows: ground at G^1, inner set of cut off springs, line conductor 31, primary winding 16, transmitter 11, contact springs 23, 22 and 21, line conductor 30, outside set of cut off springs and the windings of the line relay 32 to battery. Upon attracting its armature the line relay 32 closes a circuit for the operating winding 36. Upon energizing, the operating winding attracts both the plunger arm 33 and the cut off armature 34; the former through the medium of its plunger (not shown) forcing the bank springs 40 to 43, inclusive, into engagement, respectively, with contacts 44 to 47, inclusive; and the latter disconnecting the line conductors 30 and 31 from the line relay 32 and from the grounded pole of battery. By the engagement of bank springs 40 and 43, respectively, with contacts 44 and 47, the line conductors 30 and 31 are extended by way of normally closed contacts of the switching relay 58 to the impedance coil 51 and the line relay 50 of the selector E'. The line relay 50 is accordingly energized over the closed line circuit, including substation A', and upon attracting its armature closes a circuit for the slow acting release relay 52. Upon energizing, relay 52 completes a holding circuit for the line switch C^4 which may be traced as follows: ground at G^2, working contact of armature 60 and the said armature, conductor 61, contact 45, bank spring 41, holding winding 35, and terminal 49 to battery. The line relay 32 is slow acting in order that it may retain its armature in operated position until after the above traced circuit has been completed. A branch of the holding circuit extends by way of conductor 37 to multiple test contacts in the banks of the connector switches which have access to the line of substation A', whereby a ground potential upon these test contacts the line is made busy. By the engagement of bank spring 42 with contact 46, the master switch D is operated in the usual manner to advance the plungers of all the remaining idle line switches into position before the terminals of the next idle trunk line.

The foregoing trunk selecting operations have occurred automatically in response to the removal of the receiver. The calling subscriber will now operate his calling device in accordance with the first digit in the desired number, or the digit 2, thereby twice separating the impulse springs 18 and producing two interruptions in the circuit of the line relay 50. In response to these interruptions of its circuit, the line relay 50 is deënergized a couple of times and at each deënergization transmits an impulse from ground G^3 through the low resistance slow acting relay 53 and the vertical magnet 56 in series, slow acting relay 52 remaining in operated position notwithstanding the interruptions in its circuit produced by the momentary deënergizations of the line relay. The vertical magnet 56 responds to the impulses transmitted by the line relay and operates to raise the switch shaft and the wipers 80, 81 and 82 until the latter stand opposite the second horizontal level of bank contacts. The relay 53 is energized in series with the vertical magnet, and being slow acting, retains its armatures in operated position during the series of impulses. At the first upward movement of the shaft the off normal springs 59 are closed, thereby completing an initial energizing circuit for the stepping relay 54 which extends from the grounded conductor 61 by way of the lower armature of relay 53, the off normal springs 59, and the winding of the said relay 54 to battery. Upon energizing, the relay 54 locks itself independent of relay 53 at its upper armature and at its lower armature prepares a circuit for the rotary magnet 55 which is held open during the vertical movement of the switch by the relay 53. In addition to those described the slow acting relay 53 has a new function, in that at its upper armature it connects the lower low resistance winding of impedance coil 51 in parallel with the upper winding. The lower winding of relay 51 is preferably non-inductive and its inclusion in the line reduces the resistance and impedance of the control circuit including the line relay 50, thereby greatly improving the operation of the selector switch in response to impulses. On long rural telephone lines this feature is of considerable value.

To proceed with the operation, when the slow acting relay 53 deënergizes at the end of the vertical movement of the switch a circuit is completed for the rotary magnet 55 extending from the grounded conductor 61, by way of the springs controlled by the lower armature of relay 53, the lower armature of relay 54 and the winding of the rotary magnet 55 to battery. Upon energizing, the rotary magnet advances the wipers 80, 81 and 82 into engagement with the first set of bank contacts in the second level. Near the end of its stroke the rotary magnet opens its interrupter contact and thereby breaks the locking circuit of the stepping relay 54. Upon the deënergization of the stepping relay, the circuit of the rotary magnet is in turn broken and the rotary magnet also deënergizes. The operation now depends upon whether or not the first trunk line is busy or not. If this trunk line is busy the test contact with which the private or test wiper 81 is in engagement will have a ground potential upon it and the circuit of the stepping relay 54 will again be closed. Upon energizing once

more, the stepping relay completes the circuit of the rotary magnet as before and the switch wipers are advanced to the second set of contacts. Since the stepping relay 54 and the rotary magnet each interrupt the circuit of the other it will be seen that the switch wipers will continue to be advanced step by step as long as the test wiper 81 engages busy or grounded test contacts. When a test contact associated with an idle trunk line is reached, assumed to be the test contact 87, the test wiper 81 will find no ground potential and the stepping relay 54 will not be energized. Instead the switching relay 58 which until now has been short circuited is energized over a circuit which may be traced briefly as follows: grounded conductor 61, winding of the switching relay 58, interrupter contact of the rotary magnet 55, off normal springs 59, and the winding of the stepping relay 54 to battery. Relay 58 is sufficiently high in resistance to render the relay 54 inoperative. Upon energizing, relay 58 opens a contact in the circuit of the release magnet 57 at its lower armature; at its upper armature shifts the connection of the test wiper 81 from its upper to its lower terminal; and at its two inner armatures disconnects the line conductors 30 and 31 from their connection in the selector E′ and extends them by way of wipers 80 and 82, bank contacts 86 and 88, conductors 92 and 94, and contacts controlled by relay 101 and 102 to the windings of the impedance coil 153 and the line relay 103, respectively, of the connector F^3. The line relay 103 is accordingly energized over the calling subscriber's loop and closes the usual circuit for the slow acting release relay 104. This latter relay, upon energizing, completes a holding circuit for the selector E′ and the line switch C^4 as follows: ground at G^5, spring 121 and its resting contact, armature 129 and its working contact, winding 152 of induction coil P, conductor 93, bank contact 87, wiper 81, and the upper armature of relay 58 and its working contact to junction point 62, where the circuit divides, one branch extending by way of the previously traced circuit through relays 58 and 54 to battery and the other branch joining the conductor 61 over which it supplies holding ground to the line switch C^4.

The calling subscriber may now operate his calling device in accordance with the second digit 8 of the called number, thereby producing a series of interruptions in the circuit of the line relay 103. In response to these interruptions of its circuit the line relay 103 is deënergized a corresponding number of times and at each deënegization transmits an impulse to the vertical magnet 110 over the following path: ground at G^6, wiper 142 of the frequency selector S, conductor 154, armature 126 and its resting contact, armature 128 and its working contact, winding of low resistance slow acting relay 105 and winding of the vertical magnet 110, and the side switch wiper 114 in first position to battery. In response to impulses received over the above circuit the vertical magnet operates to raise the connector shaft step by step until the wipers 170 to 173, inclusive, stand opposite the eighth horizontal level of bank contacts. The relay 105 is energized in series with the vertical magnet and retains its armature during the series of impulses as usual. At its upper armature 130, relay 105 connects the right hand winding of the impedance coil 153 in multiple with the left hand winding in order to reduce the resistance and impedance of the control circuit of the line relay 103, this being the same operation that was described in the case of the selector E.′ In addition the relay 105 closes a circuit for the private magnet 108 as follows: ground at G^7, armature 131, spring 132, and the winding of the private magnet 108 to battery. At the end of the vertical movement of the switch the relay 105 and the private magnet 108 are deënergized, the latter performing its well known function of advancing the side switch wipers 113, 114 and 115 to their second position.

The third digit 4 of the desired number may now be called in the same manner as the preceding digits. A series of four interruptions is now produced in the circuit of the line relay 103 and the said relay accordingly is again deënergized momentarily a number of times. Now, however, the side switch wiper 114 having been advanced to its second position, impulses are transmitted to the rotary magnet 111 as follows: ground at G^6, wiper 142 of the frequency selecting switch S, conductor 154, armature 126 and its resting contact, armature 128 and its working contact, winding of the relay 105, resting contact of spring 134 and the said spring, winding of the rotary magnet 111, and the side switch wiper 114 in second position to battery. In response to impulses over the above circuit the rotary magnet is operated to rotate the connector shaft until the wipers 170 to 173, inclusive, arrive at the fourth set of contacts in the eighth level. The slow acting relay 105 is energized as before and performs the same operations including the closure of the circuit of the private magnet 108. At the end of the rotation of the switch the relay 105 and the private magnet deënergize and the side switch wipers are advanced to their third position, it being assumed that the called line is idle.

The normal conductors 210, 211 and 212 which terminate in the fourth set of contacts in the eighth level extend to and ter-

minate in the individual line switch C^3 (Fig. 1) in the same manner that the normal conductors 37, 38 and 39 terminate in the individual line switch C^4 (Fig. 2). When the side switch of the connector is advanced to third position, therefore, a circuit is completed for the cut off or holding winding of the called line switch C^3 which may be traced as follows: ground at G^8 and the side switch wiper 115 in third position, lower private wiper 171, conductor 210, and the cut off winding of line switch C^3 to battery. The cut off armature of the called line switch is thereupon attracted to clear the called line of its normal battery and ground connections. Ground G^8 also extends to the multiples of the test contact with which the wiper 171 is in engagement and the called line is thus made busy to the remaining connectors in the group.

The wipers of the connector having been advanced into engagement with the set of bank contacts associated with the desired called line the next operation is the establishment of a signaling circuit for ringing the bell at the desired station on the line. In order to accomplish this the frequency selecting switch S must be operated. The calling subscriber accordingly will now operate his calling device for the final digit 2 of the called number with the result that two interruptions are produced in the circuit of the line relay 103. The consequent deënergizations of the line relay now produce two current impulses in the circuit of the stepping magnet 112 of the frequency selector S. This circuit may be traced as follows: ground at G^6, wiper 142, conductor 154, armature 126 and its resting contact, armature 128 and its working contact, winding of relay 105, winding of the stepping magnet 112 and the side switch wiper 114 in third position to battery. In response to the two impulses received over the above circuit the magnet 112 is operated to advance the wipers 142 and 143 two steps, whereby they are brought into engagement with the third contacts in their respective banks. At the first movement of the wiper 142 ground G^6 is disconnected from conductor 154. Since the relay 105 is energized in series with the magnet 112, however, the armature 126 of the line relay is not disconnected from ground, but the movement of the wiper 142 has no effect on the operation for armature 126 is temporarily supplied with ground from G^7 by way of armature 131, and spring 132 and its working contact. Relay 105 also closes the circuit of the private magnet 108 as usual and the private magnet is therefore energized during the operation of the frequency selector S in order to disconnect the line wipers 172 and 173. At the end of the final series of impulses the relay 105 and the private magnet 108 are deënergized. The side switch having already arrived at its most advanced position is not further affected by the deënergization of the private magnet. A signaling circuit has now been established as follows: ground at G^9, 33-cycle generator AC^2, contact of the ringing interrupter IR (relay 150 being energized) generator lead 155, wiper 143 of the frequency selector switch S, conductor 144, resting contact of armature 138 and the said armature, armature 141 and its resting contact, wiper 173 and the bank contact engaged thereby, normal conductor 212, to and through substation A^{10}, normal conductor 211, wiper 172, resting contact of armature 140 and the said armature, armature 137 and its resting contact, upper winding of the ring cut off relay 107, side switch wiper 113, in third position, to battery. By the operation of the ringing interrupter IR ringing current from the generator AC^2 is projected intermittently out over the called line to signal the called subscriber, the construction of the interrupter being such that two rapidly succeeding alternating current impulses are produced followed by a silent period of several times the length of the interval between impulses. When, however, the ringing current is cut off from the line by the deënergization of relay 150 the generator lead 155 is connected to the positive pole of the booster battery shown just above to the right of relay 150. The ring cut off relay 107 is so adjusted that it is not energized by the ringing current while the receiver at the called station is on the hook. When the receiver is removed, however, the relay 107 is energized either by current from the main battery in series with the generator then in use or by current from the main battery in series with the booster battery.

The ringer at substation A^{10} is tuned to respond to the 33 cycle and since the subscriber at this station has been instructed to answer when a two bell ring is received he will now remove his receiver and immediately release the switch hook to its final or talking position. The ring cut off relay 107 is thereupon energized at once irrespective of the position of the ringing interrupter IR and establishes a locking circuit for itself as follows: ground at G^{10}, off normal spring 147 and the contact engaged thereby (brought into engagement at the first upward movement of the switch shaft), armature 139 and its working contact and the lower winding of the ring cut off relay 107 to battery. As a further result of its energization relay 107 disconnects the line wipers 172 and 173 from its upper winding and from the generator lead 144 and connects them instead to the upper and lower heavy talking conductors, respectively. Transmitter current for the called substation is now supplied as follows: ground at G^{10}, off nor-

mal spring 147 and the contact engaged thereby, armature 139 and its working contact, the lower winding of the answering bridge relay 102, resting contact of spring 119 and the said spring, working contact of armature 138 and the said armature, armature 141 and its resting contact, wiper 173, normal conductor 212 to and through the substation A^{10}, normal conductor 211, wiper 172, resting contact of armature 140 and the said armature, armature 137 and its working contact, spring 117 and its resting contact, upper winding of the answering bridge relay 102, and the winding 151 of induction coil P to battery. The current flow over the above circuit serves to energize the relay 102 which at its armature 123 short-circuits the winding 151 of the induction coil P and at its armatures 122 and 124 reverses the incoming line conductors 92 and 94 as regards their connection to the windings of impedance coil 153 and the line relay 103. In addition, at the working contact of spring 125, controlled by armature 124, the upper condenser is connected to complete the talking circuit. The reversal of the line conductors described is useful in certain cases for controlling a meter or coin collecting device associated with the calling line, but since there is nothing new in this operation no measured service devices have been shown.

The required connection has now been established. Talking current is supplied to the transmitter at the called substation through the windings of relay 102 as already explained; while talking current for the transmitter at the calling substation is supplied through the windings of relay 103 and impedance coil 153. The path for the voice currents through the several switches has been drawn in heavy lines and will be readily understood without further explanation.

When the conversation is finished both subscribers will replace their receivers. By the replacement of the receiver at substation A′ the line relay 103 of connector F^3 is deënergized, followed by the deënergization of the slow acting release relay 104. A circuit is thereupon established for the release magnet 109 as follows: ground at G^5, spring 121 and its resting contact, armature 129 and its resting contact, off normal spring 146 and the contact in engagement therewith, and the winding of the release magnet 109 to battery. By the energization of the release magnet the switch shaft and the side switch wipers are restored to normal position in the usual manner, the circuit of the magnet being broken when the shaft reaches its lowest position. As a further result of the deënergization of relay 104 the holding circuit extending back to the selector E′ and the line switch C^4 is broken. As a result the switching relay 58 at the selector E′ is deënergized to close a circuit for the release magnet 57 and the selector is thereupon restored to normal in substantially the same way as was the connector F^3. Upon the cessation of current flow in the holding winding 35 of the line switch C^4 the plunger is withdrawn from the bank, whereupon all the apparatus involved in the connection will have been restored to normal position.

In the foregoing it has been assumed that the called line was idle when connection was extended thereto. If the called line had been busy a somewhat different operation at the connector switch would have resulted for the purpose of transmitting a busy signal to the calling subscriber. In order to explain how this is done it will be assumed that the line of substation A^{10} when called, as explained in the foregoing paragraphs, was in use. Under these circumstances there is a ground potential upon the lower test contact of the contact set associated with the called line either by way of the normal conductor 210 or by way of the bank multiple. It follows therefore that when the slow acting relay 105 is deënergized at the end of the second series of impulses directed to the connector F^3 that the private magnet 108 is not deënergized as is the case when the called line is idle but is held up by current flow over the following path: grounded busy test contact, private or test wiper 171, side switch wiper 115 in second position, contact springs controlled by armature 135 of test relay 106, winding of the said test relay, contact springs controlled by the armature of the rotary magnet 111, resting contact of spring 132 and the said spring, and the winding of the private magnet 108 to battery. The private magnet being maintained energized, the side switch wipers are locked in second position and the line wipers 172 and 173 are maintained disconnected at armatures 140 and 141 of the private magnet. The test relay 106 is energized in series with the private magnet and at its armature 135 completes a locking circuit for itself and the said magnet which extends from ground G^{10} and which is independent of the test wiper. In other words ground G^{10} is substituted by the operation of armature 135 for ground on the busy test contact. In addition, the test relay 106 opens the circuit of the rotary magnet 111 at spring contacts controlled by armature 133 and at armature 136 connects a lead from the busy signaling machine Q to the lower talking conductor. A distinctive signal is thus transmitted to the calling subscriber to inform him that the desired line is for the present inaccessible. As is usual under such circumstances, the calling subscriber will then replace his receiver whereupon the

automatic switches are restored as hereinbefore described.

All two bell stations are called from the second group of connectors like station A^{10}. The one bell stations, however, are called from the first group of connectors which have associated with them the ringing equipments shown in Fig. 5. Considering station A^9 which we may assume to be a one bell 33 cycle station, the number of this station will be 1842 and connection may be extended thereto in substantially the same manner as above described; except that the selector E′, being operated in accordance with the digit 1 rather than in accordance with the digit 2, selects an idle connector in the first group instead of an idle connector in the second group. The operation of the selected connector is of course the same as has been already described and the only other difference occurring in the establishment of the connection which needs to be mentioned is the substitution of the one bell signal for the two bell signal. This it will be readily understood is accomplished by the use of a single segment in the common ringing interrupter as is shown clearly in Fig. 5. There is nothing unusual in the manner of extending connections to straight or four party line stations and consequently no detailed explanation will be given.

Having described the operation of the apparatus in completing local connections I will now explain how connections are extended from the local or mixed service exchange to a distant automatic exchange as for example the exchange Z (Fig. 1). The call number for each of the exchanges to which trunk connections may be extended is determined by the group of connectors from which the trunk lines are accessible and by the location of the first trunk line in the banks of the connectors in the group. It follows therefore that since the trunk lines extending to the exchange Z terminate in the last four contact sets in the tenth level of the second group of connectors, the telephone number to be called in order to extend a connection to an idle one of these trunk lines is the number 207. For convenience it will be assumed that the subscriber at substation A′ desires to obtain connection with some subscriber at the exchange Z, and it will be further assumed that the first three of the trunk lines which extend to the exchange Z are busy. The operation of the line switch C^4 and the operation of the first selector E′ responsive, respectively, to the removal of the receiver and to the calling of the first digit of the number are the same as was described in the explanation of the establishment of a local connection. Likewise the operation of the connector F^3 in response to the calling of the digits 0 and 7 is precisely the same as has already been described except of course that it is now being operated to a different level and to a different contact set in the selected level. In the case now under consideration, however, after the connector is operated to establish connection with the first trunk line of the desired group, if this first trunk line is busy it is necessary to select an idle trunk line of the group, and thereafter a switching operation is performed by which the line conductors are extended by direct metallic connection through to the line conductors of the selected idle trunk line. These operations will now be described.

If we assume as before mentioned that the first three trunk lines which terminate, respectively, in the seventh, eighth and ninth sets of contacts in the tenth level are busy there will be a ground potential upon both the upper and lower test contacts of each contact set. It follows therefore that when the connector F^3 is operated to bring its wipers 170 to 173, inclusive, into engagement with the seventh set of contacts in the tenth level, and the slow acting series relay 105 deënergizes at the end of the final series of controlling impulses, a circuit will be established through the test relay 106 and the private magnet 108 as follows: ground on the lower test contact of the seventh contact set in the tenth level, test wiper 171, side switch wiper 115 in second position, contact springs controlled by armature 135, winding of test relay 106, contact springs controlled by the armature of the rotary magnet 111, resting contact of spring 132 and the said spring, and the winding of the private magnet to battery. By the establishment of the above circuit the private magnet 108 is maintained energized thus holding the side switch wipers in second position. The test relay 106 is energized in series with the private magnet and upon attracting its armature 133 completes a circuit for the rotary magnet 111 as follows: ground on the upper test contact of the seventh contact set in the tenth level, test wiper 170, armature 133, contact spring 134, winding of the rotary magnet 111 and the side switch wiper 114 to battery. By the operation of the rotary magnet the connector wipers are advanced one step into engagement with the eighth set of contacts in the tenth level. Near the end of its stroke the armature of the rotary magnet connects ground G^{14} to the private magnet and at the same time breaks the energizing circuit of the test relay 106, the test relay accordingly being deenergized. By the falling back of the test relay the circuit of the rotary magnet is interrupted and the magnet is therefore deenergized. It being assumed that the trunk line terminating in the eighth contact is also busy, the former circuit through the test relay 106 and the private magnet 108 will

now be reëstablished and the rotary magnet will again be energized to advance the connector wipers into engagement with the ninth set of contacts. The ninth set of contacts being also busy the same operation is again repeated and the wipers of the connector are advanced into engagement with the tenth set of contacts which we will assume to be idle. When the rotary magnet deënergizes for the last time, since there is no ground potential upon the test contact with which the wiper 171 is now in engagement, the test relay 106 will not again be energized and the private magnet 108 will be permitted to deënergize. By this latter operation the side switch wipers are advanced in the usual manner to their third position.

By the advance of side switch wipers 115 and 113 to their third positions a circuit is completed for the switching relay 101 as follows: ground at G^8, side switch wiper 115 in third position, test wiper 171, conductor 201, contact point 246, spring 245, conductor 200, resistance 204, test wiper 170, armature 133 and its resting contact, off normal contact 145 (closed only on the tenth level), winding of relay 101, and the side switch wiper 113 to battery. Upon the energization of the switching relay 101 a circuit is completed for the ring cut off relay 107 as follows: ground at G^5, contact spring 121 and its working contact, and the lower winding of the relay 107 to battery. Ground at G^5 is also connected by way of contact spring 121 and armature 120 to conductor 93 in order to guard against the release of the selector E′ and the line switch C^4 upon the deënergization of relay 104 which occurs an instant later. Relays 101 and 107 being in energized position a direct metallic connection has been established from conductors 92 and 94 by way of armatures 116 and 118 of relay 101, armatures 137 and 138 of relay 107, armatures 140 and 141 of private magnet 108 and line wipers 172 and 173 to the trunk conductors 202 and 203, respectively.

It follows therefore that the line relay 227 of the repeater M which is connected in bridge of conductors 202 and 203 in series with the battery will be energized over the calling subscriber's loop, thereby closing at its armature 233 an energizing circuit for the slow acting relay 226. Relay 226, upon energizing in turn, completes a circuit from ground G^{15} which extends by way of armature 232 and the winding of slow acting relay 225 to battery. Relay 225, upon energizing, has the function of breaking the connection between conductors 200 and 201 and of connecting ground G^{15} to the conductor 200, thereby maintaining the energizing circuit of the switching relay 101 of the connector F^3 independent of the former ground connection by way of the lower test wiper 171. As a further result of its energization relay 225 completes a control circuit extending to the distant automatic exchange Z which may be traced as follows: ground at G^{16}, winding of the line relay 267, resting contact of armature 279 and the said armature, left hand windings of repeating coil R′ in parallel, line conductors of trunk line 6 in parallel, right hand windings of repeating coil R in parallel, armature 231 and its working contact, working contact of armature 234 and the said armature, and the resistance 247 to battery. The line relay 267 is accordingly energized and completes an energizing circuit for the slow acting relay 268 which relay, upon energizing in turn, connects ground G^{17} by way of its armature 274 to the conductor 263 in order to make the trunk line 6 busy at the exchange Z. As a further result of the operation of relay 268 the right hand windings of the repeating coil R′ are connected at armatures 273 and 275 to the conductors 265 and 266 respectively. Since the line relay 267, in addition to closing the circuit of the relay 268, also short circuits the condenser which is connected in series with the two right hand windings of the repeating coil R′, a conductive bridge is now closed across the conductors 265 and 266 with the result that the line switch in which these conductors terminate is operated in the usual manner to select an idle selector switch.

The calling subscriber may now proceed to operate the dial of his calling device in accordance with the digits in the telephone number of the subscriber in the automatic exchange Z with whom he desires to obtain connection, thereby producing successive series of interruptions in the circuit of the line relay 227 of the repeater M. During each series of interruptions the line relay 227 is deënergized a number of times and thereby interrupts the control circuit including the line relay 267 of the repeater M′, this latter relay being likewise deënergized intermittently to interrupt the bridge across the conductors 265 and 266. Thus it will be seen that the interruptions produced by the calling device at the calling substation will be repeated by the line relays 227 and 267 of repeaters M and M′ in order to effect the operation of a series of switches in the exchange Z, whereby the connection to the line of the called subscriber is completed. The bell at the called substation is then rung automatically in the usual manner and when the called subscriber responds conversation may be held as desired. There being nothing unusual in the signaling or talking circuits no detailed explanation need be given.

When the conversation is finished both subscribers will hang up their receiver. When the receiver at substation A′ is re-

placed the line circuit is broken and the line relay 227 at repeater M is accordingly deenergized. The deënergization of relay 227 opens the control circuit including the line relay 267 of repeater M′ and the resulting deënergization of this latter relay permanently opens the bridge across the conductors 265 and 266. The automatic switches in the exchange Z are accordingly released and restored to normal position in the usual manner. Returning to the repeater M the deënergization of the line relay 227 also breaks the circuit of the slow acting relay 226 which relay upon retracting its armature opens the circuit of the slow acting relay 225 and also disconnects ground G^{15} from conductor 200. By the removal of ground from conductor 200 the energizing circuit of the switching relay 101 of connector F^3 is broken and inasmuch as relay 225 is slow acting this circuit remains open long enough to permit relay 101 to deënergize. By the retraction of armature 120 of relay 101 ground G^5 is disconnected from the holding conductor 93 and is connected instead to the release magnet 109, thereby causing the release of the connector F^3. It should be mentioned that the connector is released and the side switch wiper 115 restored to first position before the slow acting relay 225 at the repeater M has had time to deënergize. By the removal of ground from the holding conductor 93 the selector E′ and the line switch C^4 are restored to normal in the usual manner.

In calling into a group of trunks on the tenth level, if all the trunks in the group are busy the connector in use will stop on the last trunk anyway, because of the resistance as 204 for instance which is included in series with the private normal conductor associated with the last trunk, this resistance being high enough to prevent the operation of the rotary magnet. In such a case the test relay of the connector and the private magnet are maintained energized until the connection is released and the calling subscriber will hear the busy signal when he places the receiver to his ear.

It is understood that the trunk lines connecting the exchange X or mixed service exchange with the automatic exchange Z are two way trunk lines and are adapted to handle connections in either direction. To provide for handling calls from the exchange Z to the exchange X the group of four trunk lines may terminate in a selector level in the former exchange; and considering the particular trunk line number 6 which is shown in the drawings, the conductors 262, 263 and 264 may terminate in the first set of contacts of the level which is reserved for this purpose. Suppose now that a subscriber in the exchange Z desires to obtain connection with a subscriber in the exchange X. After removing his receiver the calling subscriber will first operate his calling device in accordance with the proper digits in order to control one or more selector switches for the purpose of obtaining connection with an idle trunk line. If we assume that the trunk line number 6 is the one with which connection is established the line relay 269 will energize as soon as the connection is completed and will in turn complete a circuit for the slow acting relay 270. Relay 270, upon energizing, connects ground G^{18} to the conductor 263 in order to maintain the operated selector or selectors in operated position. By the energization of relays 269 and 270 a control circuit including the line relay 229 in the repeater M is completed as follows: ground at G^{19}, winding of relay 229, resting contact of armature 231 and the said armature, right hand windings of repeating coil R in parallel, line conductors of trunk line number 6 in parallel, left hand windings of repeating coil R′ in parallel, armature 279 and its working contact, working contact of armature 277 and the said armature, and the resistance to battery. The closure of the above control circuit is followed by the energization of relays 229 and 228 in the repeater M, the latter relay being effective to ground conductors 200 and 201 and thereby render the trunk line busy to connector switches such as the connector F^3 in the exchange X. Relays 228 and 229 also close a bridge across the conductors 241 and 242 to operate the line switch C^6 for the purpose of selecting and connecting with an idle selector switch. Now when the calling subscriber in the distant automatic exchange operates the dial of his calling device the interruptions of the line circuit which are produced are repeated by means of line relays 269 and 229, and thereby cause the operation of the selected selector and a connector in the exchange X in order to complete the required connection to the desired subscriber's line. Since the connector switch under these circumstances operates exactly the same as was described in the explanation of the establishment of a local connection no further details need be given. When the receiver is replaced at the distant exchange Z the operating or control circuits are broken in the order in which they were established and the connection is released.

In extending a connection from the mixed service exchange X to the manual exchange Y it is only necessary for the calling subscriber to dial sufficient digits to obtain connection with an idle trunk line, the connection being completed to the line of the called subscriber by the operator. The connector F^3 only used in a connection of this kind operates to select an idle trunk substantially the same as when an automatic

exchange is being called. No switching through operation takes place, however, for the off normal contact 145 is closed when on the tenth level and an extra digit must be called to operate the frequency selecting switch S as when calling a local line. In accordance with the location of the Y exchange trunks in the drawing the proper digits to be called would be the digits 2, 9, 4 and one additional digit, preferably the digit 2. When the operator plugs in to answer the call and throws the listening key the relay 107 at the connector is energized to cut off the ring and the calling subscriber is then able to ask for the desired number.

At this time it will be appropriate to call attention to a feature in the connector by which the operator at a manual exchange, such as the exchange Y for example, is given a distinctive tone on certain calls to notify her to rebate the charge. Ordinarily of course all calls from the exchange X to the manual exchange Y will have to be paid and it is the duty of the operator at the latter point to charge all incoming calls from the exchange X to the proper parties. It may be, however, that certain subscribers who are furnished telephone service from the exchange X are in reality located about as close to the exchange Y as they are to the exchange X and therefore are entitled to communicate with subscribers in the exchange Y free of charge. In order to notify the operator at the manual exchange when she is being called by an X exchange subscriber who is entitled to free service, special equipment is provided comprising a signaling device K at the exchange X and comprising also an induction coil such as the induction coil P which is associated with each of the connectors, such as the connector F^3. In the exchange X the holding windings of the line switches associated with lines whose subscribers are entitled to free calls to the exchange Y are not connected direct to battery but on the contrary extend to battery by way of the secondary winding of the induction coil of the signaling device K. Thus if we assume for the sake of illustration that the party line comprising conductors 30 and 31 extends in the direction of the exchange Y as shown in the drawing and that the subscribers on this line are located near the end of the line it may be that these subscribers will be entitled to free service to the exchange Y. To accomplish this the holding winding of the line switch C^4 is disconnected from terminal 49 and is connected instead to terminal 48. When connected in this way if a connection is extended by means of the selector E' and conductor F^3 to the manual exchange Y a distinctive tone produced by the signaling device K will be transmitted by way of the holding conductors 61 and 93, the induction coil P and the selected trunk line. When the operator first answers the call her head set is preferably connected directly in bridge of the trunk line in order to operate the ring cut off relay 107 and thereby stop the ringing operation. It follows that immediately upon the energization of relay 107 the battery supply relay 102 will be energized and the left hand winding of the induction coil P will be short circuited. The operator at the manual exchange, however, may have a condenser connected in series with her head set and normally short circuited through the contacts of a special listening key. With this arrangement the operator is instructed to listen in with her special listening key on all calls incoming from the exchange X. When the special listening key is thrown the condenser will be cut in series with the operator's head set and the battery supply relay 102 at the exchange X will therefore be deënergized. Under these conditions the operator will be able to hear the tone if it is present on the line and will rebate the charge for the call accordingly. Since there is nothing particularly difficult in the design of the operator's cord circuit it has not been thought necessary to illustrate the same and any suitable arrangement may be used instead of the one herein proposed.

Attention will now be directed to the ring back equipment through the medium of which the party line subscriber is enabled to signal another subscriber on his own line. This equipment comprises a plurality of ring back switches one of which is the switch H' (Fig. 4) and the common rotary ringing switch I. In general the method of handling reverting calls in my present system is similar to the method disclosed in the patent to Hovland No. 1,158,221, wherein there is described a reverting call or ring back system in which the calling subscriber by manipulating his dial in accordance with the proper digits operates a ring back switch at the exchange to select the two frequencies of ringing current which corresponds to the calling and called substations. The calling subscriber then hangs up his receiver, whereupon mechanism in the ring back switch is operated to effect the application of the selected ringing currents to the calling line alternately. The called subscriber is thus signaled as usual; while the calling subscriber is also signaled so that he may know that the operation is proceeding properly and also that he may know by the cessation of the ringing of the response of the called party. Owing to the fact that in the present system the selective ringing is accomplished by a combination of the one and two bell principle, rather than on the harmonic principle alone as in the Hovland system, the apparatus and circuits employed are radically different although the general

principle of operation is substantially the same.

Each party line subscriber is supplied with a list of special numbers which are to be used in calling the other parties on his own line. These numbers of course conform to the wiring of the banks of the ring back switches, which it may be stated is largely an arbitrary arrangement, although considerable care has been taken to devise as simple a scheme as possible. The bank wiring of one of the ring back switches and the wiring of the ringing switch I is shown complete in Fig. 4 and the special call numbers which correspond to the wiring shown are given in the table below.

Calling station.	*Called station.*	*Number.*
A' calling	A^2, or	
A^2 "	A'	311
A' "	A^3	313
A' "	A^4	315
A' "	A^5	317
A' "	A^6	319
A' "	A^7	310
A' "	A^8	321
A^3 "	A^2	323
A^3 "	A^4	325
A^3 "	A^5	327
A^3 "	A^6	329
A^3 "	A^7	320
A^3 "	A^8	331
A^5 "	A^2	333
A^5 "	A^4	335
A^5 "	A^6	337
A^5 "	A^7	339
A^5 "	A^8	330
A^7 "	A^2	341
A^7 "	A^4	343
A^7 "	A^6	345
A^7 "	A^8	347
A^2 "	A^8	349
A^2 "	A^4	340
A^2 "	A^6	351
A^4 "	A^6	353
A^4 "	A^8	355
A^6 "	A^8	357

The operation of the apparatus in a reverting call will now be explained, it being assumed for this purpose that the subscriber at substation A' (Fig. 2) desires to call the subscriber at substation A^4. By referring to the table it will be seen that the number to be called in this case is the number 315. Upon the removal of the receiver at substation A' the line switch C^4 is operated in the manner already explained to extend the line conductors 30 and 31 to the trunk conductors which terminate in an idle selector switch, assumed to be the selector E'. In response to the calling of the first digit 3 of the number the first selector is operated to raise its shaft in the usual manner until the wipers 80, 81 and 82 arrive at the third horizontal level of bank contacts, after which the wipers are automatically rotated to pick out an idle set of contacts in the selected level. Assuming that the contact set comprising bank contacts 89, 90, and 91 is the set selected, upon the energization of the switching relay 58 the line conductors are further extended into connection with trunk conductors 98 and 100 which terminate in the windings of the line relay 300 of the ring back switch H' (Fig. 4). The line relay 300 is accordingly energized over the two sides of the calling line in series in the usual manner and upon attracting its armature 316 completes an energizing circuit for the slow acting release relay 301. Upon energizing in turn, relay 301 connects ground G^{26} to the holding conductor 99 at its armature 317, thereby completing the usual holding circuit by which the selector E' and the line switch C^4 are maintained in operated position.

The calling subscriber at substation A' may now operate his calling device in accordance with the second digit 1 of the number, thereby producing a momentary interruption in the circuit of the line relay 300. The line relay 300 is accordingly deenergized momentarily and transmits an impulse of current to the vertical magnet 306 over the following path: ground at G^{25}, armature 316 and its resting contact, armature 318 and its working contact, winding of the slow acting series relay 302, winding of the vertical magnet 306, and the side switch wiper 309 in first position to battery. In response to this impulse of current the vertical magnet is operated to raise the switch shaft one step, the wipers 330 and 331 being thereby brought into alinement with the first horizontal level of bank contacts. The slow acting relay 302 is energized in series with the vertical magnet and operates the private magnet 308 in the usual manner. Both the relay 302 and the private magnet are deënergized after the vertical operation of the switch, the deënergization of the private magnet being effective to cause the advance of the side switch wipers from first to second position.

The calling subscriber will now operate his calling device in accordance with the third digit 5 of the number, producing this time five interruptions in the circuit of the line relay 300. The resulting deënergizations of the line relay 300 now cause five impulses of current to be transmitted through the rotary magnet 307, side switch wiper 309 having been advanced to its second position. By the operation of the rotary magnet 307 the switch shaft is rotated until the wipers 330 and 331 come into engagement with the fifth set of bank contacts in the first level, these bank contacts being indicated in the drawing by the reference characters 371 and 372. The slow acting

relay 302 and the private magnet 308 are operated as before and the latter upon de-energizing permits the side switch wipers to advance to their third and final position.

The calling subscriber will now hang up his receiver. Since this operation opens the line circuit the line relay 300 is deënergized and closes a circuit for the relay 312 as follows: ground at G^{25}, armature 316 and its resting contact, armature 318 and its working contact, winding of the slow acting series relay 302, winding of relay 312, and the side switch wiper 309 in third position to battery. Upon energizing, relay 312 completes a new circuit for the slow acting release relay 301 as follows: ground at G^{27}, off normal contact 311 (closed at the first upward movement of the switch shaft), armature 315 and its right hand working contact, armature 321 and its resting contact, and the winding of relay 301 to battery. In addition relay 312 closes a circuit for starting the operation of the ringing switch I which extends over the following path: ground at G^{27}, off normal contact 311, armature 315 and its left hand working contact, conductor 352, bank contact normally engaged by the wiper 355 of the ringing switch I, the said wiper 355, contact springs of the interrupter relay 351, and through the said interrupter relay 351 and the motor magnet 350 in parallel to battery. The motor magnet 350 thus receives an impulse of current by which it is operated to advance the wipers 354, 355 and 356 of the ringing switch into engagement with the second set of bank contacts. Since all the bank contacts which are adapted to be engaged by the wiper 355, except the first, are multipled together and connected to ground G^{28} it will be evident that a circuit has now been established for the motor magnet 350 and the interrupter relay 351, whereby the ringing switch I will be caused to advance its wipers successively into engagement with all of the contact sets in its bank finally returning to their first or normal position. In other words, upon receiving the initial starting impulse the switch I makes a complete revolution and returns to normal position. Of course if the relay 312 is still energized the switch I will then immediately start on a second revolution and will thus rotate continuously as long as the conductor 352 is grounded.

When the wipers 354, 355 and 356 of the ringing switch arrive at the contact set comprising bank contacts 360, 361 and 362 a circuit is completed for the ringing relay 304 of the ring back switch as follows: ground at G^{28}, bank contact 361, wipers 355, 354, bank contact 360, conductor 369, bank contact 372 of the ring back switch, wiper 331, upper winding of the ringing relay 304 and the side switch wiper 310 to battery. Upon energizing, the ringing relay 304 completes a signaling circuit for operating the ringer at substation A^4 over the following path: ground at G^{29}, ringing current generator AC^2, the resistance lamp, bank contact 362, wiper 356, conductor 353, working contact of armature 322 and the said armature, working contact of armature 313 and the said armature, conductor 98, bank contact 89, wiper 80, contacts controlled by the switching relay 58 of selector E′, bank contact 44, spring 40, line conductor 30, through the ringers at all the party line substations in parallel, conductor 31, spring 43, bank contact 47, contacts controlled by the switching relay 58, wiper 82, bank contact 91, conductor 100, armature 314 and its working contact, winding of ring cut off relay 303 and through the exchange battery to ground G^{30}. As soon as the wipers of the ringing switch advance to the next set of contacts the ringing relay 304 is of course deënergized and the above described signaling circuit is broken, but is immediately completed again when the wipers arrive at the contact set comprising bank contacts 363, 364 and 365, these latter contacts being connected in multiple with the contacts 360, 361 and 362, respectively. It will be seen then that the ringer at substation A^4 will be operated twice for the ringer at this substation is tuned to respond to the 33 cycle ringing current delivered by the ringing current generator AC^2. Station A^4 being a two bell station the two rings received serve to notify the subscriber that he is being called. When the wipers of the ringing switch arrive at the contact set comprising bank contacts 366, 367 and 368 a circuit is completed for the ringing relay 304 over the following path: ground at G^{28}, bank contact 367, wipers 355 and 354, bank contact 366, conductor 370, bank contact 371, wiper 330, lower winding of the ringing relay 304 and the side switch wiper 310. The ringing relay 304 is accordingly again energized and the signaling circuit is again completed. This time, however, the wiper 356 being in engagement with bank contact 368 the 16 cycle ringing current generator AC^1 is included in the circuit instead of the 33 cycle generator AC^2. It follows accordingly that the ringer at the one bell 16 cycle station A′ will be actuated to notify the calling subscriber that the signaling operation is proceeding satisfactorily. In case the called subscriber at substation A^4 does not answer immediately the above described signaling operations will be repeated during the second revolution of the ringing switch I and will continue to be repeated at intervals until a response is made or until the calling subscriber again removes his receiver, at which time a release will occur as presently

set forth. It is to be noted that in the silent periods between rings the conductor 98 is connected to ground G^{31} in order that the ring cut off relay 303 may be operated immediately upon the removal of the receiver at the called substation whether the receiver is removed during a ringing period or a silent period. The ring cut off relay of course is so adjusted that it will not energize until the receiver is removed from the hook. But as soon as the subscriber at substation A^4 answers the said relay 303 operates, either by current from the exchange battery alone or by current from the exchange battery and the generator in use in series, and closes a locking circuit for itself as follows: ground at G^{27}, off normal contact 311, armature 315 and its right hand working contact, armature 321 and its working contact, and the winding of the said relay 303 to battery. In addition by attracting its armature 320 relay 303 disconnects ground G^{26} from the holding conductor 99, thereby breaking the holding circuit by which the selector E′ and the line switch C^4 are being maintained in operated position. The line switch C^4 and the selector E′ immediately release and restore to normal in the usual manner. But since the receiver at substation A^4 is off the hook the line switch C^4 will at once operate again to extend the line conductors 30 and 31 again into connection with the line relay of the selctor E′. At the ring back switch H′ the ring cut off relay 303 also opens the circuit of the slow acting release relay 301 and this relay upon deënergizing completes a circuit in the usual manner for the release magnet 305. The operation of the release magnet restores the ring back switch to normal position and the locking circuit of the cut off relay 303 and also the circuit of the release magnet are broken when the shaft reaches its normal position. The ringing switch I will complete the revolution upon which it is engaged and will then stop unless some other ring back switch similar to the switch H′ is in use. When the calling subscriber at substation A′ notices the fact that his bell has stopped ringing he will know that the called party has answered and he will therefore remove his own receiver also and converse as desired. Talking current for the transmitters at the calling and called substations is supplied from the relay 50 and the impedance coil 51 in the first selector E′. When the receivers are replaced on the line the line switch C^4 is restored in the usual manner.

What I claim as my invention is:

1. In a telephone system, an automatic switch, a closed control circuit for said switch including a source of current, means for producing a series of interruptions in said circuit to control the operation of said switch, and automatic means for increasing the current flow in said circuit to a point above normal between successive interruptions thereof.

2. In a telephone system, an automatic switch, a closed circuit including a source of current and a control relay for said switch, means for producing a series of interruptions in said circuit to cause deënergizations of said relay for operating said switch, and automatic means for increasing the current flow in said circuit after each interruption to a point above normal in order to facilitate the energization of said relay after each deenergization.

3. In a telephone system, an automatic switch and a closed control circuit therefor including a battery, means for producing a series of interruptions in said circuit to operate said switch, and means in said switch for automatically decreasing the resistance of said circuit while the switch is operating.

4. In a telephone system, an automatic switch and a closed control circuit therefor including a battery, means for producing variable series of interruptions in said circuit to directively control the operation of said switch, and means in said switch for automatically decreasing the resistance of said circuit while the switch is operating.

5. In a telephone system, an automatic switch and a closed control circuit therefor including a battery, means for producing a series of interruptions in said circuit to operate said switch, and means in said switch for automatically lowering the impedance of said circuit while the switch is operating.

6. In a telephone system, an automatic switch and a closed control circuit therefor including a battery, means for producing variable series of interruptions in said circuit to directively control the operation of said switch, and means in said switch for automatically lowering the impedance of said circuit while the switch is operating.

7. In a telephone system, an automatic switch and a control circuit therefor, means for transmitting directive current impulses over said circuit to variably operate said switch, and means in said switch for automatically lowering the resistance of said circuit during the transmission of impulses.

8. In a telephone system, an automatic switch and a control circuit therefor, means for transmitting directive current impulses over said circuit to variably operate said switch, and means in said switch for automatically lowering the impedance of said circuit during the transmission of impulses.

9. In a telephone system, an automatic switch and a control circuit therefor, means for transmitting directive current impulses over said circuit to variably operate said switch, and means in said switch for auto-

matically lowering the resistance and impedance of said circuit during the transmission of impulses.

10. In a telephone system, a trunk line, a main progressively movable switch individual to said trunk line and an auxiliary progressively movable switch individual to said trunk line, means for operating said switches in succession, operating circuits for said switches having a common conductor, means in the auxiliary switch for opening said conductor at the beginning of its operation, and means in the main switch effective until after the auxiliary switch has completed its operation for bridging the open connection in said conductor.

11. In a telephone system, a plurality of subscribers' lines, a group of trunk lines, means for operating said connector to establish connection with a desired subscriber's line, or to select and establish connection with an idle trunk line, an operating magnet included in said means, and a relay operating as a busy test relay when a subscriber's line is selected, and operating as a stepping relay for said magnet when an idle trunk is being selected.

12. In a telephone system, an automatic connector switch, a plurality of trunk lines accessible to said switch and divided into groups, a pair of test contacts for each trunk line, the two contacts of certain pairs being conductively connected, a pair of test wipers for said connector, and associated testing mechanism and circuits in said connector such that the division of said trunk lines into groups is determined by the absence of conductive connections between the pair of test contacts associated with the last trunk line of each group.

13. In a telephone system, an automatic connector switch, a plurality of trunk lines accessible to said switch and divided into groups, a pair of test contacts for each trunk line conductively connected, a resistance included in certain of said connections, a pair of test wipers coöperating with said pairs of contacts, and testing mechanism and circuits associated with said wipers such that the division of said trunk lines into groups is determined by the presence of a resistance in the connection between the test contacts associated with the last trunk line of each group.

14. In a telephone system, an automatic connector switch, a group of trunk lines accessible to said switch, two series of test contacts in said connector, there being a test contact in each series for each trunk line, conductive connections between the test contacts associated with each trunk line except the last, means for operating said connector to connect with the first of said trunk lines if the same is idle, a test wiper for each series of test contacts, and means controlled by the coöperation of said wipers with said test contacts for causing said connector to automatically select an idle trunk line if the first is busy.

15. In a telephone system, an automatic connector switch, a group of trunk lines accessible to said switch, two series of test contacts in said connector, there being a test contact in each series for each trunk line, conductive connections between the test contacts associated with each trunk line except the last, means for operating said connector to connect with the first of said trunk lines if the same is idle, a test wiper for each series of test contacts, and means controlled by the coöperation of said wipers with said test contacts for causing said connector to automatically select an idle trunk line if the first is busy and effective to stop said connector on the last trunk line whether the same is busy or idle.

16. In a telephone system, an automatic connector switch, a plurality of groups of trunk lines accessible to said switch, two series of test contacts in said connector corresponding to the several trunk lines, conductive connections between the two test contacts which are associated with each trunk line, except that between the test contacts associated with the last trunk line of each group the connections are omitted, means for operating said connector to connect with the first trunk line of any group if the same is idle, a test wiper for each series of test contacts, and means in said connector coöperating with said wipers to cause said connector to automatically select an idle trunk line if the first is busy.

17. In a telephone system, an automatic connector switch, a plurality of groups of trunk lines accessible to said switch, two series of test contacts in said connector corresponding to the several trunk lines, conductive connections between the two test contacts which are associated with each trunk line, except that between the test contacts associated with the last trunk line of each group the connections are omitted, means for operating said connector to connect with the first trunk line of any group if the same is idle, a test wiper for each series of test contacts, and means in said connector cooperating with said wipers to cause said connector to automatically select an idle trunk line if the first is busy and effective to stop said connector on the last trunk line of the group whether the same is busy or idle.

18. In a telephone system, an automatic connector switch, a group of trunk lines accessible to said switch, two series of test contacts in said connector corresponding to the several trunk lines, conductive connections between the two test contacts associated with each trunk line, a resistance included in the connection between the test contacts asso-

ciated with the last trunk line of the group, means for operating said connector to connect with the first trunk line of the group if the same is idle, a test wiper for each series of test contacts, and means controlled by the coöperation of said wipers with said test contacts for causing said connector to automatically select an idle trunk line if the first is busy.

19. In a telephone system, an automatic connector switch, a group of trunk lines accessible to said switch, two series of test contacts in said connector corresponding to the several trunk lines, conductive connections between the two test contacts associated with each trunk line, a resistance included in the connection between the test contacts associated with the last trunk line of the group, means for operating said connector to connect with the first trunk line of the group if the same is idle, a test wiper for each series of tests contacts, and means controlled by the coöperation of said wipers with said test contacts for causing said connector to automatically select an idle trunk line if the first is busy, and effective to stop said connector on the last trunk line of the group whether the same is busy or idle.

20. In a telephone system, subscribers' lines terminating in a central exchange, a plurality of other exchanges, some manual and some automatic, a group of trunk lines extending to each exchange, an automatic connector switch having access to said subscribers' lines and to said trunk lines, means for operating said connector to establish connection with a desired subscriber's line or to automatically select and establish connection with an idle trunk line in any desired group, and means for causing said connector to function in three different ways characteristic of the three kinds of lines to which it has access.

21. In a telephone system, a plurality of subscribers' lines and a plurality of trunk lines divided into two classes, the trunk lines in each class being divided into groups, a connector switch having access to all said lines, means for operating said connector to establish connection with a desired subscriber's line, or to automatically select and connect with an idle trunk line in any desired group, inductive connections in the talking conductors extending through said connector, and means for automatically closing direct metallic talking conductors through said connector only when a trunk line in a particular class is selected.

22. In a telephone system, a plurality of subscribers' lines and a plurality of trunk lines divided into two classes, the trunk lines in each class being divided into groups, a connector switch having access to all said lines, means for operating said connector to establish connection with a desired subscriber's line, or to automatically select and connect with an idle trunk line in any desired group, means associated with said connector for automatically projecting signaling current over any connected line, and means operated automatically if the connected line is a trunk line in a particular class for preventing the initiation of the signaling operation.

23. In a telephone system, a plurality of subscribers' lines and a plurality of trunk lines divided into two classes, the trunk lines in each class being divided into groups, a connector switch having access to all said lines, means for operating said connector to establish connection with a desired subscriber's line, or to automatically select and connect with an idle trunk line in any desired group, a bridged battery supply relay in said connector for feeding talking current to a connected line, and means for automatically disconnecting said relay if the connected line is a trunk line in a particular class.

24. In a telephone system, telephone lines, a plurality of stations on each line, a plurality of groups of different characteristic signaling circuits, the total number of circuits being equal to the total number of stations on a line, and means for connecting a calling line with a called line and for selectively signaling the desired station, comprising selecting mechanism responsive to a digit in the called number for selecting a group of said circuits, and responsive to another digit for selecting the required circuit in the selected group.

25. In a telephone system, a party line, ringing current generators of different frequency, a plurality of one bell stations on said line having ringers adjusted, respectively, to the frequency of said generators, a plurality of two bell stations on said line having ringers similarly adjusted, two groups of connectors having access to said line and provided, respectively, with one and two bell ringing equipment, frequency selecting means associated with each connector, and means for connecting with said line via a connector of either group, together with means for operating the frequency selector of the connector in use, whereby the said stations may be selectively signaled.

26. In a telephone system, a party line, stations on said line divided into groups, as many groups of connectors having access to said line as there are groups of stations on said line, as many ringing current generators of different frequency associated with each group of connectors as there are stations in a group, a different characteristic signal controlling mechanism associated with each group of connectors, means for selecting the proper group of connectors to determine the character of the signaling operation to

be performed, means for selecting an idle connector in the selected group and for operating the same to connect with said line, and a frequency selector in each connector, together with means for operating the frequency selector of the operated connector to select the proper ringing generator to signal the desired station on the line.

27. In a telephone system, party lines, means for performing as many different characteristic signaling operations as there are stations on a line, the said signaling operations being divisible into classes, a plurality of groups of connectors, the connectors of each group being adapted to perform signaling operations of a different class, and said party lines being accessible to the connectors of all of said groups, means operated when a connection is to be established for selecting the group of connectors which is adapted to perform the required class of signaling operations, means for selecting an idle connector in the selected group and for operating the same to connect with the desired line, and means for then determining the precise kind of signaling operation which is to be performed in order to signal a wanted substation on the connected line.

28. In a telephone system, a party line, a plurality of one bell substations and a plurality of two bell substations on said line, an automatic ring back apparatus at the exchange for enabling one party to selectively signal the other parties on the same line.

29. In a telephone system, a party line, a plurality of one bell stations on said line, the ringers at said stations being responsive to different frequencies of ringing current, a similar plurality of two bell stations on the line, and automatic ring back apparatus at the exchange for enabling any party on the line to selectively signal the other parties on the same line.

30. In a telephone system, a party line, a plurality of one bell stations on said line, the ringers at said stations being responsive to different frequencies of ringing current, a similar plurality of two bell stations on the line, and automatic ring back apparatus at the exchange for enabling any one party on the line to call any of the other parties, said apparatus comprising means for suitably projecting the proper frequencies of ringing current over said line to signal the calling and called stations alternately.

31. In a telephone system, party lines, a plurality of substations on each line, and apparatus at the exchange for enabling any subscriber to signal the other subscribers on the same line, said apparatus comprising a plurality of ring back switches accessible to said lines in common and a ringing switch common to said ring back switches and having a plurality of ringing positions.

32. In a telephone system, a party line, a trunk line terminating in an automatic switch, means for connecting said line with said trunk line, and automatic ring back apparatus including an automatically operated step by step mechanism accessible to said switch and adapted to project while in motion ringing currents of proper frequency back over the said trunk line and party line to signal a calling and called station alternately.

33. In a telephone system, an automatic switch and a control circuit therefor, means for transmitting directive current impulses over said circuit to variably operate said switch, and means for automatically lowering the resistance of said circuit during the transmission of impulses.

34. In a telephone system, an automatic switch and a control circuit therefor, means for transmitting directive current impulses over said circuit to variably operate said switch, and means for automatically lowering the impedance of said circuit during the transmission of impulses.

35. In a telephone system, a party line, a plurality of one bell stations on said line, the ringers at said stations being responsive to different frequencies of ringing current, a similar plurality of two bell stations on said line, and automatic ring back apparatus at the exchange comprising means for selecting ringing currents of proper frequencies, and for projecting the selected currents back over said line at the proper intervals to signal a calling and a called station alternately.

36. In a telephone system, a party line, a plurality of one bell stations on said line, the ringers of said stations being responsive to different frequencies of ringing current, a similar plurality of two bell stations on said line, a trunk line at the exchange terminating in an automatic ring back equipment, means controlled from any calling station for extending connection to said trunk line, and means for then operating said equipment to select the ringing currents of proper frequency and to project the selected currents back over said trunk line at proper intervals to signal the calling and called stations alternately.

Signed by me at Chicago, Cook county, Illinois, this 13th day of September, 1917.

BERNARD D. WILLIS.