Sept. 15, 1925. 1,553,700

G. A. E. LUNDELL

TELEPHONE EXCHANGE SYSTEM

Filed April 20, 1921 4 Sheets-Sheet 1

Fig. 1

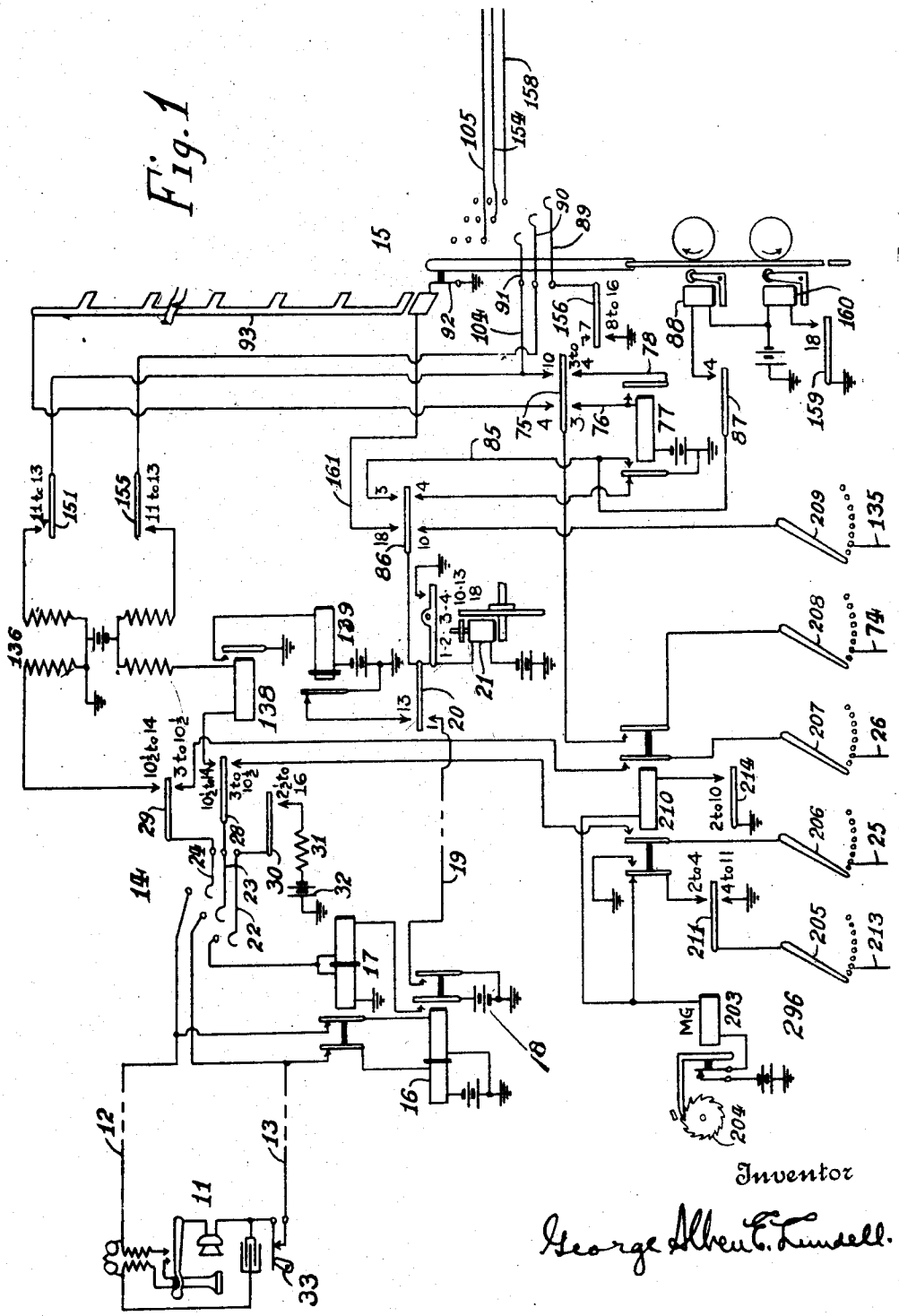

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Fig. 2

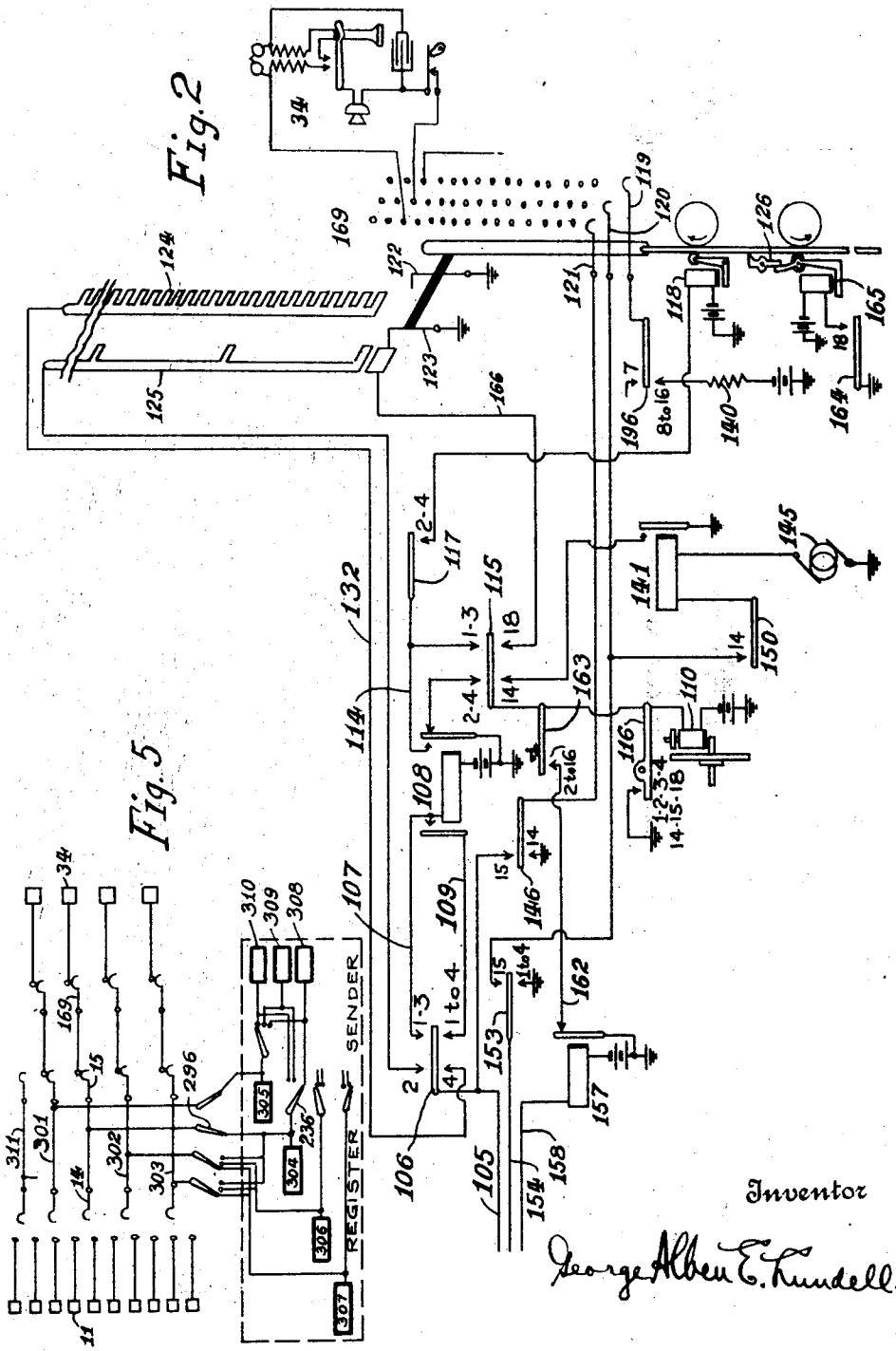

Fig. 5

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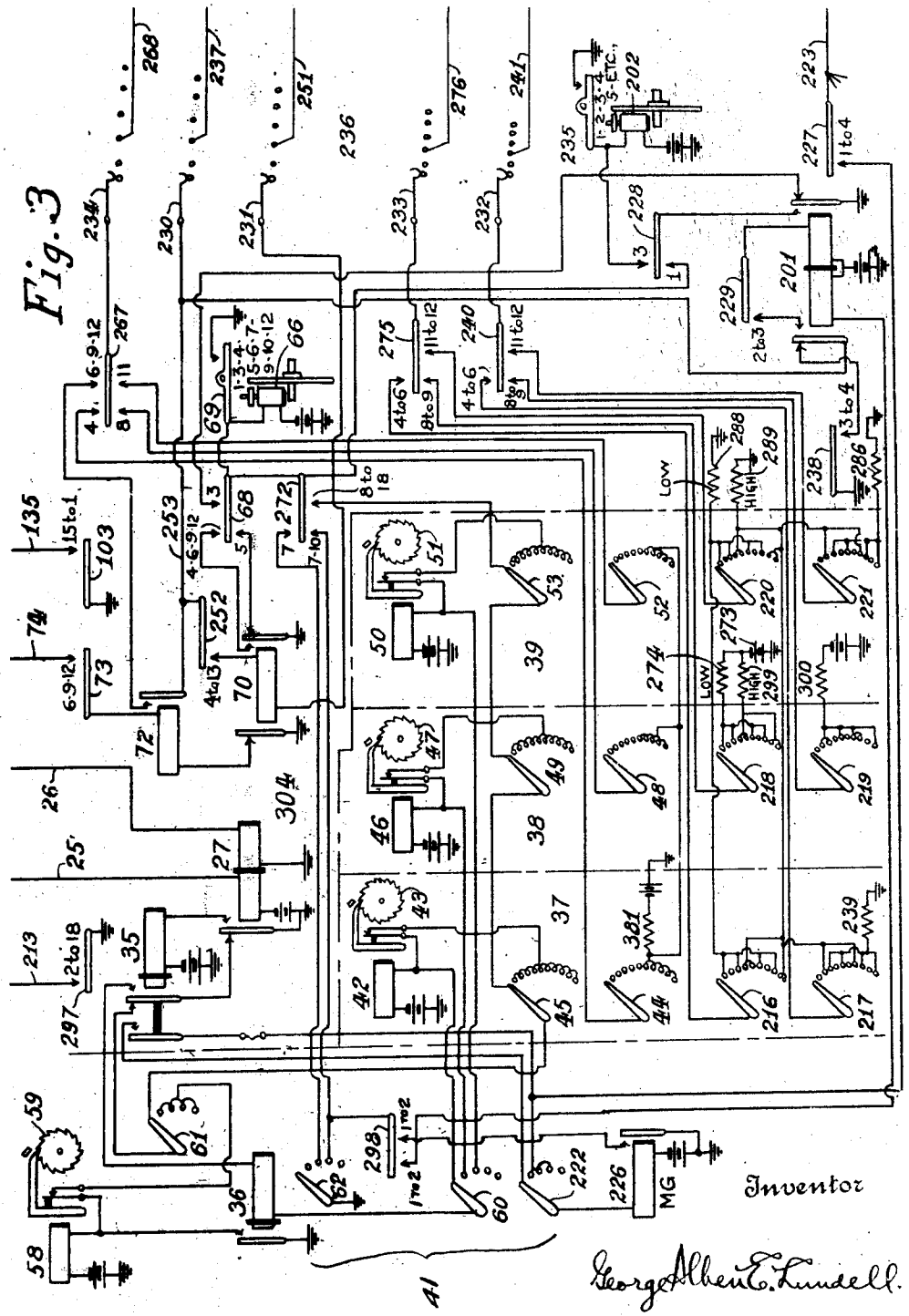
Fig. 3



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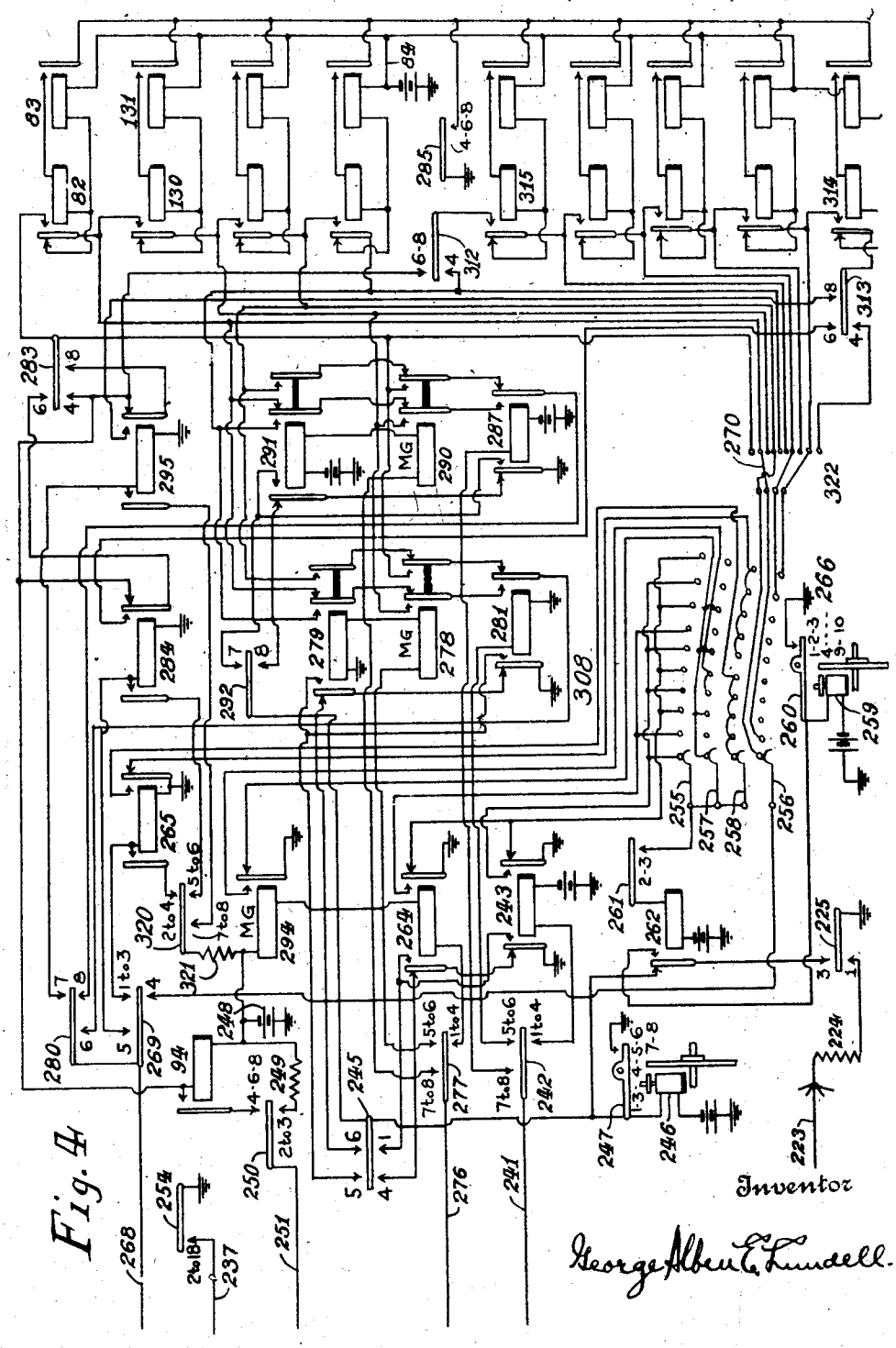

Fig. 4

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Patented Sept. 15, 1925. 1,553,700

UNITED STATES PATENT OFFICE.

GEORGE ALBEN E. LUNDELL, OF NEW YORK, N. Y.

TELEPHONE-EXCHANGE SYSTEM.

Application filed April 20, 1921. Serial No. 462,944.

To all whom it may concern:

Be it known that I, GEORGE ALBEN E. LUNDELL, a citizen of the United States, residing at 960 Anderson Avenue, New York, in the county of Bronx and State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a specification.

This invention relates to telephone exchange systems, and more particularly to such systems in which calling devices, automatic selectors, registers and senders are employed for establishing connections.

It is the object of the present invention to reduce the cost of the senders in such systems.

According to one feature, a group of calling lines are provided with a set of link circuits less in number than the number of lines; the link circuits are provided with sets of registers less in number than the number of link circuits, and the register sets have access to senders less in number than the number of register sets. Thus a minimum quantity of senders are required, and since the sender of an automatic telephone exchange is a highly complex intricate and expensive organization of circuits, such reduction in the quantity thereof will result in substantial savings in initial cost and maintenance expense.

According to another feature, the sender, whose actual working or so-called "holding" time is relatively small, may be seized by a register set as soon as the registers are only partly set under some conditions, while when a different set of conditions prevail the sender is not seized until the registers are fully set; thus in the latter case the holding time of a sender is not lengthened by a calling subscriber's delay in dialing.

According to another object discriminating means are provided to indicate when there are more senders idle and available than there are registers in the process of being adjusted, and means controlled by such indication to cause relatively early seizure of a sender whereby calling subscribers may enjoy whenever possible rapid and prompt service. According to this feature, when there are not more senders idle than sets of registers in the process of adjustment, seizure of senders is delayed until the registering process is complete, and thus a subscriber who operates his calling device skillfully and promptly is not apt to experience a delay due to lack of senders on account of other senders being held by subscribers unfamiliar with the use of a calling device.

According to another feature, remote control for impulse counting devices in combination with a selector switch intermediate to said control and said devices, is provided. Thus under traffic conditions usual in automatic telephone exchanges it is not necessary to provide as many sets of impulse counting devices as there are control mechanisms.

Other features will appear as the description of the invention progresses.

The present disclosure is only one of a variety of forms in which the invention may be practiced, and the scope of the invention is not to be determined by it, reference being had to the appended claims for that purpose.

Referring to the drawings, Figure 1 shows a calling line, a link circuit for establishing telephonic connections, and a selector switch for testing and seizing a set of registers;

Figure 2 shows a selector switch for completing connections to called lines, and shows one such line, and should be placed to the right of Figure 1;

Figure 3 shows a set of registers and a selector for testing and seizing senders, and discriminating means for varying the period at which such seizure should be made; Figure 3 should be placed below Figure 1;

Figure 4 shows a sender, and should be placed to the right of Figure 3; and

Figure 5 shows a schematic plan or layout of so much of a telephone exchange as is necessary to an understanding of the invention.

Referring to the drawings, the selector 15 is a well known automatic selector having the wipers 89, 90, 91, commutator brush 92, and a bank of selectable terminals, and constitutes the first selector of a chain necessary to the establishment of a telephonic connection. The line finder 14 may be any suitable form of switch for connecting a calling line to an idle first selector. Said switch 15 and finder 14 in combination form a so-called link circuit.

In Figure 5 there is shown diagrammatically five such link circuits 301, 302, 303, 311, 14—15. There is also represented the register sender of an automatic telephone exchange system. This expression designates

collectively that part of an automatic telephone exchange which registers a wanted number and controls the sending of impulses to select the wanted line. It is contained within the dotted line of the figure and comprises a plurality of sets of registers 304, 305, 306, 307 and a plurality of senders 308, 309, 310, and the means such as 236 for interconnecting the same.

In the following description the term "active set of registers" is used to designate a set of registers which is being set or adjusted by a calling subscriber, but which has not yet seized a sender.

Relay 201 is a testing device whereby an idle sender may be tested and seized. Switch 236 is a selecting means for selecting such sender.

Referring to the drawings, there is shown in Figure 1 the calling station 11 joined to the central office by conductors 12, 13. Line finder 14 represents a form of mechanism for connecting a calling line with an idle first selector 15. Such mechanisms are well known in the art. The combination of finder 14 and selector 15 comprises a so-called link circuit; and the number of such link circuits is less than the number of calling lines.

The calling party removes his receiver from its hook, and closes a circuit: ground, right hand winding of relay 16, right hand back contact of relay 17, conductor 12, substation 11, conductor 13, left hand back contact of relay 17, left hand winding of relay 16 to grounded battery. Relay 16 operates and connects a "hunting" test potential from a source of current 18 to the test conductor of the line. Relay 17 is differential and does not operate. A circuit is closed from ground, right hand front contact of relay 16, start wire 19, sequence switch contact 20, power magnet 21 to grounded battery. Power magnet 21 forms part of a sequence switch mechanism comprising sets of contacts such as 20 adapted to close contacts in the various positions of the sequence switch. The numerals which appear adjacent to the sequence switch contacts in the several parts of the drawings, indicate the positions of the sequence switch at which these contacts are closed; with the exception that the centering springs, one of which appears immediately above the power magnet of each switch, are open only at the positions indicated by the numerals adjacent thereto and therefor the sequence switches can stop only in these positions. Motor mechanism is provided for rotating the sequence switch through its successive positions. This mechanism is employed during the energization of the power magnet for driving the sequence switch. The sequence switch of Fig. 1 moves from position 1 to position 2.

In position 2 of the sequence switch wipers 22, 23, 24 of line finder 14 are set on the terminals of the calling line in a well known manner. The sequence switch is thereupon moved from position 2 to position 3. In position 2½ of the sequence switch of Figure 1 a guarding potential is placed on the test wire of the calling line, by way of sequence switch contact 30, resistance 31, a source of current 32. This potential energizes the left hand winding of relay 17 which operates and cuts off relay 16. The armatures of relay 16 are retracted.

In positions 2 to 4 a circuit is closed from grounded battery, back contact and winding of magnet 203, left hand back contact and armature of relay 210, sequence switch contact 211, arm 205 to conductor 213. Magnet 203 and arm 205 form part of a selector switch comprising the magnet 203 whose armature each time it releases moves a ratchet wheel 204 in a counter clockwise direction together with the arms 205, 206, 207, 208, 209. Said arms each contact sequentially with a circular row of contacts, and when they are stepped off the last contacts in their respective rows, they again contact with the first contacts.

So long as said arms are in engagement with contacts of a busy register set, having ground on its test conductor, the above described circuit is intermittently energized and said arms are advanced. Upon reaching the contacts of an idle register set, having no ground on its test conductor 213, magnet 203 does not again operate, but relay 210, which has been short circuited, is operated in the following circuit: grounded battery, back contact and winding of magnet 203, winding of relay 210, sequence switch contact 214 to ground. The current in this circuit is not sufficient to operate magnet 203 on account of the high resistance of the winding of relay 210. The operation of relay 210 applies a guarding potential through its extreme left hand front contact and arm 205 to the test conductor of the seized register. The number of register sets, such as Figure 3, is less than the number of link circuits.

A circuit is closed from grounded battery, Figure 3, left hand winding of relay 27, conductor 25, arm 206, near left hand armature and front contact of relay 210, sequence switch contact 28, wiper 23, conductor 13, substation 11, conductor 12, wiper 24, sequence switch contact 29, near right hand front contact of relay 210, arm 207, conductor 26, right hand winding of relay 27 to ground. Relay 27 operates.

The calling subscriber now manipulates the calling device 33 in accordance with the number of the wanted line. Assuming that he desires to call station 34, and that the designating number thereof is "213" the

calling device is operated to open the line twice—pause—open the line once—pause—and finally to open the line three times. Relay 27 and its associated slow release relays 35, 36 are adapted to control register switches 37, 38, 39 and steering switch 41. Register 37 consists of magnet 42 whose armature each time it retracts moves a ratchet wheel 43 and the wiper arms 44, 45, 216, 217 in a clockwise direction. Said arms each contact with a circular row of contacts and when stepped off the last contacts in their respective rows, they again contact with the first or normal contacts. Similarly, register 38 comprises the magnet 46, ratchet wheel 47, wiper arms 48, 49, 218, 219; register 39 the magnet 50, ratchet wheel 51, wiper arms 52, 53, 220, 221; and steering switch 41 the magnet 58, ratchet wheel 59 and wiper arms 60, 61, 62, 222.

The setting or adjustment of the registers by the calling device 33 in the present case assumed brings arms 44, 45, 216, 217 to their respective third contacts; arms 48, 49, 218, 219 to their second contacts and arms 52, 53, 220, 221 to their fourth contacts.

Let it be assumed that only a single sender circuit is idle at this time. Then there will be only a single circuit from common conductor 223 through a resistance coil 224, Figure 4, and sequence switch contact 225 to ground. Relay 226 is marginal and will not operate on the present current flowing through its winding, arm 222 on its second and third contacts (and when desired the left hand front contact of relay 35 in combination with arm 222 on its first contact), sequence switch contact 227 to said conductor 223 and the single resistance coil 224. A removable connection is provided in the lead to the left hand armature of the relay 35, so that the period at which the sender is picked up may be modified.

Relay 36 operates during the sending of each series of impulses by the calling party, operating the magnet 58, and upon releasing at the end of each series, magnet 58 advances arms 60, 61, 62, 222 one step. When the subscriber has sent in the impulses for the three digits of the wanted number, arms 60, 61, 62, 222 are on their fourth contacts. While the present disclosure is arranged for three digits, any desired number may be provided for by employing a suitable number of registers in the same manner as those shown.

A circuit is closed from ground, arm 62 on its fourth contact, sequence switch contact 298, left hand winding of relay 201 to grounded battery. Relay 201 operates. A circuit is closed from ground, right hand armature and front contact of relay 201, sequence switch contact 228, power magnet 66 to ground battery, and under control of its centering spring 69 the sequence switch of Figure 3 moves to position 3. A circuit is closed for the right hand winding of relay 201 from grounded battery, right hand winding of relay 201, sequence switch contact 229, left hand front contact and armature of relay 201, wiper 230, test conductor such as 237 of a sender, to ground, if said sender is busy.

Wiper 230 forms part of a selector switch consisting of power magnet 202 and wipers 230, 231, 232, 233, 234. Said wipers each contact sequentially with a row of contacts, and when said wipers are moved off the last contacts of their rows, they again contact with the first contacts thereof. Motor mechanism is provided for rotating the wipers and is employed during the energization of the power magnet 202 for driving the wipers.

In position 3 of the sequence switch, a circuit is closed from ground, right hand armature and front contact of relay 201, sequence switch contact 228, power magnet 202 to grounded battery, for energizing power magnet 202, and the wipers of switch 236 are rotated. As soon as the contacts of an idler sender are reached, relay 201 releases, there being no ground on the test conductor 237 of such a sender. Magnet 202 is thereby released provided the centering spring, which is closed between positions, is open. A circuit is closed from ground, sequence switch contact 238, left hand back contact and armature of relay 201, wiper 230 to conductor 237 whereby the sender is protected against further seizure.

A circuit is closed from ground, right hand armature and back contact of relay 201, sequence switch contact 68, power magnet 66 to grounded battery, for moving the sequence switch of Figure 3 into position 4. The number of senders, such as shown in Figure 4 is less than the number of register sets of Figure 3, being based upon the actual selecting time of selectors 15, 169, and having no direct relation, at least during hours of heavy traffic with the delaying time of a calling party. Their number may also be computed on the basis that a delay in obtaining a sender is not an extremely serious matter. On the other hand, the relatively cheap register sets are provided on the basis of a holding time that takes into account the delaying time of a calling party in operating his calling device.

Arms 44, 45, 216, 217 are assumed to have been set upon their third contacts. A circuit is therefor closed from ground, resistance coil 289, arm 217, sequence switch contact 240, wiper 232, conductor 241, sequence switch contact 242, winding of relay 243 to grounded battery. Relay 243 operates, and closes a circuit from ground, left hand armature and front contact of relay 243, sequence switch contact 245, power magnet

246 to grounded battery, for moving the sequence switch of Figure 4 to position 3. A circuit is now closed from grounded battery 248, Figure 4, resistance 249, sequence switch contact 250, conductor 251, wiper 231, winding of relay 70, sequence switch contact 252, conductor 253, left hand armature and back contact of relay 201, sequence switch contact 238 to ground, also to the independent ground applied to conductor 237 by sequence switch contact 254. Relay 70 operates and closes a circuit from ground, right hand armature and front contact of relay 70, sequence switch contact 68, power magnet 66 to grounded battery, for moving the sequence switch of Figure 3 to position 5.

A circuit is closed from ground, right hand armature and front contact of relay 243, wiper 255 on its first, fourth, sixth and ninth contacts, sequence switch contact 261, winding of relay 262 to grounded battery.

Wiper 255 forms part of a translator switch consisting of power magnet 259 and wipers 255, 256, 257, 258. Said wipers each contact sequentially with a row of contacts, and when moved off the last contacts of their rows, they again contact with the first contacts thereof. Motor mechanism is provided for rotating the wipers and is employed during the energization of magnet 259.

A circuit is closed from ground, sequence switch contact 225, armature and front contact of relay 262, winding of power magnet 259 to grounded battery for energizing power magnet 259, when the wipers are on their first, fourth, sixth and ninth contacts. A similar circuit to that described above for maintaining relay 262, and in turn energizing magnet 259, is closed on the third, fifth, eighth and tenth contacts from ground, right hand armature and back contact of relay 264. Another circuit is closed on the sixth to tenth contacts, inclusive, from ground and right hand armature and back contact of relay 265. It will thus be seen that relay 262 and magnet 259 are energized on the present call so long as the wipers of switch 266 contact with any except the second contacts. When these contacts are reached, relay 262 releases and the wipers are stopped under control of centering spring 260. A circuit is closed from ground, sequence switch contact 225, armature and back contact of relay 262, winding of power magnet 246 to grounded battery, for moving the sequence switch into position 4. Sequence switch contact 250 now opens the circuit of relay 70, and this relay releases. A circuit is closed from ground, right hand armature and back contact of relay 70, sequence switch contact 68, power magnet 66 to grounded battery for moving the sequence switch of Figure 3 to position 6. A circuit is now closed from ground, left hand back contact of relay 70, winding of relay 72, sequence switch contact 73, conductor 74, arm 208, extreme right hand front contact of relay 210, sequence switch contact 75, conductor 76, winding of relay 77 to grounded battery. Relays 72 and 77 operate. Relay 77 closes a locking circuit for itself by way of conductor 78 independent of conductor 76. Relay 72 closes a circuit from ground, sequence switch contact 254, conductor 237, wiper 230, conductor 253, armature and front contact of relay 72, sequence switch contact 267, wiper 234, conductor 268, sequence switch contact 269, wiper 256 on its second contact, jumper 270, armature and back contact of relay 82, winding of relay 83, conductor 84 to grounded battery. Relay 83 operates and prepares a locking circuit for itself, but said locking circuit is at this time not energized on account of the short circuit by way of the armature and front contact of relay 72.

A circuit is now closed from ground, left hand armature and front contact of relay 77, conductor 85, sequence switch contact 86, power magnet 21 to grounded battery, for moving the sequence switch of Figure 1 out of position 3 to position 4. A circuit is closed from ground, left hand armature and front contact of relay 77, conductor 85, sequence switch contact 87, driving magnet 88 to grounded battery. Wipers 89, 90, 91 and commutator brush 92 are moved upwardly. Brush 92 contacts during such movement with conducting and insulated portions of a commutator plate 93. Upon striking the first conducting portion, relay 72 is short circuited, and upon releasing, removes in turn the short circuit around the winding of relay 82 and this relay operates. Relays 77 and 83 remain operated. Upon striking the next insulated portion relays 72 and 94 operate. When brush 92 reaches the next conducting portion, relay 72 releases and relay 70 operates. The operating circuit of relay 70 at this time comprises grounded battery, Figure 4, winding, front contact and armature of relay 94, sequence switch contact 250, conductor 251, wiper 231, winding of relay 70, sequence switch contact 252, conductor 253, wiper 230, conductor 237, sequence switch contact 254 to ground. Upon striking the next insulated portion there is no circuit for relay 77 and this relay releases, and deenergizes driving magnet 88 thus stopping wipers 89, 90, 91 and brush 92. A retaining pawl (not shown) maintains the brush support in its position during the connection. A circuit is closed from ground, left hand back contact of relay 77, sequence switch contact 86, power magnet 21 to grounded battery, for moving the sequence switch out of position 4.

An idle trunk may now be seized in any well known manner, in position 7 of the se-

quence switch, after which the sequence switch moves to position 10. A guarding potential is connected to the test conductor 158 of the selected trunk, over sequence switch contact 156, and the circuit of the winding of relay 157 is closed at this same contact. Relay 157 operates. The operation of relay 70 closes the following circuit; ground, right hand armature and front contact of this relay, sequence switch contact 68, power magnet 66 to grounded battery, moving the sequence switch of Figure 3 into position 7.

A circuit is closed from ground, arm 62 on its fourth, (or third) contact, sequence switch contact 272, winding of power magnet 66 to grounded battery, for moving the sequence switch of Figure 3 into position 9. The energizing circuit of relay 243 is broken at sequence switch contact 240, it being understood that the grounded battery of Figure 4 is the same battery as shown in Figure 3. A circuit is closed from ground, left hand back contacts of relays 243 and 264, sequence switch contact 245, power magnet 246 to grounded battery, moving the sequence switch of Figure 4 to position 5.

Arms 48, 49, 218, 219 being assumed to be on their second contacts on the present call, a circuit is closed from grounded battery 273, low resistance coil 274, arm 218, sequence switch contact 275, wiper 233, conductor 276, sequence switch contact 277, windings of relays 278 and 279 to ground. Relays 278 and 279 operate. A circuit is closed from ground, left hand armature and back contact of relay 281, lefthand armature and front contact of relay 279, sequence switch contact 245, winding of power magnet 246, to grounded battery, for moving the sequence switch 246 from position 5 to position 6. A circuit is closed from ground, left hand armature and back contact of relay 70, winding of relay 72, sequence switch contact 73, conductor 74, arm 209, extreme right hand front contact of relay 210, sequence switch contact 75, conductor 104, wiper 91, conductor 105, sequence switch contact 106 of Figure 2, conductor 107, winding of relay 108 to grounded battery. Relays 108 and 72 operate. Relay 108 closes a locking circuit for itself by way of conductor 109 independent of conductor 107. Relay 72 closes a circuit from ground, sequence switch contact 254, conductor 237, wiper 230, conductor 253, armature and front contact of relay 72, sequence switch contact 267, wiper 234, conductor 268, sequence switch contact 280, right hand back contact of relay 281, right hand front contact of relay 278, sequence switch contact 283, right hand back contact of relay 284, winding of relay 94 to grounded battery. Relay 94 operates and closes a locking circuit for itself, but said locking circuit is at this time not energized on account of the short circuit by way of the armature and front contact of relay 72.

A circuit is closed from ground, right hand armature and front contact of relay 108, conductor 114, sequence switch contact 115, power magnet 110 to grounded battery. The sequence switch of Figure 2 moves to position 2, under control of its centering spring 116. A circuit is now closed from ground, right hand armature and front contact of relay 108, conductor 114, sequence switch contact 117, driving magnet 118 to grounded battery, operating the magnet 118. Wipers 119, 120, 121 and commutator brushes 122 and 123 are moved upwardly. Brushes 122 and 123 contact during such advancement with conducting and insulated portions of commutator plates 124 and 125 respectively. When brush 123 strikes the first conducting portion of commutator 125, relay 72 is short circuited, and releases, thus removing the short circuit around the winding of relay 70. Relay 70 operates. When the brush 123 strikes the insulated portion beyond, relay 108 releases, its maintaining circuit over conductor 74 having been opened at the left hand back contact of relay 70. The circuit of magnet 118 is thus opened and wipers 119, 120, 121 and brushes 122, 123 are stopped, being held in their present position by a retaining pawl 126. A circuit is closed from ground, right hand armature and back contact of relay 108, conductor sequence switch contact 115, power magnet 110 to grounded battery, moving the sequence switch of Figure 2 into position 3.

The operation of relay 70 closes the following circuit: ground, right hand armature and front contact of relay 70, sequence switch contact 68, power magnet 66 to grounded battery, moving the sequence switch of Figure 3 out of position 9 and into position 10. Relays 278 and 279 release, their circuit being opened at contact 275. A circuit is closed from ground, left hand back contacts of relays 281 and 279, sequence switch contact 245, power magnet 246 to grounded battery, moving the sequence switch of Figure 4 to position 7. Relays 94 and 70 release, their energizing circuit being broken at sequence switch contact 250. A circuit for moving the sequence switch of Figure 3 out of position 10 is closed by way of arm 62 on its fourth contact and sequence switch contact 272. Under control of its centering spring 69 this sequence switch moves to position 12.

It being assumed in the present call that arms 52, 53, 220, 221 have been adjusted to their fourth contacts, a circuit is closed from ground, resistance 286, arm 221, sequence switch contact 240, wiper 232, conductor 241, sequence switch contact 242, winding of re-

lay 287 to grounded battery. Another circuit is closed from ground, low resistance coil 288, arm 220, sequence switch contact 275, wiper 233, conductor 276, sequence switch contact 277, windings of relays 290, 291 to grounded battery. Relays 290 and 291 operate. A circuit is closed from ground, left hand back contact of relay 287, left hand front contact of relay 291, sequence switch contact 292, power magnet 246, to grounded battery, for moving the sequence switch from position 7 to 8.

A circuit is closed from ground, left hand armature and back contact of relay 70, winding of relay 72, sequence switch contact 73, conductor 74, arm 209, extreme right hand armature and front contact of relay 210, sequence switch contact 75, conductor 104, wiper 91, conductor 105, sequence switch contact 106, conductor 107, winding of relay 108 to grounded battery. Relays 108 and 72 operate. Relay 108 closes a locking circuit for itself as before. Relay 72 closes a circuit from ground, sequence switch contact 254, conductor 237, wiper 230, conductor 253, armature and front contact of relay 72, sequence switch contact 267, wiper 234, conductor 268, sequence switch contact 280, right hand armatures and front contacts of relays 287 and 290, armature and back contact of relay 130, winding of relay 131, conductor 84 to grounded battery. Relay 131 operates and prepares a locking circuit for itself, but said locking circuit is at this time not energized on account of the short circuit by way of the armature and front contact of relay 72.

A circuit is closed from ground, right hand armature and front contact of relay 108, conductor 114, sequence switch contact 115 power magnet 110 to grounded battery. The sequence switch of Figure 2 moves from position 3 to position 4. In position 4 the following circuit is closed: ground, right hand armature and front contact of relay 108, conductor 114, sequence switch contact 117, driving magnet 118 to grounded battery, energizing magnet 118. The wipers 119, 120, 121 and brushes 122, 123 are again advanced. For each set of terminals passed by wipers 119, 120, 121 the brush 122 makes and breaks once the circuit from ground, brush 122, conducting portions of commutator 124, and thus intermittently short circuits the relay 72. Relays 130, 83, 82, 94 and 70 operate in order, and finally the circuit of relay 108 is entirely open and this relay releases, magnet 118 deenergizes and wipers 119, 120, 121 stop on the line terminals corresponding in number to that set up on the registers 38 and 39, that is to say, on the terminals of the wanted line. Relay 70 being operated, a circuit is closed from ground, right hand armature and front contact of this relay, sequence switch contact 68, sequence switch power magnet 66 to grounded battery, and the sequence switch of Figure 3 moves to position 1 under control of its centering spring 69. Relays 287, 290 and 291 release, their winding circuits being broken at sequence switch contacts 240 and 275. A circuit is closed from ground, left hand armatures and back contacts of relays 287 and 291, sequence switch contact 292, winding of power magnet 246 to grounded battery, for moving the sequence switch of Figure 4 to position 1. Relays 131, 130, 83, 82, 94 release, their operating circuits being broken at sequence switch contacts 285 and 250.

In position 15 to 1 of the sequence switch of Figure 3 a circuit is closed from ground, sequence switch contact 103, conductor 135, arm 209, sequence switch contact 86, power magnet 21 to grounded battery. The sequence switch of Figure 1 moves from position 10 to 13. Sequence switch contacts 28 and 29 break the circuit to conductors 25 and 26 and relays 27, 35 release. A circuit is closed for returning switches 41, 37, 38 and 39, the return circuit comprising arms 61, 45, 49, 53. Sequence switch contact 214 (Figure 1) breaks the circuit of the winding of relay 210, and this relay releases. A circuit is closed from ground, winding of repeating coil 136, sequence switch contact 29, wiper 24, conductor 12, substation 11, conductor 13, wiper 23, sequence switch contact 28, winding of relay 138, winding of repeating coil 136 to grounded battery. Relay 138 operates and closes a local circuit for operating relay 139.

The release of relay 108, as previously described, closes the following circuit: ground, right hand armature and back contact of relay 108, conductor, sequence switch contact 115, power magnet 110 to grounded battery. The sequence switch of Figure 2 moves to position 14. In position 7 the usual busy test of the called line may be made in any suitable manner, and in positions 8 to 16 a guarding potential is applied to the test conductor of the called line by way of grounded battery, resistance coil 140, sequence switch contact 196 and wiper 119. In position 14 a circuit is closed from a grounded source of signalling current 145, winding of relay 141, sequence switch contact 150, wiper 120, signalling apparatus of substation 34, wiper 121, sequence switch contact 146, to ground. Relay 141 is adjusted not to operate on the present current flowing. When the called party answers the increase in current which results when his receiver is lifted causes the operation of relay 141. A circuit is then closed from ground, armature and front contact of relay 141, sequence switch contact 115, winding of power magnet 110 to grounded battery, for moving the sequence switch to po-

sition 15. A circuit is closed from ground, winding of repeating coil 136 of Figure 1, sequence switch contact 151, conductor 104, wiper 91, conductor 105, sequence switch contact 146, wiper 121, substation 34, wiper 120, sequence switch contact 153, conductor 154, wiper 90 sequence switch contact 155, winding of repeating coil 136 to grounded battery, energizing the transmitter of substation 34.

The subscribers are now connected for conversational purposes. When the conversation is finished, the receivers are replaced upon their hooks. The circuits of relays 138 and 139 are broken and these relays release. A circuit is then closed from ground, armature and back contact of relay 139, sequence switch contact 20, power magnet 21, to grounded battery, moving the sequence switch of Figure 1 into position 18. Sequence switch contacts 30 and 156 break the circuits of relays 17 and 157 respectively, and these relays release. The line finder mechanism 14 may be restored in position 17 of the sequence switch.

A circuit is closed by way of ground, sequence switch contact 159 for energizing return magnet 160 and the operation of this magnet withdraws the retaining pawl and returns wipers 89, 90, 91 and brush 92 to normal. At normal, a circuit is closed from ground, brush 92, conductor 161, sequence switch contact 86, power magnet 21 to grounded battery, moving the sequence switch of Figure 1 into position 1. The circuit of magnet 160 is deenergized by the opening of sequence switch contact 159. A circuit is also closed from ground, armature and back contact of relay 157, Figure 2, conductor 162, sequence switch contact 163, power magnet 110, to grounded battery, for moving the sequence switch of Figure 2 into position 18. A circuit is closed from ground, sequence switch contact 164, return magnet 165 to grounded battery, for energizing return magnet 165 and the operation of this magnet withdraws pawl 126 and wipers 119, 120, 121 and brushes 122, 123 are returned to normal. At normal, a circuit is closed from ground, brush 123, conductor 166, sequence switch contact 115, power magnet 110 to grounded battery, moving the sequence switch of Figure 2 into position 1. The circuit of magnet 165 is deenergized by the opening of sequence switch contact 164.

The apparatus of Figures 1, 2, 3 and 4 is now fully restored and ready for a subsequent call.

The present embodiment discloses means for selecting any combination of digits other than "213" in the case assumed. For the first digit of the number the following conditions prevail when calling numerals listed in the first column.

Numeral 1; one impulse sent from calling device 33; arms of switch 37 are set on their second contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 4 to 6 conductor 276 is connected to ground through low resistance coil 288; conductor 241 is open; relays 294, 264 are operated; relays 265, 243 are not operated; switch 266 is set on its first contact; four impulses are sent to selector 15.

Numeral 3; three impulses sent from calling device 33; arms of switch 37 are set on their fourth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 4 to 6 conductor 276 is connected to ground through low resistance coil 288; conductor 241 is connected to ground through resistance coil 239; relays 294, 264, 243 are operated; relay 265 is not operated; switch 266 is set on its third contact.

Numeral 4; four impulses sent from calling device 33; arms of switch 37 are set on their fifth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 4 to 6 conductor 276 is connected to ground through high resistance coil 289; conductor 241 is open; relay 264 is operated; relays 265, 294, 243 are not operated; switch 266 is set on its fourth contact.

Numeral 5; five impulses are sent from calling device 33; arms of switch 37 are set on their sixth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 4 to 6 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 is connected to ground through resistance coil 239; relays 264, 243 are operated; relays 265, 294 are not operated; switch 266 is set on its fifth contact.

Numeral 6; six impulses are sent from calling device 33; arms of switch 37 are set on their seventh contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 4 to 6 conductor 276 is connected to ground through low resistance coil 288 and conductor 241 is open; relays 265, 294, 264 are operated; relay 243 is not operated; switch 266 is set on its sixth contacts.

Numeral 7; seven impulses are sent from calling device 33; arms of switch 37 are set on their eighth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 4 to 6 conductor 276 is not connected to ground, and conductor 241 is connected to ground through the resistance coil 289; relays 265, 243 are operated; relays 294, 264 are not operated; switch 266 is set on its seventh contacts.

Numeral 8; eight impulses are sent from

calling device 33; arms of switch 37 are set on their ninth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 4 to 6 conductor 276 is connected to ground through low resistance coil 288, and conductor 241 to ground through resistance coil 239; relays 265, 294, 264, 243 are operated; the arms of switch 266 are set on their eighth contacts.

Numeral 9; nine impulses are sent from calling device 33; arms of switch 37 are set on their tenth contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 4 to 6 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 is not connected to ground; relays 265, 264 are operated; relays 294, 243 are not operated; arms of switch 266 are set on their ninth contacts; seven impulses are sent to selector 15.

Numeral 0; ten impulses are sent from calling device 33; arms of switch 37 are set on their eleventh contacts; in position 4 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 4 to 6 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 through the resistance coil 239; relays 265, 264, 243 are operated; relay 294 is not operated; arms of switch 266 are set on their tenth contacts; nine impulses are sent to selector 15.

Switch 266 acts as a translator switch, being adapted to translate the numeral of the first digit into a series of impulses which will control selector 15 to extend the connection to selector 169 in which the terminals of the called line appear. Changes in the arrangement may be conveniently made by changing the jumpers 270 in the distributing board 322.

For the second digit the following conditions prevail when calling different numerals.

Numeral 2; two impulses sent from calling device 33; arms of switch 38 are set on their third contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 8 and 9 conductor 276 is open and conductor 241 is connected to grounded battery through resistance coil 300; relay 281 is operated; relays 278, 279, 284 are not operated.

Numeral 3; three impulses are sent from calling device 33; arms of switch 38 are set on their fourth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through low resistance coil 274 and conductor 241 is connected to grounded battery through resistance 300; relays 278, 279, 281 are operated; relay 284 is not operated.

Numeral 4; four impulses are sent from calling device 33; arms of switch 38 are set on their fifth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through high resistance coil 299 and conductor 241 is open; relay 279 is operated; relays 278, 281, 284 are not operated; four tens impulses are sent to selector 169.

Numeral 5; five impulses are sent from calling device 33; arms of switch 38 are set on their sixth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is not connected to grounded battery; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through high resistance coil 299 and conductor 241 is connected to grounded battery through resistance 300; relays 279, 281 are operated; relays 278, 284 are not operated; five tens impulses are sent to selector 169.

Numeral 6; six impulses are sent from calling device 33; arms of switch 38 are set on their seventh contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through low resistance coil 274 and conductor 241 is open; relays 278, 279, 284 are operated; relay 281 is not operated; six tens impulses are sent to selector 169.

Numeral 7; seven inpulses are sent from calling device 33; arms of switch 38 are set on their eighth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 8 and 9 conductor 276 is not connected to grounded battery and conductor 241 is connected to grounded battery through resistance coil 300; relays 281, 284 are operated; relays 278, 279 are not operated; seven tens impulses are sent to selector 169.

Numeral 8; eight impulses are sent from calling device 33; arms of switch 38 are set on their ninth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through low resistance coil 274 and conductor 241 to grounded battery through resistance 300; relays 278, 279, 281, 284 are operated; eight tens impulses are sent to selector 169.

Numeral 9; nine impulses are sent from calling device 33; arms of switch 38 are set on their tenth contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through

resistance coil 381; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through high resistance coil 299, and conductor 241 is open; relays 279, 284 are operated; relays 278, 281 are not operated; nine tens impulses are sent to selector 169.

Numeral 0; ten impulses are sent from calling device 33; arms of switch 38 are set on their eleventh contacts; in position 8 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 8 and 9 conductor 276 is connected to grounded battery 273 through high resistance coil 299, and conductor 241 is connected to grounded battery through resistance coil 300; relays 279, 281, 284 are operated; relay 278 is not operated; ten tens impulses are sent to selector 169.

For the third digit the following conditions prevail when calling different numerals.

Numeral 1; one impulse sent from calling device 33; arms of switch 39 are set on their second contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 11 and 12 conductor 276 is connected to ground through low resistance coil 288, and conductor 241 is open; relays 290, 291 are operated; relays 287, 295 are not operated; one impulse is sent to selector 169.

Numeral 2; two impulses are sent from calling device 33; arms of switch 39 are set on their third contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 11 and 12 conductor 276 is not connected to ground and conductor 241 is connected to ground through resistance coil 289; relay 287 is operated; relays 290, 291, 295 are not operated; two impulses are sent to selector 169.

Numeral 4; four impulses are sent from calling device 33; arms of switch 39 are set on their fifth contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 11 and 12 conductor 276 is connected to ground through high resistance coil 289; and conductor 241 is not connected to ground; relay 291 is operated; relays 287, 290, 295 are not operated; four impulses are sent to selector 169.

Numeral 5; five impulses are sent from calling device 33; arms of switch 39 are set on their sixth contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is not connected to battery; in positions 11 and 12 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 is connected to ground through resistance coil 286; relays 291, 287 are operated; relays 290, 295 are not operated; five impulses are sent to selector 169.

Numeral 6; six impulses are sent from calling device 33; arms of switch 39 are set on their seventh contacts; in position 11 conductor 268 is connected to grounded battery through resistance coil 381; in positions 11 and 12 conductor 276 is connected to ground through low resistance coil 288 and conductor 241 is not connected to ground; relays 290, 291, 295 are operated; relay 287 is not operated; six impulses are sent to selector 169.

Numeral 7; seven impulses are sent from calling device 33; arms of switch 39 are set on their eighth contacts; in position 11 conductor 268 is connected to grounded battery through resistance coil 381; in positions 11 and 12 conductor 276 is not connected to ground and conductor 241 is connected to ground through resistance coil 289; relays 287, 295 are operated; relays 290, 291 are not operated; seven impulses are sent to selector 169.

Numeral 8; eight impulses are sent from calling device 33; arms of switch 39 are set on their ninth contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 11 and 12 conductor 276 is connected to ground through low resistance coil 288 and conductor 241 to ground through resistance 286; relays 287, 290, 291, 295 are operated; eight impulses are sent to selector 169.

Numeral 9; nine impulses are sent from calling device 33; arms of switch 39 are set on their tenth contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 11 and 12 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 is not connected to ground; relays 291, 295 are operated; relays 287, 290 are not operated; nine impulses are sent to selector 169.

Numeral 0; ten impulses are sent from calling device 33; arm of switch 39 are set on their eleventh contacts; in position 11 of the sequence switch of Figure 3 conductor 268 is connected to grounded battery through resistance coil 381; in positions 11 and 12 conductor 276 is connected to ground through high resistance coil 289 and conductor 241 is connected to ground through resistance coil 286; relays 287, 291, 295 are operated; relay 290 is not operated; ten impulses are sent to selector 169.

In the case assumed and described, only a single sender was supposed to be available. If instead, a larger number of senders, say three, are available, and only one calling party is engaged in operating his calling device, then when relay 226 is connected to common conductor 223 the current flowing is greater in intensity than in the case cited.

due to there now being three resistances such as 224 in multiple. Marginal relay 226 therefore operates, and thus causes the operation of relay 201, magnet 202 and switch 236 earlier in the progress of the call than in the previous case. Thus the sender is seized and the selector 15 is set earlier.

Supposing there are three senders idle and available but also three active sets of registers, being set or adjusted and not yet connected with a sender. Then although there are three resistances such as 224 in multiple, there are also three relay windings such as those of relays 226 in parallel, the circuit of each of them being similar to that of the others, and the potential of conductor 223 is approximately what it was in the original case described, the several windings of the relays 226 shunting current from each other. Therefore in this case the relays 226 do not operate and the seizure of the senders is delayed until in each case the arms of switches 41 leave their fourth contacts, that is, until the full wanted numbers are registered. It will be seen that when there are more senders idle and available than there are active sets of registers, the potential of conductor 223 is relatively near ground, and relay 226 tends to operate; and when there are not more the relay 226 is adjusted not to operate.

It will be noted that conductor 268 is used for a double purpose. In positions 4, 8 and 11 of the sequence switch of Figure 3, the conductor referred to is employed to register the positions of the arms 44, 48 and 52 respectively, while in the sending positions 6, 9 and 12 of the same switch, it is used for sending impulses from relay 72 to the counting devices of Figure 4.

What is claimed is:

1. In a telephone exchange system, a calling device for indicating a number, an automatic selector arranged to establish a desired telephonic connection, a plurality of sets of registers constructed to be controlled by said calling device, means for connecting said calling device to one of said sets of registers, a plurality of senders each constructed to control the operation of the automatic selector, means for variably interconnecting one of said sets of registers with one of said senders, and means to control the sender according to the adjustment of the set of registers connected thereto, said last named means including a conductor common to said senders, means for varying the potential on said conductor controlled by said plurality of senders, and means for testing the potential on said conductor arranged to control said variably interconnecting means.

2. In a register sender for automatic telephone exchanges, a set of registers for registering a number, a plurality of senders, means for interconnecting said set of registers with one of said senders, a progression switch progressively advanced upon registration of a number and arranged to cause operation of said interconnecting means at a predetermined period of registration of a number, and automatic means controlled by the number of idle senders for causing the operation of said interconnecting means at a different period, said last named means including a conductor common to said senders, means for varying the potential on said conductor controlled by said plurality of senders, and means for testing the potential on said conductor arranged to control said interconnecting means.

3. In a telephone exchange system, a plurality of sets of registers, a lesser plurality of senders, a selector for connecting one of said sets with one of said senders, a conductor common to said sets and said senders, means for varying the potential on said conductor according to variations in the number of idle senders and active sets, and a marginal relay actuated when the potential of said conductor reaches a predetermined point for rendering said selector active.

4. In a register sender for automatic telephone exchanges, a plurality of sets of registers, a lesser plurality of senders, means for interconnecting one of said sets with one of said senders, and means controlled by the relative number of active sets and idle senders for determining when said interconnecting means shall operate.

5. In a full automatic telephone exchange system, a plurality of sets of registers proportional in number to the average duration of the holding time of one of said sets, a plurality of senders proportional in number to the holding time of one said senders and less in number than the sets of registers, a conductor common to said registers and senders, means for varying the potential on said conductor controlled by said senders means for interconnecting one of said sets of registers with one of said senders, and means for testing the potential of said conductor and for controlling said interconnecting means.

6. In a register sender for automatic telephone exchanges, a plurality of sets of registers, a different plurality of senders, a seizing device for each of said sets whereby an idle one of said senders may be seized, and means for delaying the actuation of said seizing device when the number of active sets of registers exceeds the number of idle senders.

7. In a telephone exchange system, a register, a sender normally independent thereof comprising an impulse counter, a relay in said register adapted to intermittently actuate said counter, a selector for interconnecting said register and said sender, and a sin-

gle conductor extending from said selector to said sender for indicating the adjustment of said register and for controlling said counter.

8. In a register sender for automatic telephone exchanges, a set of registers for registering a number, a plurality of senders, means for interconnecting said set of registers with one of said senders, a progression switch progressively advanced upon registration of a number and arranged to cause operation of said interconnecting means at a predetermined period of registration of a number, and automatic means controlled by the number of idle senders for causing the operation of said interconnecting means at a previous period.

9. In a telephone exchange system having selectors, a remotely controlled impulse counter, a sender for controlling the selectors of the exchange system controlled by said counter, means for interconnecting said counter and said sender, and automatic means controlled by the conjoint action of said counter and said sender for controlling the operation of said interconnecting means.

10. In a telephone exchange system having selectors, a set of registers for registering a number to be selected, a sender normally disconnected from said set of registers, and means controlled by the conjoint action of said set of registers and said sender for interconnecting said register set and said sender.

11. In a telephone exchange system having selectors for establishing desired connections, a plurality of sets of registers for registering numbers, a different plurality of senders normally disengaged therefrom, means for interconnecting one of said set of registers with one of said senders, means controlled by said set of registers for causing operation of said interconnecting means at a predetermined time, and means controlled by the conjoint action of said senders for causing the operation of said interconnecting means at a different time.

12. In a register sender for automatic telephone exchanges, a set of registers for registering a number, a plurality of senders, means for interconnecting said set of registers with one of said senders, a progression switch progressively advanced upon registration of a number and arranged to cause operation of said interconnecting means at a predetermined period of registration of a number, and automatic means controlled by the number of idle senders for causing the operation of said interconnecting means at a different period.

In testimony whereof, I hereunto set my hand.

GEORGE ALBEN E. LUNDELL.