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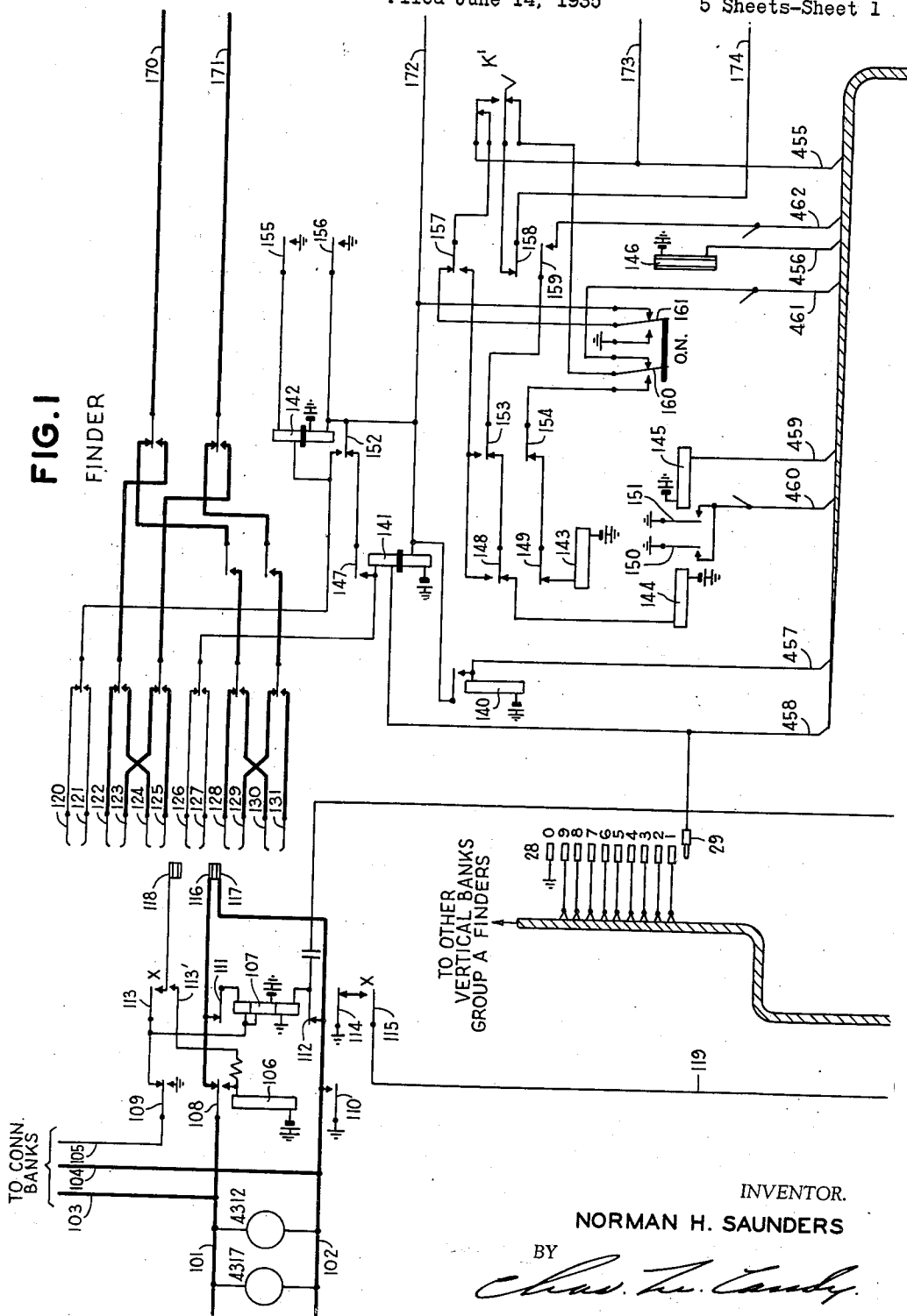
N. H. SAUNDERS

2,115,320

AUTOMATIC TELEPHONE SYSTEM

Filed June 14, 1935

5 Sheets-Sheet 1



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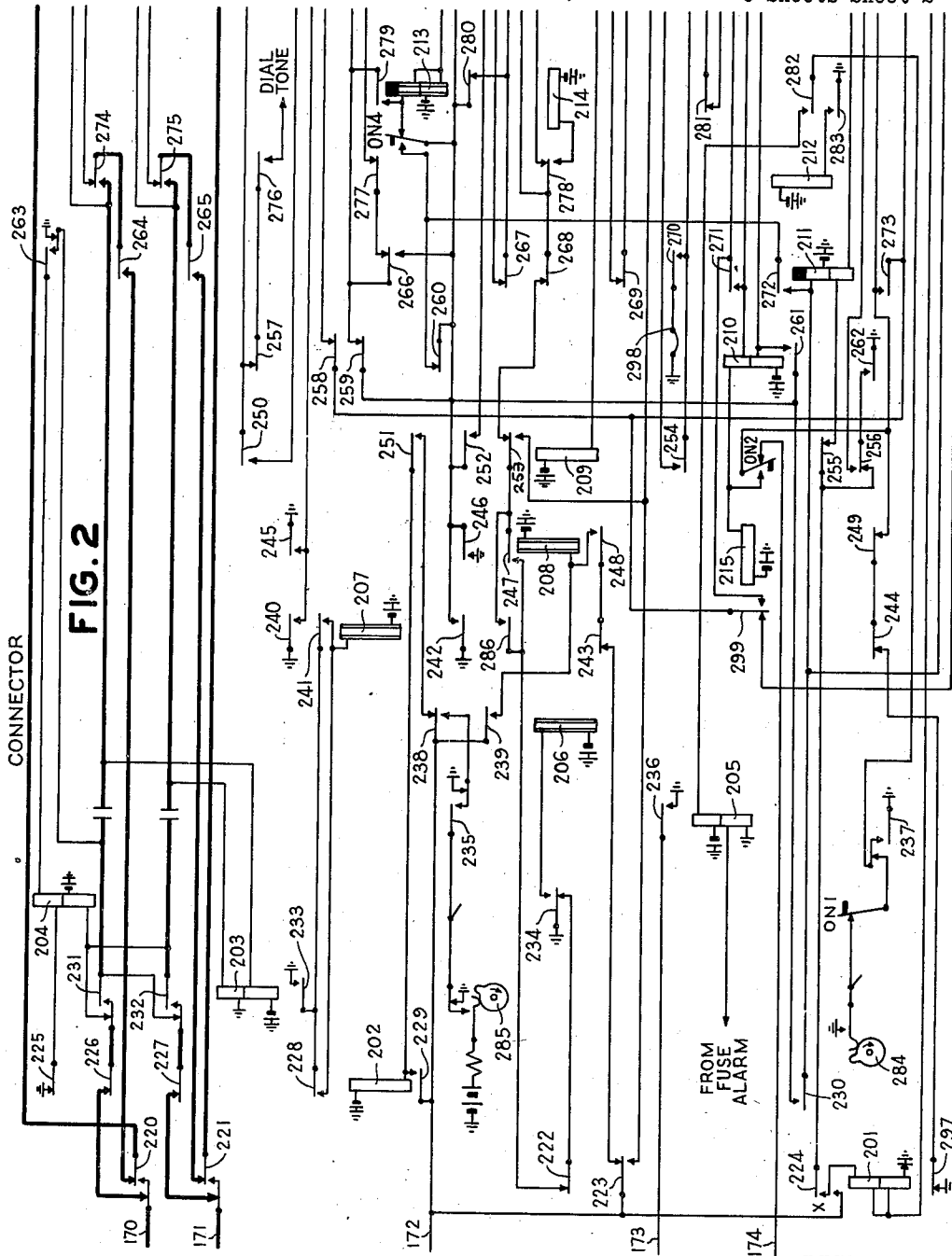
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AUTOMATIC TELEPHONE SYSTEM

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5 Sheets-Sheet 2



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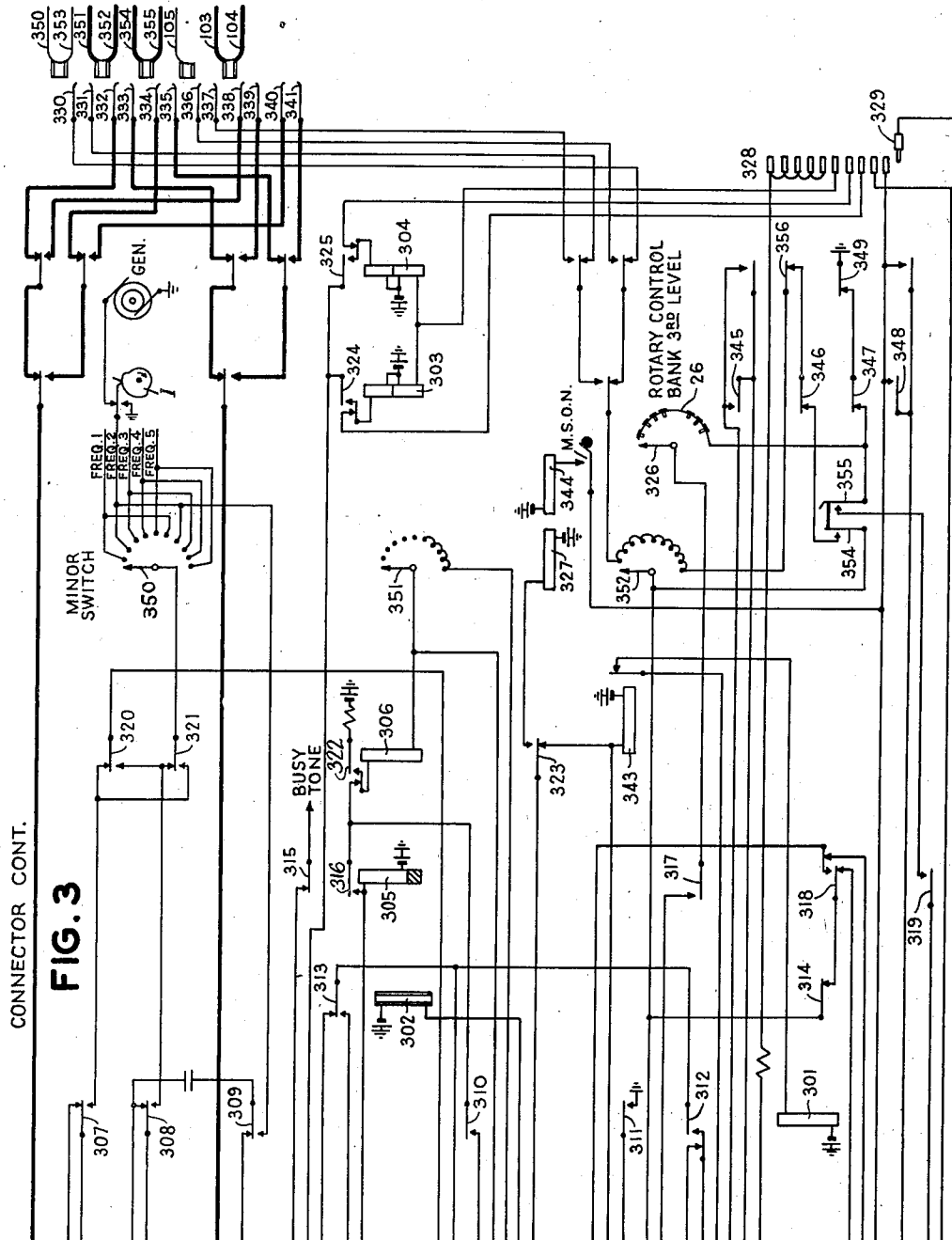
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AUTOMATIC TELEPHONE SYSTEM

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5 Sheets-Sheet 3



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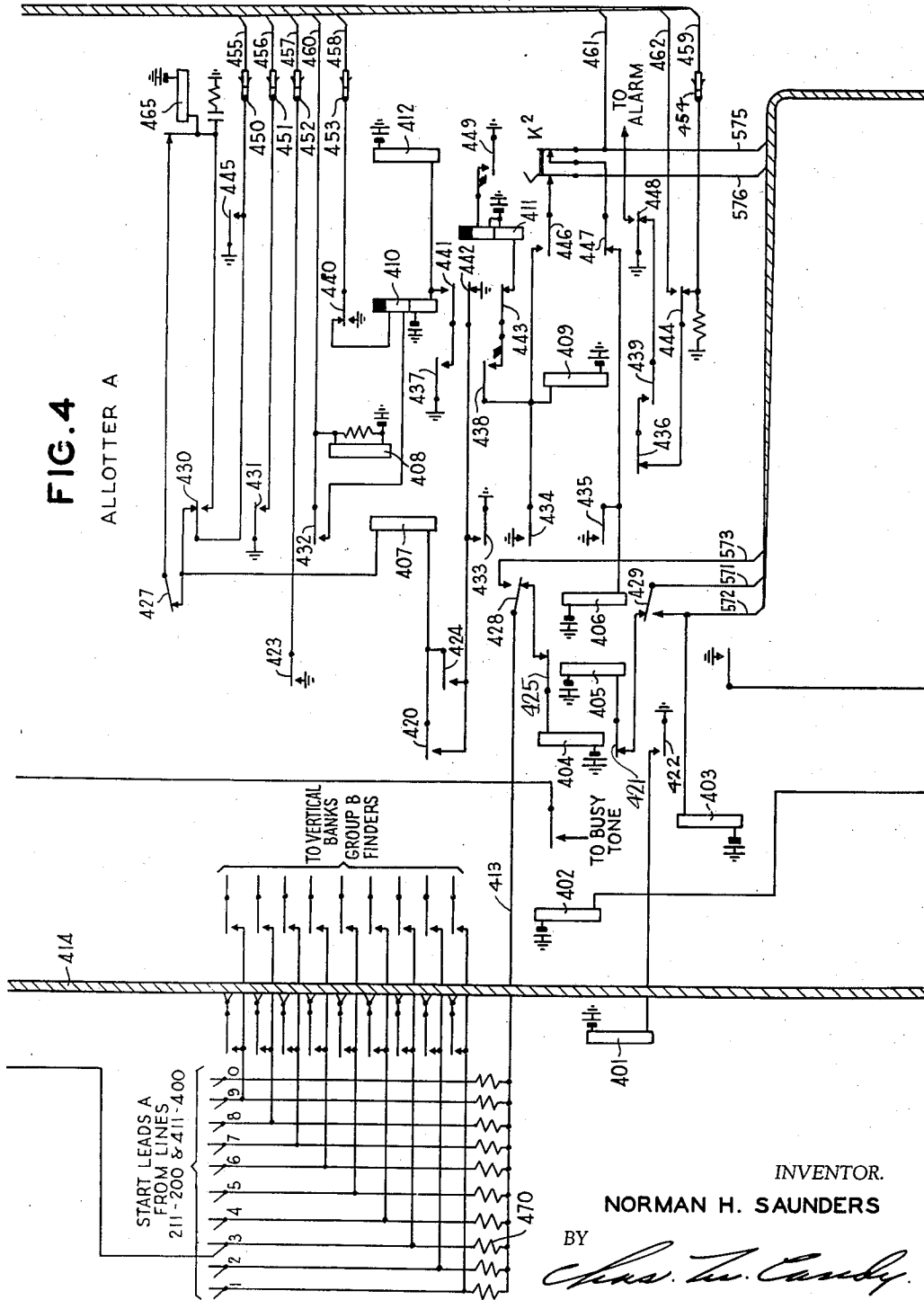
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AUTOMATIC TELEPHONE SYSTEM

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5 Sheets-Sheet 4



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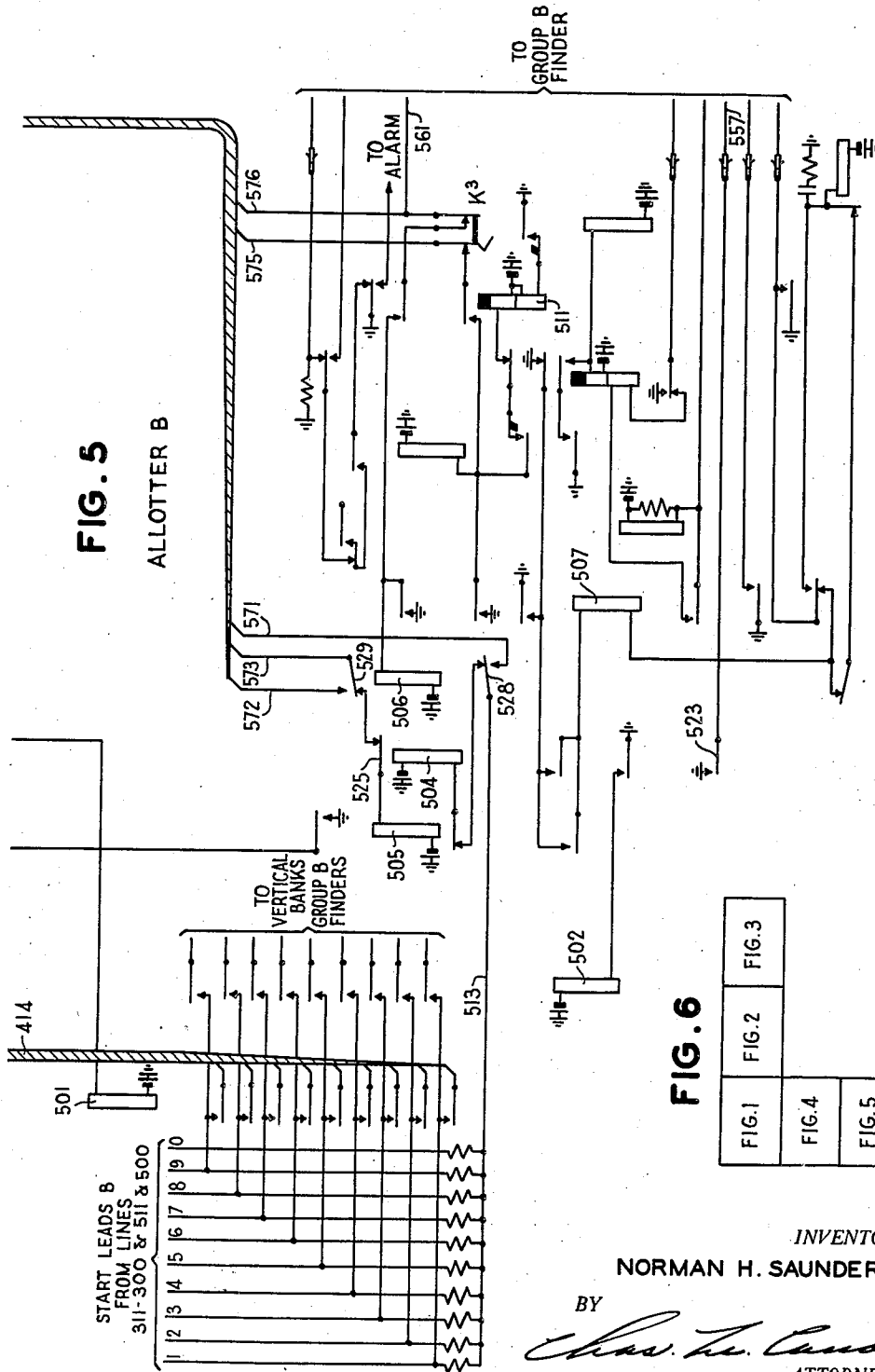
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AUTOMATIC TELEPHONE SYSTEM

Filed June 14, 1935

5 Sheets-Sheet 5



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2,115,320

AUTOMATIC TELEPHONE SYSTEM

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Application June 14, 1935, Serial No. 26,593

16 Claims. (Cl. 179—18)

The present invention relates in general to automatic telephone systems, but more especially to automatic systems of the Strowger step by step type, and the object of the invention is to produce a better and cheaper system for use in giving service in an exchange comprising between about three-hundred and six-hundred lines.

In further explanation of the object of the invention, it may be pointed out that the standard Strowger switch has a capacity of one-hundred lines. By using finders and connectors linked together in pairs an automatic switchboard for one-hundred lines may readily be constructed, and such is the common practice for small exchanges of this size. It has also been found feasible to equip the finders and connectors with two sets of wipers and thus increase their capacity to two-hundred lines, which is the largest sized exchange heretofore built, so far as is known, using finder connector links of the step-by-step type.

In the range extending from about three-hundred lines to one-thousand lines it has been the practice to insert first selectors. A common arrangement is to use finders paired with the first selectors, and connectors arranged in groups accessible to the selectors, constituting what is commonly known as a one-thousand line system. This larger type of system is more expensive per line than the one-hundred line or two-hundred line system hereinbefore referred to, because it introduces an additional order of switches.

In view of the facts stated in the foregoing, it will be understood that the manufacturer is somewhat handicapped in selling automatic equipment for exchanges which are just a little too large for a simple finder connector link system. A system of the one-thousand line type has to be used, which results in a sudden rise in the cost per line, which although entirely justified by the equipment which has to be supplied, is nevertheless difficult to satisfactorily explain to the customer.

More specifically it is the object of the present invention to devise a system which will fill the existing gap between the one-hundred line or two-hundred line system and the one-thousand line system, by producing an exchange in this capacity range which can be sold at a cost per line comparable with the cost per line of the smaller system and considerably less than the cost per line of the one-thousand line system.

The object is accomplished by new and improved arrangements for mounting the switch-

ing equipment and by new and improved circuits which make it possible to use finders and connectors of much larger capacity than has heretofore been considered possible. In a representative system, such as will be described herein, the switching equipment comprises finder connector links, each finder and each connector having four sets of wipers, which gives them access to four-hundred lines. Thus a system is produced capable of giving service in an exchange of this size, and at the same time the necessity for providing first selectors is obviated. The system is arranged so that additional banks and wipers may readily be added to increase the capacity to six-hundred lines whenever the occasion should arise.

Further details of the system will be explained hereinafter in connection with the drawings, in the course of a full explanation of the equipment and circuits of which it is comprised.

Referring to the drawings, Figs. 1 to 5, inclusive, are circuit drawings which show the circuits which are necessary to enable the system to be explained; while Fig. 6 shows how the circuit drawings are put together. Of these circuit drawings, Fig. 1 shows a line circuit and a finder switch, Figs. 2 and 3 show a connector switch, while Figs. 4 and 5 show two allotters with the associated common start wires.

The general arrangement of the system will first be described briefly. There are four-hundred lines. The majority of these lines are subscribers' lines, but a few of them may be trunk lines extending to another exchange. Each line is provided with a line circuit comprising two relays. Thus the line shown at the left of Fig. 1 comprising conductors 101 and 102, is provided with line equipment consisting of relays 106 and 107. Relay 107 is a combined line and cut-off relay, while relay 106 is a lockout relay. From the line circuit conductors are extended to the multiple banks of the finder switches. There is also a branch for each line which extends to the banks of the connectors. Thus in the case of the line shown, the branch which extends to the connector banks comprises conductors 103, 104, and 105.

All connections in the system are set up by means of finder connector links, each link comprising a finder switch and a connector switch. These switches are of the well known Strowger vertical and rotary type. Each finder and each connector is provided with four sets of wipers so that it may have access to all four hundred lines of the system. There may be around thirty

links, more or less, depending on the amount of traffic.

The subscribers are assigned numbers beginning with the digits 2, 3, 4, and 5, that is, the second, third, fourth, and fifth hundreds are used. Subscribers' numbers all have four digits, of which the first three are line selecting digits while the fourth is a party selecting or ringing current selecting digit. Trunks may have two, three, or four digit numbers, depending upon factors which will be explained.

While the link circuits are all in one large group from the standpoint of each line being able to serve all the lines in the system, these link circuits are nevertheless divided into two groups as regards the arrangements which are provided for starting the finders. The lines are divided into groups A and B, the lines which have numbers in the even thousands constituting group A, and the lines which have numbers assigned in the odd hundreds constituting group B. The finders are divided into two corresponding groups, the basis of the division being that the finders of group A normally serve the lines in group A, while the finders in group B normally serve the lines in group B. It will be understood, however, that each finder has access to all the lines, as stated hereinbefore, and if no finder in group A is available at the time that a line in that group makes a call, then a finder in group B will be taken for use. The same is true as regards lines in group B calling when no finders in the associated group are available.

The starting of finders is controlled by means of two allotters. Fig. 4 shows allotter A which is associated with the finders of group A, Fig. 5 shows allotter B which is associated with the finders of group B. The finder switch which is shown in Fig. 1 is a finder in group A, and consequently is accessible from the bank of allotter A, Fig. 4, as indicated by the cable including conductors 457, 458, etc. The allotter A may be a 25-point switch of the type which has a movement in a forward direction only. Only one set of contacts is shown, being the set of contacts which is assigned to the particular finder which is shown in Fig. 1. The other sets of contacts are individual to and are wired to the other finders of group A. Allotter B in Fig. 5 is similar to the allotter A, Fig. 4. Allotter B is associated with the finders of group B and the various sets of contacts in its bank are wired to the finders of that group, the same as the contact sets of allotter A are wired to the finders of group A.

For each group of lines there are ten common start leads. The common start leads for the lines of group A are shown appropriately labeled at the left of Fig. 4. There is one start lead for each tens group of lines, corresponding to each level of the finder switches. The common start wires are accordingly numbered for convenience from 1 to 0. Each common start lead is connected by way of a resistance to a main start conductor 413, which extends to the allotter A. Each line circuit is provided with an individual start lead. The manner in which these individual start leads are connected will now be explained. The individual start lead for lines 11 to 10 of the second hundred and for lines 11 to 10 of the fourth hundred are connected to common start lead No. 1 of the A group, Fig. 4. The individual start leads for the lines 21 to 20 of the second and fourth hundreds are connected to common start lead No. 2, while the individual start leads for lines 31 and 30 of the second and

fourth hundreds are connected to the common start lead No. 3, and so on. Thus it will be seen that as regards the line shown, which belongs to the fourth hundred, the individual start lead 119 is connected to the No. 3 common start lead. The manner in which the other individual start wires of group A are connected up will be clear from the foregoing. As regards the individual start leads for the lines of group B, these are connected up to the common start leads B shown in Fig. 5 in the same way that the connections are made in group A.

The common start leads not only function as a means of starting the finder switches through the medium of the allotters, but they also serve to mark the levels in the finder banks in which calling lines are located. Each finder switch is provided with a so-called vertical bank, the vertical bank of the finder switch, Fig. 1, being indicated at 28. By reference to Figs. 1 and 4 it will be seen that the energization of relay 401 associated with the allotter A is effective to extend the common start leads 1 to 9, inclusive, by way of cable 414 to the vertical bank contacts 1 to 9, respectively, of vertical bank 28. The cable 414 is common to all finders of group A and the conductors thereof are multiplied into all the vertical banks such as 28 which are associated with such finders.

By reference to Fig. 5 it will be observed that relay 501 has the function of connecting all the common start leads of group B by way of cable 414 to the vertical banks of the finders of group A. This relay 501 is energized whenever a finder in group A is started up to find a calling line in group B.

It should be pointed out also that there is a cable similar to cable 414 which extends to the vertical banks of the finders in group B. Relays 502 and 402, under control of allotter B, serve to connect the common start leads of groups B and A to this cable. The conductors leading to the right from relay contacts of relays 402 and 502 are appropriately labeled to indicate the foregoing arrangement. All of this will be more clearly understood from the detailed explanation of the operation of the system.

The mechanical construction of the switch-board may be in accordance with the well known practice in the Strowger system, or it may be as disclosed in the copending application of Mahoney, Serial No. 18,774, filed April 29, 1935.

The operation of the equipment in setting up a number of representative connections will now be described. The first connection which will be considered is a call from station 4312, on line 101-102, to another subscriber in the system whose number will be assumed to be 3312.

Upon removal of the receiver at station 4312, the subscriber's talking equipment is bridged across the line, thereby closing a circuit over the line conductors 101-102 for the combined line and cut-off relay 107. It will be observed that the three windings of relay 107 are connected across the line in series with the battery. The upper winding of relay 107 is made of wire having high resistance, so that the relay is inefficient under these operating conditions and pulls up only part way, closing the contacts marked X and leaving the position of the other contacts unaltered. The closure of the upper contact X places battery potential through the middle winding of relay 107 on test contact 118, thus marking the line as calling in the banks of the finders such as the finder shown in Fig. 1. The closure of the lower

contact X places ground on the individual start wire 119.

Since the individual start wire 119 is connected to the No. 3 common start lead, Fig. 4, a circuit is completed which extends from the grounded common start lead by way of 470, 413, 428, and 425 to relay 404 of the allotter A, Fig. 4. Relay 404 accordingly energizes. At 422 relay 404 closes a circuit for relay 401, and the latter relay upon operating connects all the common start leads by way of 414 to the vertical test banks of the finders in group A. Thus a ground is placed on the No. 3 test contacts in these vertical test banks, including the No. 3 test contact in bank 28, Fig. 1.

The energization of relay 404 also opens the circuit of relay 405 at 421 and closes a circuit for relay 407 at 420. Upon energizing, relay 407 closes a locking circuit for itself at 433. In addition, relay 407 closes a circuit for relay 409 at 434, and a circuit for relay 406 at 435. The latter circuit is to guard against release of relay 406 in the event that only one finder switch is available, as will be explained more fully later on. Relay 407 also shifts the circuit of wiper 450 at 430 for reasons to be presently explained, prepares the test circuit at 432 for test relay 410, and at 431 places ground on the wiper 451. This latter operation grounds the individual start wire 456 extending to the finder shown in Fig. 1.

When the circuit of relay 409 is closed, this relay operates, at 437 prepares a locking circuit for relay 410, at 439 closes an impulsing circuit for the finder, Fig. 1, and at 438 attempts to close a circuit for relay 411. The contact engaged by spring 438, however, is weighted and upon the operation of relay 409 this contact is set into vibration with the result that the circuit to relay 411 is intermittently opened and closed. Relay 411 cannot operate under these conditions. As a matter of fact, this relay never does operate if the calling line is found in the normal manner. The function of relay 411 will be fully explained later on.

The effect of grounding the individual start wire 456 is to operate the start relay 146 of the finder, Fig. 1.

Upon energizing, relay 146 prepares a circuit for rotary magnet 144 at 159, disconnects conductor 174 from the conductor 461 at 158, shifts the circuit of the guard wire 455 at 157 in order to prepare for energizing the stepping magnet 465 of the allotter, prepares a circuit for test relay 142 at 155, and at 156 closes circuits through the polarizing windings of test relays 141 and 142. These relays, however, do not operate at this time.

As already mentioned, the relay 409 of the allotter closes the impulsing circuit for the finder when it pulls up, so that the finder is started in its vertical movement by the time the so-called start relay 146 has pulled up. The circuit for the vertical magnet extends from ground by way of 448, 439, 436, 444, 454, and 459 to vertical magnet 145. On the closure of this circuit the vertical magnet of the finder energizes and advances all the sets of wipers into position opposite the first levels in their respective banks, at the same time shifting the off normal springs 160 and 161. It is understood that the vertical movement is in reality a horizontal movement in view of the way the switches are mounted, but it is thought that the explanation will be clearer if the familiar term "vertical" is retained. When the vertical magnet 145 energizes it also grounds conductor 460 at 151, thereby operating the stepping relay 408 of the allotter. Upon energizing

relay 408 opens the circuit of vertical magnet 145 at 436, whereupon the vertical magnet falls back and opens the circuit of relay 408. Relay 408 then falls back and again closes the circuit of vertical magnet 145, causing the magnet to advance the switch wipers another step. This operation in which the vertical magnet and relay 408 are alternately energized continues until upon the third step of the vertical magnet the vertical test wiper 29 arrives at the No. 3 test contact in the vertical bank 28.

The operation of stopping the vertical movement will now be explained. Upon the third step relay 408 of the allotter energizes by way of 151 and opens the vertical magnet circuit at 436. The vertical magnet accordingly falls back and breaks the circuit of relay 408 at 151. Relay 408, however, does not fall back but remains held up over a circuit which extends from the grounded No. 3 test contact in the vertical bank 28 by way of 29, 458, 453, 440, upper winding of the test relay 410, 432, and winding of relay 408. Relay 410 energizes over the above circuit in series with relay 408, the latter relay holding up as stated prevents the circuit of the vertical magnet from again being closed.

Upon energizing, the test relay 410 locks itself at 441 and also closes a circuit for relay 412. The latter relay pulls up and attempts to close a circuit for relay 411, but without effect under normal conditions because the contact engaged by spring 449 is constructed similar to the contact engaged by spring 438 of relay 409, the operation of which was previously described. Relay 410 also opens the initial energizing circuit of relay 407 at 442, but relay 407 holds up over its locking contact 433. By opening contact 443 relay 410 prevents the energization of relay 411 by way of the circuit previously closed at contact 438 of relay 409. At 444 relay 410 shifts the impulse or operating circuit from conductor 459 to conductor 462, thus accomplishing the changeover from vertical to rotary operation at the finder, Fig. 1. At 440, relay 410 grounds wiper 453 and also breaks the circuit which includes the upper winding of relay 410 and stepping relay 408. The latter relay now falls back in order to start the rotary movement of the finder switch, Fig. 1.

It will be understood now that all of the four sets of wipers with which the finder, Fig. 1, is provided are standing opposite the third levels in their respective banks. Only two of these sets are connected up, however, because relay 140 has not been energized. The wiper sets which are connected up are the set which comprises test wiper 120 and line wipers 122 and 123, this set having access to lines in the second hundred, and the set comprising test wiper 126 and line wipers 128 and 129, this latter wiper set having access to lines in the fourth hundred. The calling line, being a line in the fourth hundred, is accessible only to the latter set of wipers.

As mentioned hereinbefore, the rotary movement is started by the falling back of stepping relay 408, consequent upon the energization of test relay 410. The circuit for the rotary magnet extends from ground by way of 448, 439, 436, 444, 462, 159, 153, and 148 to the rotary magnet 144. The rotary magnet controls the circuit of stepping relay 408 at 150 and consequently the stepping operation during the rotary movement is similar to that which takes place during the vertical movement. As the wipers are rotated step by step responsive to the operation of rotary magnet 144, the test wiper 120 searches for battery potential

on the test contacts in the third level of its bank, and the test wiper 126 likewise tests for battery potential on the test contacts of the third level of its bank. Test wiper 120 finds no battery potential, but as soon as test wiper 126 engages test contact 118 of the calling line battery potential is found and a circuit is closed for energizing test relay 141. Relay 141 operates over a circuit extending from ground at the allotter, Fig. 4, by way of 440, 453, 458, upper winding of relay 141, wiper 126, 118, 113, and the middle winding of cut-off relay 107 to battery, this circuit serving also to fully energize relay 107.

By the energization of relay 141, the circuit of release magnet 143 is opened at 149, the rotary magnet circuit is opened at 148, the relay locks itself at 147, and at its two upper contacts the calling subscriber's line is connected through to trunk conductors 170 and 171.

The connecting through of the calling line to trunk conductors 170 and 171 results in the energization of line relay 204 of the connector, Fig. 2. Upon energizing, relay 204 closes a circuit for the slow acting relay 206 at 234. Relay 206 accordingly energizes and at 238 places ground on holding conductor 172. This operation completes a holding circuit for relays 141 and 107.

When relay 107 pulls up in series with relay 141 of the finder it disconnects ground from the start lead 119 at 114, and also disconnects its upper and lower windings from the subscriber's line at 111 and 112. In addition, relay 107 connects lock-out relay 106 to the holding circuit at 113'. It will be observed also that at this time the holding circuit for relay 107 provides a ground potential for the test conductor 105 extending to the connector banks, where the calling line is made busy.

When ground is disconnected from individual start wire 119, relay 404 of the allotter falls back, provided there is no other line in group A which is in calling condition. When relay 404 falls back it breaks the circuit of relay 401 which falls back also.

Returning now to the energization of test relay 141 of the finder, when this relay pulls up it closes at 148 a circuit which extends from the grounded impulse or operating conductor 462 by way of 159, 153, 148, 157, key K', 455, 450, and 430 to the stepping magnet 465 of the allotter A, Fig. 4. Stepping magnet 465 accordingly energizes and opens its interrupter contact, thus breaking the circuit of relay 407. Relay 407 therefore falls back and at 435 it removes ground from relay 406, but the latter relay holds up over conductor 461. In addition relay 407 breaks the circuit of relay 409 at 434, opens its own locking circuit at 433, breaks the circuit of start relay 146 of the finder at 431, and at 430 alters the circuit which was formerly traced over wiper 450 to the stepping magnet 465 so that this circuit includes the interrupter contact of the magnet. This interrupter contact being now open, for magnet 465 is energized, the foregoing shifting of the magnet circuit results in the opening of the circuit and the deenergizing of the magnet. When magnet 465 deenergizes, the wipers of the allotter are advanced one step into association with a set of contacts which is individual to the next finder. The allotter now proceeds to hunt for an idle finder under control of wiper 450. If the next finder is busy, there will be ground on the conductor corresponding to 455 and the stepping magnet 465 will reoperate to advance the wipers of the allotter into association with the next finder, this operation continuing until an idle finder is reached. It will be

noted that relay 407 cannot pull up responsive to a new call as long as the allotter is hunting for an idle finder, because the relay 407 will be short circuited by ground on contacts engaged by wiper 450.

When the circuit of relay 409 is broken by the deenergization of relay 407, the said relay 409 will fall back and break the circuits of relays 410 and 412. These relays accordingly fall back also.

In the finder switch, Fig. 1, when ground is removed from conductor 456 by the falling back of relay 407 in the allotter, relay 146 falls back. At 158 relay 146 prepares a circuit for release magnet 143, and at 157 ground from the off normal springs of the finder is extended to guard wire 455, thereby maintaining the finder in busy condition with respect to the allotter in Fig. 4.

The equipment is now ready for the calling subscriber at station 4312 to dial the number of the called station, but before proceeding with this operation, the explanation of the allotter and finder circuits will be completed.

Referring to the allotter A, Fig. 4, it will be seen that relay 406 is normally energized over common conductor 461. This conductor is common to all of the link circuits and has a branch at each line circuit which is normally grounded. Thus in the case of the link shown in the drawings, the branch of conductor 461 for that link circuit may be traced by way of off normal spring 160, key K', and spring 158 of relay 146, to conductor 174. Conductor 174 in turn may be traced by way of ON2, Fig. 2, 249, 244, and 297 to ground. Due to the fact that the connection between conductors 174 and 461 includes the serially related contacts of relay 146 and the off normal contact 160 (also contacts of busy key K'), it will be appreciated that whenever the link circuit is in use the connection between these conductors will be broken and the conductor 461 will no longer be grounded at the link circuit shown. If there are other idle link circuits in group A, however, conductor 461 will still remain grounded.

It will be assumed now that all of the links except one are busy, and that the remaining idle link circuit is the one shown in the drawings. The allotter A will have its wipers associated with this link circuit, due to the fact that the guard wires such as 455 of all the other link circuits will be grounded. If a call comes in now from one of the lines in group A, relay 404 will operate over conductor 413 as previously explained, followed by the energization of relay 407. The finder, Fig. 1, is operated to connect with the calling line in the manner described, and at the beginning of the operation the last ground is removed from conductor 461 by the energization of start relay 146. Relay 406 in the allotter does not fall back, however, because it is held up temporarily at contact 435 of relay 407. As soon as the finder completes its operation, ground is placed on guard wire 455 as previously explained, and the stepping magnet 465 is energized to break the circuit of relay 407. This relay then falls back as in the case previously described, but now it breaks the circuit of relay 406, since conductor 461 is no longer grounded. Relay 406 thereupon falls back and at 427 breaks the automatic hunting circuit of the allotter stepping magnet 465. Since all the link circuits are now busy all of the guard wires 455 will be grounded and unless the circuit of 465 were opened the allotter would continue to hunt indefinitely. In addition to the

foregoing relay 406 transfers the starting circuits, as will now be explained.

Assuming now that another line in group A makes a call, a circuit will be completed over the main start conductor 413 by way of 428 (relay 406 deenergized) 573, 529, 525, and relay 505 of the allotter B, Fig. 5. Relay 505 accordingly pulls up and controls the allotter B through the medium of relay 507 to start up an idle finder in group B. The finders in group B are just like the group A finder which is shown in Fig. 1, and the allotter B is like the allotter A, so that the ensuing operation need not further be described. It should be noted, however, that relay 505 of allotter B closes a circuit for relay 402 instead of 401. By the energization of relay 402 the common start leads of group A lines are connected to the vertical banks of the group B finders. This is obviously essential because the calling line is starting a finder of group B rather than a finder of group A.

The handling of a call from a line in group B will now be explained briefly. When the receiver is removed from a line in group B, ground is placed on one of the common start leads shown at the left of Fig. 5 thereby closing a circuit over the associated resistance and main start wire 513, to relay 504 of the allotter B. Relay 504 controls the allotter B through the medium of relay 507 in order to start up an idle finder switch of group B. It will be observed that relay 504 also closes a circuit for relay 502, by means of which the common start leads of group B are connected up in the vertical banks of the group B finders.

Assuming now that all of the finders of group B become busy, ground will be removed from the common conductor 561, which corresponds to conductor 461 of Fig. 4, and as the last finder completes its operation, relay 507 of the allotter will fall back and permit the release of relay 506. Upon relay 506 deenergizing, the main start wire 513 is transferred by way of 528, 571, 429, and 421 to relay 405 of allotter A. Accordingly, another call coming in from a line in group B will cause the energization of relay 405 of allotter A, which will start up a finder switch in group A. Relay 405 closes a circuit for relay 501, which connects the common start leads of group B into the vertical banks of the finders of group A.

Attention is directed to the fact that whenever a line in group B makes a call, the finder which is started up to connect with the calling line must undergo a wiper switching operation, since the finder wipers which are normally connected are those which serve the lines of group A. This wiper switching operation is performed by a relay such as relay 140, Fig. 1. Assume, for instance, that a calling line of group B starts up a finder in group A by means of relay 405 of the allotter, Fig. 4. When relay 405 energizes it grounds wiper 452 at 423, thereby closing a circuit over conductor 457 of the finder in use to relay 140 of such finder. In a similar manner when a line in group B makes a call and starts a finder in group B by means of relay 504 of the allotter B, relay 504 will connect ground at its contact 523 to the conductor 557 of the finder in use, and will energize the relay of such finder which corresponds to relay 140 of the finder shown in Fig. 1.

In case all of the links of both groups A and B are in use, a circuit is completed for placing a busy tone on all the subscribers' lines so that any subscriber upon removing the receiver will hear the busy signal. When all the links are in use relays

406 and 506 will both be deenergized. If another call comes in now from group A a circuit will be completed over conductor 413 by way of 428, 573, 529, and 572, to relay 403. This relay accordingly energizes and applies a busy tone to all the subscribers' lines which are not engaged in conversation. Of course, any line which is actually involved in a connection will have its relay such as 107 energized so that the associated line will be clear. A similar circuit to the foregoing may be traced by way of the main start wire 513 to relay 403 and is effective in a similar manner if a call should be made from a line in group B.

It will be recalled now that when the operation of the allotter A was being described it was explained that relay 411 tried to operate at the initiation of the vertical movement of the finder and also at the initiation of the rotary movement, but was prevented from so doing because of the special construction of the contacts engaged by springs 438 and 449, which introduce a delay in the response of relay 411. In the ordinary operation of the system relay 411 never operates because its first circuit is opened at 443 upon the completion of the vertical movement of the finder, and its second circuit is opened at 449 by the falling back of relay 412 upon the completion of the rotary movement of the finder. In the event that something should go wrong, however, which will prevent the starting of a finder, or the completion of its vertical or rotary movement, relay 411 will energize. When relay 411 operates it disconnects at 447 the common ground conductor 461 from relay 406, opens the impulsing circuit at 448, at 446 locks the relay 409 to the branch conductor 576 of the common ground conductor 561 associated with the allotter B, and at 448 also closes an alarm circuit to call the attention of the attendant to the fact that trouble has occurred. Also at 445 relay 411 closes a circuit for stepping magnet 465, which energizes and breaks the circuit of relay 407. Relay 407 falls back and alters the stepping circuit of magnet 465 to include its interrupter contact, so that the magnet deenergizes and advances the allotter one step. Relay 407 falling back also opens the circuit of relay 406. After 407 falls back relay 409 remains held up by 576 and 561, as stated. In this manner the allotter A is held out of service, and at the same time by the deenergization of relay 406 the main start wire 413 is transferred to allotter B, so that calls from group A may be handled by finders of group B. If the group B finders should all become busy, then ground is removed from conductors 561 and 576 with the result that relays 409 and 411 are deenergized and subsequent calls will try to get through by way of allotter A. In the meantime the trouble will no doubt have been fixed. At any rate, the next call will get a different finder due to the fact that the allotter has been advanced.

The key K', Fig. 1, is a link busy key provided for the purpose of rendering the associated link circuit busy. When this key is operated it disconnects conductor 174 from the common ground conductor 461, and at the same time it connects conductor 174 to the guard wire 455 so as to make the associated link circuit test busy in the bank of the allotter.

Key K2, Fig. 4, is a busy key for the allotter A. When this key is operated it opens the branch 576 of conductor 561 so as to drop back relay 409 if energized, and it disconnects the common

ground conductor 461 from relay 406 so as to release this relay and transfer the main start wire 413 to allotter B. The allotter B, Fig. 5, is provided with a similar busy key K3.

Returning now to the point where the calling line was extended by means of the finder, Fig. 1, to the connector, Figs. 2 and 3, it was described how the line relay 204 was energized, followed by the energization of relay 206 for the purpose of placing ground on the holding conductor 172. An additional result of the energization of relay 206 is the energization of relay 208, the circuit extending from the grounded conductor 172 by way of 239 to relay 208. Upon energizing, relay 208 locks itself at 248, and at 246 completes a circuit which extends through the vertical off normal contacts ON4 to relay 213. Upon energizing, relay 213 locks itself at 279, prepares a circuit for relay 205 at 282, and at 283 closes a circuit for relay 212. Upon energizing, relay 212 prepares a circuit for the vertical magnet 214 at 278, and at 276 connects dial tone to the calling subscriber's line. The latter operation gives the calling party an audible signal which notifies him that he can begin to dial the desired station.

It will be assumed, however, that for some reason or other the calling subscriber fails to dial, and the operations which take place under this condition will be described. Fig. 2 of the drawings shows two cams 284 and 285. These cams are mounted on a constantly rotating shaft, and make about one revolution per minute. These cams and the associated contact springs are common to all the link circuits. When relay 213 of the connector pulls up responsive to the seizure of the link, it prepares a circuit for relay 205 at contact 282 as explained above, and if the subscriber fails to dial, cam 284 will presently close a circuit for relay 205, the circuit extending from ground by way of ON1, contacts controlled by 237, 282, and upper winding of relay 205. Upon energizing, relay 205 locks itself at 237, and at 235 substitutes the ground which is associated with the springs of cam 285 for the ground which was formerly connected to the holding conductor 172 by relay 206. About one minute later, cam 285 will operate its associated contact springs, thereby inserting a booster battery in the holding circuit including conductor 172. This operation raises the potential sufficient to operate relay 106 in the subscriber's line circuit. Upon energizing, relay 106 locks itself across the line at contacts 108 and 110, disconnects the line conductor 161 from the finder bank at 108, and disconnects the test conductor 105 from relay 107 at 109, at the same time placing ground on this test conductor to maintain the line busy. The opening of the line conductor 101 causes the line relay 204 in the connector to fall back, followed by the deenergization of relays 206, 208, 213, 212, and 205. Relay 206 on falling back removes ground from the holding conductor 172, which permits relay 141 of the finder and relay 107 of the subscriber's line circuit to fall back also. Relay 141 upon deenergizing closes a circuit at 149 for the release magnet 143 of the finder. The operation of the release magnet restores the switch shaft to normal, and the circuit of the magnet is broken at off normal springs 169 when the shaft is completely restored.

It will be appreciated that the purpose of the arrangement described in the foregoing is to prevent the link from being tied up when it is not

actually being used in setting up a connection. The apparatus functions as described not only if a calling subscriber should delay dialling but also if the receiver should be accidentally displaced from the hook, or if the line should be short circuited at any point. Any of these occurrences will cause the link circuit to be taken for use the same as on a regular call, but if no dialling occurs the link is very shortly freed and the line is locked out by means of the associated relay 106. It will be noted that the locked out condition depends on the maintaining of a bridge across the line, so that whenever the trouble becomes clear the lock out relay will automatically be released and the line circuit will be restored to normal condition.

Attention is directed also to the fact that the lower winding of relay 205, Fig. 2, is connected to a conductor coming from the power panel where it is connected to the individual fuse alarm terminal for this particular link circuit. If the fuse which is individual to the link circuit should become broken or blown out battery will be placed on this conductor, resulting in the energization of relay 205 over its lower winding. If the link circuit is in use at the time, the connection or partial connection will be released as described in the foregoing and the calling line will be locked out, requiring the subscriber to replace his receiver before he can call again. In any event, the link is made busy at 236, where ground is applied to the guard wire 455.

Returning again to the point where the calling line was extended to the connector, Figs. 2 and 3, it will be assumed that dialling begins. The number of the called station, it will be remembered, is 3312, and therefore the first digit to be dialled is the digit 3. It will be assumed, however, that by some mischance the calling subscriber dials the digit 1 instead of the digit 3. This may happen by reason of faulty manipulation of the dial. A single impulse or interruption corresponding to the digit 1 may also be produced by an accidental momentary depression of the switchhook.

When the single interruption corresponding to the digit 1 occurs, the line relay 204 of the connector, Fig. 2, falls back momentarily. Relay 206 is slow to release and remains operated during the momentary interruption of its circuit. When relay 204 falls back it transmits an impulse over a circuit which extends from ground by way of 234, 222, 247, 253, 268, and 278 to the vertical magnet 214. Responsive to this impulse, the vertical magnet 214 operates and advances the shaft of the connector one step. When the shaft moves off normal, the various off normal springs are shifted, including ON4, but relay 213 remains locked up by way of 246, 259, and 279. The movement of the switch shaft also brings the vertical wiper 329, Fig. 3, into engagement with the first contact in the vertical bank 328. Relay 302 is energized in parallel with the vertical magnet. Shortly after the vertical magnet has operated, relay 302 falls back and closes a circuit for the connector release magnet 215, the circuit extending from ground by way of 246, 313, 258, 299, wiper 329, and contact engaged thereby, and ON2 (now shifted), to the release magnet 216. Responsive to the closure of the above circuit the release magnet energizes and restores the switch shaft to normal. It will be noted that when the release magnet 215 energizes it breaks its own operating circuit at 299. These springs do not open, however, until the armature is nearly operated and do not prevent the effective operation of the release magnet, because only a momentary

energization of the magnet is required to disengage the usual double-dog of the switch and lock it under the release link. This construction is well known and need not be further explained.

It will be seen from the foregoing that if the first digit dialled is the digit 1, the only result is to operate and then immediately release the switch, thus absorbing or cancelling the digit.

It will be assumed now that the dialling of the called number proceeds in the proper manner, the first digit dialled being the digit 3. When the digit 3 is dialled three momentary interruptions are produced in the circuit of the line relay 204, and this relay accordingly falls back momentarily three times, transmitting three impulses over the previously traced circuit to vertical magnet 214 and relay 302 in parallel. Vertical magnet 214 operates three times and advances the switch shaft three steps. The vertical wiper 329 is thus positioned on the third contact in the vertical bank 328. Relay 302 is slow acting and holds up during the series of impulses.

When the series of impulses is finished, relay 302 very shortly deenergizes and completes a circuit for wiper selecting relay 303. This circuit extends from ground by way of 246, 313, 258, 299, and wiper 329 and contact engaged thereby, to relay 303. Upon energizing, relay 303 locks itself at 324, and at 348 closes a circuit for the release magnet 215. The release magnet circuit extends from ground by way of 246, 313, 258, 348, and ON2 to the release magnet 215. Responsive to the closure of the foregoing circuit, release magnet 215 operates and disconnects wiper 329 at 299. Also at 299 the release magnet closes a circuit for off normal relay 210 which extends from ground by way of 246, 313, 258, 299, 345, (relay 303 being now energized), upper winding of relay 210, and winding of release magnet 215 to battery. Relay 210 cannot operate over the above circuit just at this time because the winding of the relay is short circuited by ground on the operating circuit which was formerly traced to the release magnet by way of ON2. However, an instant later the switch shaft will be restored due to the operation of the release magnet and the off normal springs ON2 will be shifted back to normal position, opening the operating circuit for the release magnet 215. This removes the short circuit from the upper winding of relay 210 and this relay accordingly operates over the circuit traced. Upon energizing, relay 210 locks itself at 261, and at 258 breaks the circuit which includes its upper winding and the release magnet 215, thus permitting the release magnet to deenergize. The energization of relay 210 opens the dial tone circuit at 257, and also alters some other circuits which will be explained later.

It will be seen as a result of dialling the first digit 3 of the called number the connector switch is operated to the third level and immediately released again. Moreover, the operation of the switch results in the energization of the wiper selecting relay 303, which remains locked up after the switch releases. The energization of relay 303 selects and connects up the set of wipers which comprises test wiper 331 and the two line wipers 334 and 335. This set of wipers has access to lines in the third hundred, one of which is the line of the called subscriber.

The calling subscriber may now dial the next digit of the called number, which is also the digit 3. Accordingly the line relay 204 falls back momentarily three times, and at 234 again delivers three impulses to the vertical magnet 214 and to

the slow acting relay 302 in parallel. The vertical magnet 214 advances the switch shaft three steps as before. Relay 302 energizes in parallel with the vertical magnet and holds up during the series of impulses. At the first step of the switch shaft the off normal springs are shifted, and the shifting of ON4 opens the initial energizing circuit of relay 213. The previously described locking circuit for relay 213 is now open at 259, due to relay 210 having energized, but relay 213 holds up for the time being over another locking circuit which extends from ground by way of 246, 313, and 279 to relay 213. At the end of the series of impulses the slow acting relay 302 falls back in due time. The deenergization of this relay does not now ground the vertical wiper 329 nor close the circuit of the release magnet 215, because contact 258 of relay 210 is now open. However, the falling back of relay 302 does break the circuit of relay 213, permitting this relay to deenergize. Upon deenergizing, relay 213 breaks the circuit of relay 212, which falls back also. The only result of the deenergization of relays 213 and 212, which needs to be noted at this time, is the transfer of the impulsing circuit at 278 of relay 212 from the vertical magnet 214 to the rotary magnet 343.

The calling subscriber may now dial the next digit of the called number, which is the digit 1. The line relay 204 therefore falls back once momentarily and transmits an impulse to the rotary magnet 343 in parallel with the slow-acting relay 302. The rotary magnet responds to this impulse and rotates the switch shaft and wipers one step, so that the various sets of wipers are brought into engagement with the first contacts of the third levels of their respective banks. Relay 302 operates in parallel with the rotary magnet 343. Relay 212 being now deenergized, when relay 302 operates it closes a circuit for the slow acting relay 305, said circuit extending from ground by way of 246, 313, 266, and 277 to relay 305. Upon energizing, relay 305 closes a circuit for relay 306 which extends from ground by way of 246, 280, 267, winding of relay 306, and 316 to relay 305. Relay 306 cannot energize over this circuit because it is short circuited for the time being by the previously described to ground for energizing relay 305.

Shortly after the operation of the rotary magnet is completed, relay 302 will fall back and break the circuit of relay 305. This operation also removes the short circuit from relay 306 and the latter relay energizes in series with relay 305. Upon energizing, relay 306 locks itself at 322 and also breaks the circuit of relay 305, which accordingly deenergizes. In addition to the foregoing, at 323 relay 306 transfers the impulsing circuit from the rotary magnet 343 of the connector to the stepping magnet 327 of the minor switch.

Summing up the operations which have taken place so far, as a result of the dialling of the first three digits, 3, 3, and 1, a particular set of wipers in the connector has been selected and these wipers have been operated first by the vertical magnet 214 and then by the rotary magnet 343 and thereby brought into engagement with the terminals of the called line. The wiper set selected is the set comprising wipers 331, 334, and 335. By the operations referred to, this wiper set is now in engagement with the terminal set to which test conductor 353 and line conductors 354 and 355 of the called line are connected. Although the called line has been selected the line is not tested at this time, as the testing operation

is deferred until after the operation of the minor switch has been completed.

The calling subscriber now dials the last digit of the called number, which is the digit 2. Accordingly, the line relay 204 will fall back twice momentarily and will transmit two impulses to stepping magnet 327 of the minor switch in parallel with the slow acting relay 302. Responsive to these impulses, stepping magnet 327 will advance the wipers 350, 351, and 352 of the minor switch two steps, so that each wiper engages the second contact in its associated bank. Relay 302 operates in parallel with the stepping magnet 327 and upon energizing closes a circuit for relay 305. Relay 305 accordingly energizes also. At the end of the series of impulses which operates the stepping magnet 327, slow acting relay 302 falls back and thereby connects test relay 209 to the test wiper 331. The test circuit may be traced from the test contact to which test conductor 353 of the called line is connected, by way of test wiper 331, contacts of relays 304 and 303, wiper 352 of the minor switch, 314, 318, (relay 305 being still energized), winding of test relay 209, to battery. Relay 209 accordingly tests the called line for the presence or absence of ground potential on its associated test contacts.

Assuming that the called line is busy, there will be a ground potential on the test contact with which wiper 331 is in engagement and test relay 209 will energize. Shortly after this occurs, the slow acting relay 305 will fall back, as its circuit was broken by the deenergization of relay 302. When relay 305 deenergizes, a locking circuit is completed for the test relay 209 which extends from ground by way of 262, 256, and contacts controlled by 318, to relay 209. In energized position, relay 209 opens the impulsing circuit at 253 and closes the busy signalling circuit at 250. The latter operation gives the calling subscriber an audible busy signal to notify him that the called line is busy.

On finding the called line busy, the calling subscriber will hang up his receiver. This results in the deenergization of line relay 294, followed by the deenergization of relays 206 and 208. The latter relay opens holding circuits for the various other relays in the connector that have been energized and relay 206 takes ground off the holding conductor 172. As a result of the ungrounding of conductor 172 relays 141 and 107 are deenergized. The switches are released by their respective release magnets in the well understood manner. The circuit of the release magnet of the connector may be traced from ground by way of 297, 244, 249, and ON2 to the connector release magnet 215. In parallel with the release magnet 215 is the release magnet 344 of the minor switch, the circuit of which extends from ground by way of 297, 244, 249, and the minor switch off normal springs MSON to release magnet 244. As soon as the connector is restored by the operation of release magnet 215, the off normal springs ON2 are shifted to normal position and the circuit from ground at 297 is transferred to conductor 174 of the finder switch to operate the release magnet 143.

Thus all of the equipment in the link circuit is restored to normal.

Returning now to the point where the busy test relay 209 was connected up by the deenergization of slow acting relay 302, at the end of the impulses which operated the minor switch, it will be assumed that the called line is idle. Under these circumstances there will be no ground on

the test contact engaged by test wiper 331 and test relay 209 will not pull up. Shortly after relay 302 falls back the slow acting relay 305 will fall back, and now since the test relay 209 is not energized a circuit will be completed for the switching relay 211. This circuit extends from ground by way of 262, 256, 255, lower winding of relay 211, 310, 314, 352, contacts of relays 303 and 304, relay 303 being energized, test wiper 331 and contact engaged thereby, test conductor 353 and the winding of the cut-off relay of the called line to battery. The line circuit of the called line is not shown in the drawings but is similar to the line circuit which is shown in Fig. 1. On the closure of the above circuit the switching relay 211 of the connector and the cut-off relay of the called line operate in series, the operation of the latter relay serving to clear the called line in the usual manner.

When relay 211 energizes it locks itself at 272. Relay 211 also cuts in the upper winding of line relay 204 at 263, and at 267 opens the circuit of relay 306. Since the minor switch has been advanced only two steps, relay 306 has no circuit through wiper 351, and therefore it deenergizes. Relay 211 also closes points in the talking circuit at 264 and 265, and at 270 closes a circuit for the pick-up relay 301 in order to start the ringing operation. The latter circuit extends from ground by way of 298, 270, contacts controlled by 312, 281, and interrupter contacts of rotary magnet 343, to relay 301. Relay 301 energizes and locks itself at 312.

The results of the energization of relay 301 are the closure of the ringing circuit at 307 and 308, and the closing of a circuit at 309 for transmitting ring back tone to the calling subscriber. The ringing circuit may be traced from ground by way of generator GEN, interrupter I, ringing conductor labeled FREQ.2, wiper 350 of the minor switches, 321 308, 275, 265, 221, and contacts of relays 303 and 304 to line wiper 335. From this point the circuit extends out over conductor 355 of the called line and to ground or to the other side of the line, depending on how the ringer at the called station is connected. If the ringer is bridged across the line, the return path of the ringer current will be by way of the other line conductor 352, line wiper 334, contacts of relays 304 and 303, 220, 264, 274, 307, 320, and lower winding of ring cut-off relay 213 to battery and ground.

When the called subscriber removes his receiver, relay 213 pulls up in the usual manner and locks itself at 279. Relay 211 is now energized so that this locking circuit can be established by way of ground, 246, 266, and 279. At 281 relay 213 breaks the circuit of relay 301, and the latter relay falls back. Relay 213 also closes a circuit for relay 212 at 283. Upon energizing, relay 212 completes the talking circuit at 274 and 275. The talking circuit is shown in heavy lines and need not be traced in detail. Upon the closure of the talking circuit the back bridge relay 203 will pull up over the called line. Upon energizing relay 203 reverses the direction of current flow in the calling line at 231 and 232. This is a standard operation which is introduced in order to give supervision to an operator if the calling line is a trunk from an operator's position. In the connection under discussion the reversal of current has no particular function.

The required connection having been established, the calling and called subscribers may converse as desired. When the conversation is

finished, the subscribers will replace their receivers. The release of the connection is controlled by the hanging up of the receiver at the calling station, which causes line relay 204 to fall back. This breaks the circuit of relay 206 which falls back and breaks the circuit of relay 208. The connection is accordingly released in the manner previously described.

In the foregoing explanation it was specified if the called line was an individual line or a party line. The fact is that it could be either, as the operation is the same. This means that individual and party lines may be arranged indiscriminately, and have similar four digit numbers assigned. In case of an individual line the last digit, of course, would preferably be assigned in accordance with the frequency of ringing current which is used to ring the individual lines, this being usually the No. 2 frequency. In case of party lines the last digit of the number determines the ringing current or party selection. There may be as many as ten stations on a party line. At five of the stations the ringers would be connected between one side of the line and ground, while at the other five stations the ringers would be connected between the other side of the line and ground. In accordance with this arrangement, the circuit of relay 306 is arranged so that when the switching relay 211 pulls up relay 306 will drop back if wiper 351 of the minor switch is standing on any position from 1 to 5, inclusive. Thus the ringing current frequency selected by the wiper 350 is projected out over the lower side of the subscriber's line. However, if wiper 351 has been positioned on any contact from 6 to 0, inclusive, relay 305 will hold up by way of said wiper 351 after the relay 211 has energized, with the result that the ringing circuit connections to the line are reversed at 320 and 321, so that ringing current is projected out over the other side of the line.

The lines of the fourth and fifth hundreds are called in the same way as the lines in the third hundred, except, of course, that a different set of wipers is selected at the connector in use. In selecting a line in the fourth hundred the first digit dialled is the digit 4 and it follows that the vertical wiper 329 will be set on the fourth contact in its bank when the first digit is dialled, resulting in the energization of relay 304 instead of relay 303. The operation of relay 304 connects up the set of wipers which comprises test wiper 336 and line wipers 338 and 339. In calling a line in the fifth hundred, the first digit dialled will be the digit 5. Since the vertical wiper 329 is set on the fifth contact in its bank responsive to this digit, both relays 303 and 304 will be energized. By the operation of both these relays simultaneously the set of wipers which comprises test wiper 337 and line wipers 340 and 341 is connected up. Otherwise the operations are the same as the operations which have already been described. The lines in the second hundred are called by means of the normally connected set of wipers which comprises test wiper 330 and line wipers 332 and 333. Since this set of wipers is normally connected, the calling of a line in the second hundred does not involve the operation of any relay such as 303 or 304, and consequently is somewhat different. This can conveniently be explained later in the course of the description of the establishment of a trunk connection, as the groups of trunk lines are assigned numbers in the second hundred and are accessible to the normally connected set of wipers.

Before taking up the establishment of trunk connections an additional feature of the regular exchange operation will be described. This feature is the handling of reverteive calls on party lines. A reverteive call is a call from one subscriber on a party line to another subscriber on the same line, and is made by dialling the regular directory number of the called subscriber. In order to explain the operations which take place in this type of call it will be assumed that the subscriber at station 4312, Fig. 1, desires to call the subscriber at station 4317 on the same line.

In order to establish the above connection, the subscriber at station 4312 will remove his receiver and dial the number of the called station. The removal of the receiver takes an idle link into use and the finder thereof connects with the calling line. The subscriber then dials the four digits of the called number and the connector of the link is operated the same as has been previously described. Assuming that the link which is used is the one shown in the drawings, relay 304 of the connector, Figs. 2 and 3, will be operated so as to select the set of wipers comprising 336, 338, and 339, which are then positioned on the first set of contacts in the third level of their associated banks. This set of bank contacts is the set to which normal conductors 105, 103, and 104, extending back to the line circuit, Fig. 1, are connected. It will be noted also that the minor switch is operated responsive to the last digit to position its various wipers on the seventh contacts in their respective banks. Aside from these differences, the operation of the connector is the same as it was before.

Taking up the detailed description at this point, when relay 302 falls back at the end of the impulses for the last digit, a circuit is completed over which the test relay 209 is connected to the test wiper 336, which is now in engagement with the test contact of the called line. Since the called line is also the calling line, there will be a ground potential on conductor 105 and the test relay 209 will pull up. Relay 209 remains locked up after relay 305 falls back and at 250 connects a busy tone to the calling line. So far, therefore, the operation corresponds to the normal operation in calling a busy line.

In this case, however, the calling subscriber expects to hear the busy signal, as he knows that he is calling another subscriber on his own line, so he merely replaces his receiver for a short interval, long enough to signal the called party. When the receiver is hung up at the calling station, the line relay 204 falls back and breaks the circuit of the slow acting relay 206. Line relay 204 also places ground on the test wiper 336 in order to provide a holding circuit for maintaining the connection after relay 206 falls back, this holding circuit extending from ground by way of 234, 222, 247, 253, (busy relay 209 being now energized), wiper 352, contacts of relays 303 and 304, test wiper 336, conductor 105, 109, Fig. 1, 113, 118, wiper 126, 147, and 152 to holding conductor 172. Ground on the holding conductor 172 will hold up relays 141 and 107, Fig. 1. Also a branch may be traced from conductor 172 by way of 223, 243, and 248 to relay 208, which serves to hold up relay 208 after relay 206 has deenergized. When relay 206 falls back, it closes a circuit for relay 202 at 238, said circuit including the contacts 251 of the now energized busy relay 209. Upon energizing, relay 202 locks itself at 229. Relay 202 also disconnects ground 75

from line relay 204 at 225, and opens the trunk conductors 170 and 171 at 226 and 227. Finally, at 230 relay 202 closes a circuit for relay 211, which energizes and locks itself at 272. Relay 211 upon energizing breaks one circuit of relay 306 at 267, but relay 306 holds up over another circuit including wiper 351 of the minor switch, now setting on its seventh contact. Relay 211 also closes at 270 a circuit for relay 301, which locks itself at 312 and completes the ringing circuit in the manner formerly described.

The bell at the called station now begins to ring intermittently in the usual manner. After a short interval the calling subscriber will again remove his receiver, and the called subscriber will also take off his receiver in order to answer the call. A bridge is accordingly placed across the line which operates the ring cut-off relay 213. Relay 213 locks itself at 279, breaks the circuit of relay 306 at 280, and breaks the circuit of relay 301 at 281. Relays 306 and 301 accordingly fall back. Relay 213 also closes the circuit of relay 212, which accordingly energizes and closes the heavy talking conductors at 274 and 275. This latter operation connects up the back bridge relay 203, which energizes over the line circuit through the connector wipers, feeding current for the transmitters at the calling and called stations. Upon energizing, relay 203 closes a circuit for relay 207 at 233. Relay 207 operates when its circuit is closed and locks itself at 241. At 240 and 242 relay 207 supplies holding ground for various energized relays in the connector, thus providing against the deenergization of relay 208. For a similar reason relay 207 opens the release magnet circuits at 244, and at 286 places a shunt around contact 247 of relay 208. This latter is to maintain ground on the test wiper. The circuit of relay 208 is broken at 243 when relay 207 energizes and relay 208 therefore falls back, but the connection is not released owing to the continued energization of relay 207. The maintaining of the connection therefore depends on the continued energization of back bridge relay 203, which controls relay 207.

The calling and called subscribers may now converse, and when they get through they will both replace their receivers. This brings about the deenergization of back bridge relay 203. Relay 203 falling back breaks the circuit of relay 207. When relay 207 deenergizes, the link circuit is released in the manner previously explained.

The operations involved in making certain representative trunk calls will now be explained. It will be assumed that the exchange being described is connected with a distant manual exchange over a group of ring down trunks. There may be any number of trunks in the group up to as many as ten. It will be assumed, however, that the group comprises five trunks which are terminated in the first five sets of contacts in the third level of the second hundred. These trunks are therefore accessible to the wiper set comprising test wiper 330 and line wipers 332 and 333. The first trunk of the group is indicated in the drawings, Fig. 3, and comprises conductors 350, 351, and 352. Each trunk may have a line circuit similar to the line circuit shown in Fig. 1, and at the manual exchange may terminate in a jack and drop, or similar well known ring down signalling equipment. From the location of the trunks in the connector banks as explained, the line selecting digits assigned will be 2, 3, and 1.

Adding the digit 1 to operate the minor switch,

the complete number of the trunk group will be 2311.

Assuming that the subscriber at station 4312 desires to extend a call to the manual exchange, he removes the receiver, whereupon an idle link circuit is taken into use in the manner previously explained. Assuming that the link shown in the drawings is the one which handles the call, the finder, Fig. 1, will connect with the calling line and extend it to the connector, Figs. 2 and 3. The line relay 204 will therefore energize, followed by the energization of relays 206, 208, 213, and 212, all as previously explained.

The calling subscriber will now start to dial, the first signal dialled being the digit 2. Line relay 204 therefore falls back twice momentarily and sends two impulses to the vertical magnet 214 and to the slow acting relay 302 in parallel therewith. Responsive to these impulses, the vertical magnet advances the switch shaft two steps, thereby bringing the vertical wiper 329 into engagement with the second contact in its bank. The slow acting relay 302 holds up during the impulses and falls back after the impulses cease. Upon deenergizing, relay 302 closes a circuit for relay 211 by way of 246, 313, 258, 299, wiper 329 and contact engaged thereby, and upper winding of relay 211 to battery. Upon energizing, relay 211 locks itself at 272. In addition, relay 211 closes a circuit for the release magnet 215, this circuit extending from ground by way of 246, 313, 258, 273, and off normal contact ON2, to the release magnet 215. Upon energizing, the release magnet 215 restores the switch shaft in the usual manner. Also the release magnet closes a circuit for operating relay 210, which extends from ground by way of 246, 313, 258, 299, 271, upper winding of 210, and release magnet 215 to battery. Relay 210 operates in the above circuit as soon as the off normal springs ON2 shift back on the restoration of the shaft and locks itself at 261. Relay 210 also breaks the locking circuit of relay 211 at 260, and breaks the circuit including its own upper winding and the release magnet at 258. Accordingly relay 211 and release magnet 215 deenergize.

It will be seen that as a result of the dialling of the digit 2 the connector switch has been operated and released and that the off normal relay 210 has been energized and locked up. It will be appreciated that this has been accomplished without energizing either of the wiper selecting relays 303 and 304. The connector therefore now has access to all lines in the second hundred, which are reached by way of the normally connected set of wipers.

The calling subscriber may now dial the next digit 3. As a result, the switch shaft is advanced three steps by means of the vertical magnet 214. At the end of this operation, relay 213 is deenergized in the manner previously explained, followed by the deenergization of relay 212. Thus the impulsing circuit is transferred to the rotary magnet 343.

The calling subscriber may now dial the next digit 1, as a result of which the rotary magnet 343 is operated to rotate the switch shaft one step, bringing the wipers 330, 332, and 333 into engagement with the first set of contacts in the third level of their respective banks. Relay 302 of course is operated in parallel with the rotary magnet 343 and operates relay 305, which in turn brings about the energization of relay 306 in the manner previously explained. Relay 306 trans-

fers the impulsing circuit to the stepping magnet 327 of the minor switch.

The calling subscriber may now dial the last digit of the number, which is also the digit 1. From this point on somewhat different operations are involved, and the explanation will be given more in detail. Responsive to the dialling of the digit 1, relay 204 falls back once and sends one impulse to the stepping magnet 327 and slow acting relay 302 in parallel, the stepping magnet 327 operating to advance the wipers of the minor switch one step. Relay 302 operates and closes a circuit for relay 305, which operates also. After the impulse ceases, relay 302 falls back and closes the usual test circuit, which in this case extends from the test wiper 330 by way of normally closed contacts of relays 304 and 303, wiper 352 of the minor switch, 314 and 318, to test relay 209. Assuming now that the first trunk line is busy, conductor 350 will be grounded, test wiper 330 will encounter ground potential, and the busy relay 209 will energize. Upon energizing, relay 209 closes a circuit for relay 301, which will now operate as a stepping relay for the rotary magnet 343. The circuit of relay 301 extends from ground by way of 349, 347, rotary control bank 26, the first pin in the third level, now engaged by wiper 326, wiper 326, 317, 254, contacts controlled by 312, 281, interrupter contact of rotary magnet 343, and winding of relay 301 to battery. Upon the closure of the above circuit by the busy relay, relay 301 operates and closes a circuit for the rotary magnet 343 at 311. Relay 301 also closes a circuit for slow-acting relay 305 at 310, thus maintaining this relay energized in order to maintain the busy relay 209 connected to the test wiper. On the closure of its circuit by relay 301, the rotary magnet 343 operates and rotates the connector wipers one step, at the same time opening the circuit of relay 301. Relay 301 accordingly falls back and breaks the circuit of the rotary magnet. If the second trunk of the group is busy also the busy relay 209 will remain energized and the operation will continue, relay 301 and the rotary magnet 343 operating alternately, the latter rotating the wipers step by step in search of an idle trunk line.

When an idle trunk line is found, relay 209 will fall back due to the absence of ground on the test contact engaged by wiper 330 and the circuit of relay 301 will be broken. This relay therefore cannot again energize and the rotation will cease. Slow-acting relay 305 falls back, as it will receive no more impulses from relay 301, and the usual circuit is therefore completed for relay 211. Relay 211 now pulls up in series with the cut-off relay of the selected trunk line. The remaining operations, including the transmission of ringing current over the trunk line, are the same as have been previously explained.

Some additional explanation will now be made in respect of the rotary control bank. This bank and the associated wiper 326 have been neglected so far because in any connection involving the operation of either relay 303 or relay 304 the ground connection to the rotary control bank is broken and the wiper 326 consequently can have no function. The rotary control bank therefore is in use only when a line in the second hundred is being called, or when the normally connected set of wipers is being used. The circuit drawing, Fig. 3, shows only the third level of this bank, as this is the level in which the group of trunks to the manual exchange is terminated. There being five trunks in this group, terminated

in contacts 1 to 5 of the third level, as stated, there will be four pins inserted at positions 1 to 4, inclusive, of the third level of the rotary control bank, as indicated in the drawings. Wiper 326 therefore can maintain the circuit to the stepping relay 301 through successive pins as long as busy trunk lines are encountered and the busy relay 209 is held up. The fifth pin, corresponding to the last trunk line of the group, is omitted, so that when the wipers are advanced to the fifth set of contacts wiper 326 will find no pin to engage and the circuit of relay 301 will be broken, whether the fifth trunk line is busy or not. If the fifth trunk line is busy, relay 209 will hold up and will lock itself when relay 305 falls back, and the busy signal will be transmitted to the calling party in the usual manner.

In addition to the ring down trunks extending to the manual exchange, there may be various other groups of trunk lines, including a group of dial trunks extending to an automatic exchange. The operations involved in setting up a connection to an automatic exchange will therefore be described. It will be assumed that there is a group of five one way dialling trunks terminating in the first five contact sets of the ninth level of the banks of the second hundred. That is, these trunks terminate in the ninth level of the banks which are associated with the normally connected set of wipers comprising wipers 330, 332, and 333. These trunk lines differ from the ring down trunks in that they do not have line circuits such as is shown in Fig. 1, but the three trunk conductors of each trunk line extend directly from the connector banks to a standard two-wire repeater. There will be accordingly five repeaters associated with the five trunk lines, respectively, and from the outgoing side of each repeater there will be a two conductor trunk line extending to the automatic exchange. At the automatic exchange these trunk lines may terminate in line switches or incoming selectors. Since the group of trunk lines terminates in the ninth level of the connector banks, and occupies the first five contact sets in that level, the number assigned to the group is the number 91.

Assuming now that the subscriber at station 4312 desires to extend a call to the distant automatic exchange, he will remove his receiver, whereupon an idle link circuit is taken for use. Assuming that the link circuit shown in the drawings is the one which is taken for use, the finder, Fig. 1, will connect with the calling line and extend it to the connector, Figs. 2 and 3. The connector line relay 204 and other relays will pull up responsive to the call in the manner previously described.

The calling subscriber will now dial the first digit of the number, which is the digit 9. The line relay 204 accordingly falls back momentarily nine times and sends nine impulses to the vertical magnet 214 and the slow acting relay 302 in parallel. The vertical magnet 214 steps the connector shaft nine steps, advancing the various sets of wipers carried by the shaft until they stand opposite the ninth levels of their respective banks. The vertical wiper 329 is positioned in engagement with the ninth contact in the vertical bank 328. Also the shaft springs 354 and 355 are operated, the comb 41, Fig. 7, being arranged to close these springs on the ninth level. The slow acting relay 302 responds to the first series of impulses in parallel with the vertical magnet 214 and holds up throughout the series of impulses, falling back after the impulses cease. On deenergizing, relay

302 closes a circuit for the off normal relay 210 which may be traced from ground by way of 246, 313, 258, 299, vertical wiper 329 and the ninth contact engaged thereby, and thence through the lower winding of relay 210 to battery. Upon energizing, relay 210 locks itself at 261. In addition relay 210 performs its usual functions. It also unlocks relay 213 at 259. Relay 213 accordingly falls back and permits relay 212 to de-energize. Relay 212 transfers the impulsing circuit from the vertical magnet 214 to the rotary magnet 343.

The calling subscriber may now dial the second digit of the number, which is the digit 1. Accordingly the line relay 204 falls back once momentarily and transmits an impulse to the rotary magnet 343 in parallel with the slow-acting relay 302. The rotary magnet 343 responds by rotating the switch shaft one step, bringing the wipers 330, 332, and 333 into engagement with the first trunk line of the group. Relay 302 operates in parallel with the rotary magnet 343, and now since relay 212 has fallen back a circuit is completed for slow acting relay 305, which operates also. Upon energizing, relay 305 closes at 319 a circuit for the lower winding of switching relay 201, the circuit extending from ground by way of 349, 347, 355, 319, and the lower winding of relay 201 to battery. The lower winding of relay 201 is an inefficient winding and consequently the relay operates only far enough to close its contact marked X. The closure of contact X completes a circuit for the upper winding of relay 201 which extends from ground by way of 262, 256, contact X, and the upper and lower windings of relay 201 in series to battery. It will be seen that the upper winding of relay 201 is short circuited over the previously traced circuit for the lower winding and consequently the relay remains only partly energized for the time being.

Shortly after the cessation of the impulse to the rotary magnet 343, the slow acting relay 302 will fall back, and thereby a circuit is closed for connecting the busy relay 209 to the test wiper 330. This circuit may be traced from test wiper 330 by way of normally closed contacts of relays 304 and 303 to the minor switch bank associated with wiper 352. From this point the circuit is completed by way of 356, 346, 354, 314, and 318 to the busy relay 209. If the first trunk line of the group is busy, relay 209 will energize because of the ground on the contact engaged by wiper 330, closing a circuit for relay 301. In explanation of this circuit it should be stated that the ninth level of the rotary control bank 26 is arranged as regards the first five positions in exactly the same way that the third level, shown in the drawings, Fig. 3, is arranged. That is, pins are inserted at positions 1 to 4, inclusive, of the ninth level. Accordingly, wiper 326 will now be in engagement with the first pin of this group and the circuit for relay 301 will extend from ground by way of 349, 347, rotary control bank 26, first pin of the ninth level, wiper 326, 317, 254, contacts controlled by 312, 281, and interrupter contacts of the rotary magnet 343 to relay 301.

Relay 301 operates as formerly described, closing a circuit for the rotary magnet at 311, and also closing a circuit for the slow acting relay 305 at 310. The switch wipers are accordingly rotated step by step until an idle trunk line is found, whereupon busy relay 209 will fall back, breaking the circuit of relay 301 at 254, and the rotation of the switch will cease. Relay 305 now

falls back also, since it no longer receives impulses from relay 301. Upon deenergizing, relay 305 breaks the circuit of the lower winding of relay 201 at 319, thus removing the short circuit from the upper winding of relay 201. During the rotary operation, the ground connection to the upper winding of relay 201 through contact X was temporarily disconnected by energization of relay 209, but this connection has now been re-established by the falling back of relay 209, and accordingly relay 201 now energizes fully over the circuit which extends from ground by way of 262, 256, contact X, and both windings of the relay in series to battery. Upon energizing relay 201 locks itself to the holding conductor 172. Relay 201 also opens the release magnet circuit at 237, opens the impulsing circuit at 222, and at 223 it disconnects the holding conductor 172 from the slow acting relay 208 and connects it instead to the test wiper 330. In addition, relay 201 connects the trunk conductors 170 and 171 direct to the wipers 332 and 333, respectively, at contacts 220 and 221, at the same time disconnecting these trunk conductors from the line relay 204. Relay 204 accordingly falls back and breaks the circuit of relay 206.

The two trunk conductors 170 and 171 and the holding conductor 172 now extend via the connector wipers to three conductors of the selected trunk. It follows that before the release relays of the repeater associated with the selected trunk will energize, and the latter relay will place ground on the holding conductor to maintain the connection.

The calling subscriber will now dial the necessary remaining digits to complete the connection in the automatic exchange and these digits are repeated by the repeater in the well known manner. Release of the connection is accomplished by hanging up the receiver at the calling station, which drops the line and release relays of the repeater. The release relay falling back removes ground from the holding circuit including conductor 172 and the link circuit is restored as previously described.

From the preceding explanation it will be clear that another group of ring down trunks could be terminated in the 6th, 7th, 8th, or 10th level, and could be reached by dialling a three digit number. Such a group of trunks might be a group of toll trunks leading to the toll board in an adjacent exchange. Assuming these trunks are terminated in the 10th level (of the second hundred), the number assigned would be 011. In calling the toll operator over one of these trunks, the first digit 0 will operate the connector shaft to the 10th level and at the same time will operate relay 210 by means of wiper 329. The second digit 1 will rotate the connector shaft one step, whereby wipers 330, 332, and 333 are set on the first trunk line of the group. The third digit 1 will operate the minor switch, whereupon automatic trunk hunting will take place and an idle trunk will be selected. The hunting movement is controlled through the rotary control bank, which has pins inserted at the 10th level, as explained in the case of the 3rd and 9th levels.

The invention having been described, that which is considered to be new and for which the protection of Letters Patent is desired will be pointed out in the appended claims.

What is claimed is:

1. In a finder system, a group of subscribers' lines comprising two sub-groups, a group of find-

ers, each finder having access to all said lines, starting circuits whereby the lines of one sub-group normally use part of said finders and the lines of the other sub-group normally use the rest of said finders, whereby the finders are divided into two sub-groups, two groups of marking leads associated with said two sub-groups of lines, respectively, test banks in said finders, and means responsive to a call from any line for connecting the marking leads of the associated sub-group of lines to the test banks in the corresponding sub-group of finders.

2. In a finder system, a group of subscribers' lines comprising two sub-groups, a group of finders, each finder having access to all said lines, starting circuits whereby the lines of one sub-group normally use part of said finders and the lines of the other sub-group normally use the rest of said finders, whereby the finders are divided into two sub-groups, auxiliary start circuits whereby a calling line in one sub-group may use a finder in the non-corresponding sub-group if all the finders in the other sub-group are busy, two groups of marking leads associated with said two sub-groups of lines, respectively, test banks in said finders, and means responsive to a call on any line for starting a finder in one of said sub-groups, and for connecting the marking leads of the associated sub-group of lines to the test banks of the finders in the sub-group in which the started finder is located.

3. In a finder system, a group of lines, two groups of finders having access to said lines, means responsive to a call on one of said lines for normally starting a finder in one of said groups and for starting a finder in the other group if the finders of the first group are busy, a group of common marking leads associated with said lines, test banks in said finders, and means effective when a finder is started for connecting said marking leads to the finder test banks in the group in which the started finder is located.

4. In a finder system, two groups of lines, a finder having access to the two groups of lines through two sets of wipers, respectively, an allotter, means whereby said allotter may be used by a calling line in either group to start said finder, and a wiper selecting relay in said finder controlled by said allotter in accordance with the group in which the calling line is located.

5. In a finder system, two groups of lines, two allotters, means whereby a calling line in either group may use either allotter, finders having access to said lines and controlled by said allotters, each finder having a plurality of sets of wipers, and wiper selecting means in said finders controlled by the allotters.

6. In a finder system, two groups of lines, a first group of finders, each finder having two sets of wipers, one set having access to the first group of lines being normally connected and the other set having access to the second group of lines being normally disconnected, a second group of finders, each second group finder identical with said first group finders, means whereby a calling line in the first group normally starts a first group finder and whereby a calling line in the second group normally starts a second group finder, means whereby a calling line in the first group starts the second group finders only in case all the first group finders are busy and whereby a calling line in the second group starts a first group finder only in case all the second group finders are busy, and means for automatically switching wipers in the second group finder when the same is started

by a calling line in the first group when all the first group finders are busy.

7. In a finder system, four groups of lines, a finder having access to said lines through four sets of wipers, there being a wiper set for each line group, means whereby any calling line can start said finder, means for selecting two of said four sets of wipers when the finder is started, and means whereby the two selected wiper sets search simultaneously for the calling line.

8. In a finder system, a finder having a plurality of sets of wipers, means controlled over a calling line for starting said finder to search for the calling line, means for eliminating part of said wiper sets when the finder is started, and means for eliminating the remainder of said wiper sets except one as a result of the completion of the searching operation.

9. In a finder system, four groups of lines, a finder having access to said lines through four sets of wipers, there being a wiper set for each group of lines, a group of common start leads for the first and second groups of lines, a second group of common start leads for the third and fourth groups of lines, means including said start leads for enabling any calling line to start said finder, means dependent upon the group of start leads used for selecting two of said four sets of wipers before said finder is operated, and means whereby the two selected wiper sets search simultaneously for the calling line.

10. In a finder system, a first and a second group of lines, a first group of common start leads for said first group of lines, a corresponding second group of common start leads for said second group of lines, a first group and a second group of finders normally having access to said lines, a test bank in each finder, each bank comprising one bank contact for corresponding start leads in both groups of start leads and normally disconnected therefrom, a first relay for connecting said first group start leads to said test banks in response to a call on a line in the first group, and a second relay for connecting said second group start leads to said test banks in response to a call on a line in the second group.

11. In a finder system, a first and a second group of lines, a first group of common start leads for said first group of lines, a second group of common start leads for said second group of lines, a first and a second group of finders having access to said lines, a test bank in each finder, a first relay for connecting said first group start leads to the test banks of the first group finders in response to a call on a line in the first group, a second relay for connecting said first group start leads to the test banks of the second group finders in response to a call on a line in the first group in case all the first group finders are busy, a third relay for connecting said second group start leads to the test banks of the second group finders in response to a call on a line in the second group, and a fourth relay for connecting said second group start leads to the test banks of the first group finders in response to a call on a line in the second group in case all the second group finders are busy.

12. In a finder system, a first and a second group of lines, a first group of common start leads for said first group of lines, a second group of common start leads for said second group of lines, a first and a second group of finders, said first group finders normally having access to said first group of lines and having access to said second group of lines only when all the finders

in the second group are busy, a test bank in each finder of the first group, a first relay for connecting said first group start leads to said test banks, a second relay operated in response to a call on a line in the first group for operating said first relay, a third relay for connecting said second group start leads to said test banks, and a fourth relay operated in response to a call on a line in the second group for operating said third relay only in case all the finders in the second group are busy.

13. In a finder system, a first and a second group of lines, a first group of common start leads for said first group of lines, a second group of common start leads for said second group of lines, a first and a second group of finders, said first group finders normally having access to said first group lines and having access to said second group lines only when all the second group finders are busy, a plurality of sets of wipers in the first group finders for access to said lines, wiper selecting means in each first group finder, a test bank in each first group finder, a first relay for connecting said first group start leads to said test banks, a second relay operated in response to a call on a line in the first group for operating said first relay, a third relay for connecting said second group start leads to said test banks, and a fourth relay operated in response to a call on a line in the second group for operating said third relay and said wiper switching means in the first group finder taken into use only in case all the second group finders are busy.

14. In a finder system, a group of lines, a group of finders for connecting with any of said lines, a group of common start leads, an allotter, a test bank contact in each of said finders for each of said start leads, said start leads being normally disconnected from said contacts, means controlled over any of said start leads for causing said

allotter to start one of said finders, and means controlled by said allotter when it starts one of said finders for marking the test bank contact of a calling line by connecting all of said start leads to said test bank contacts.

15. In a finder system, a group of lines, a group of finders for connecting with any of said lines, a group of common start leads, a test bank contact in each of said finders for each of said start leads, said start leads being normally disconnected from said bank contacts, means including said start leads for starting one of said finders in response to a call on one of said lines, and means responsive thereto for marking the test bank contact of the calling line by connecting said start leads to said test bank contacts.

16. In a finder system, a first and a second group of lines, a corresponding first and second group of finders for connecting with said lines in their respective groups, a test bank for each of said finders, a group of common start leads for each of said groups of lines, a test contact on each of said test banks for each of said start leads of a group, said start leads being normally disconnected from said test contacts, means for starting one of said finders responsive to a call on one of said lines, means responsive thereto for marking the test contact corresponding to the calling line by connecting the group of start leads corresponding to the line group in which the calling line is located to the test contacts of the associated finder group, a plurality of sets of wipers having access to said lines for each of said finders, wiper selecting means in each of said finders, and means for controlling said selecting means in accordance with the line group in which the calling line is located to accomplish wiper selection before the finder starts searching for the calling line.

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