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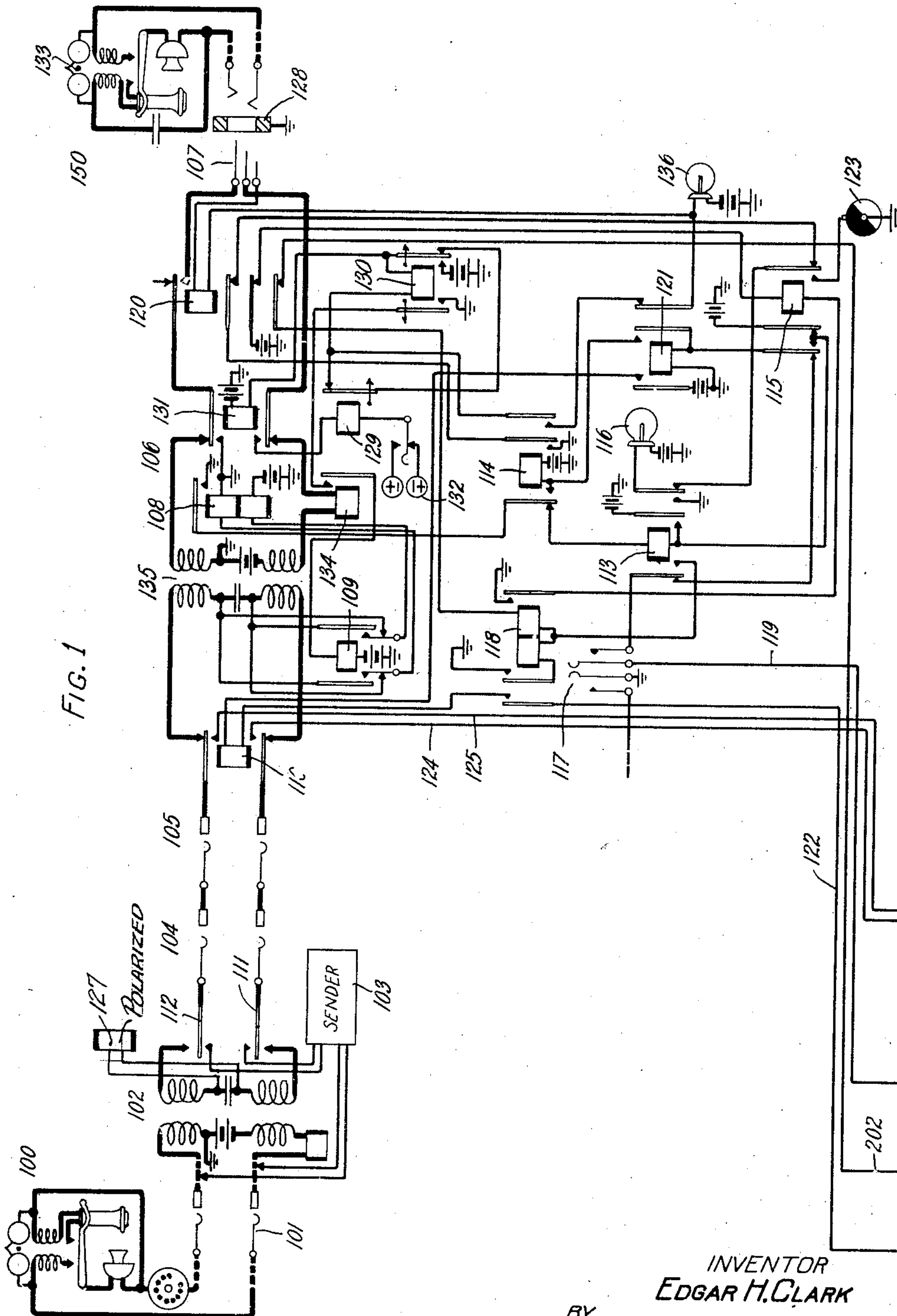
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1,743,429

TELEPHONE EXCHANGE SYSTEM

Filed June 27, 1928

4 Sheets-Sheet 1



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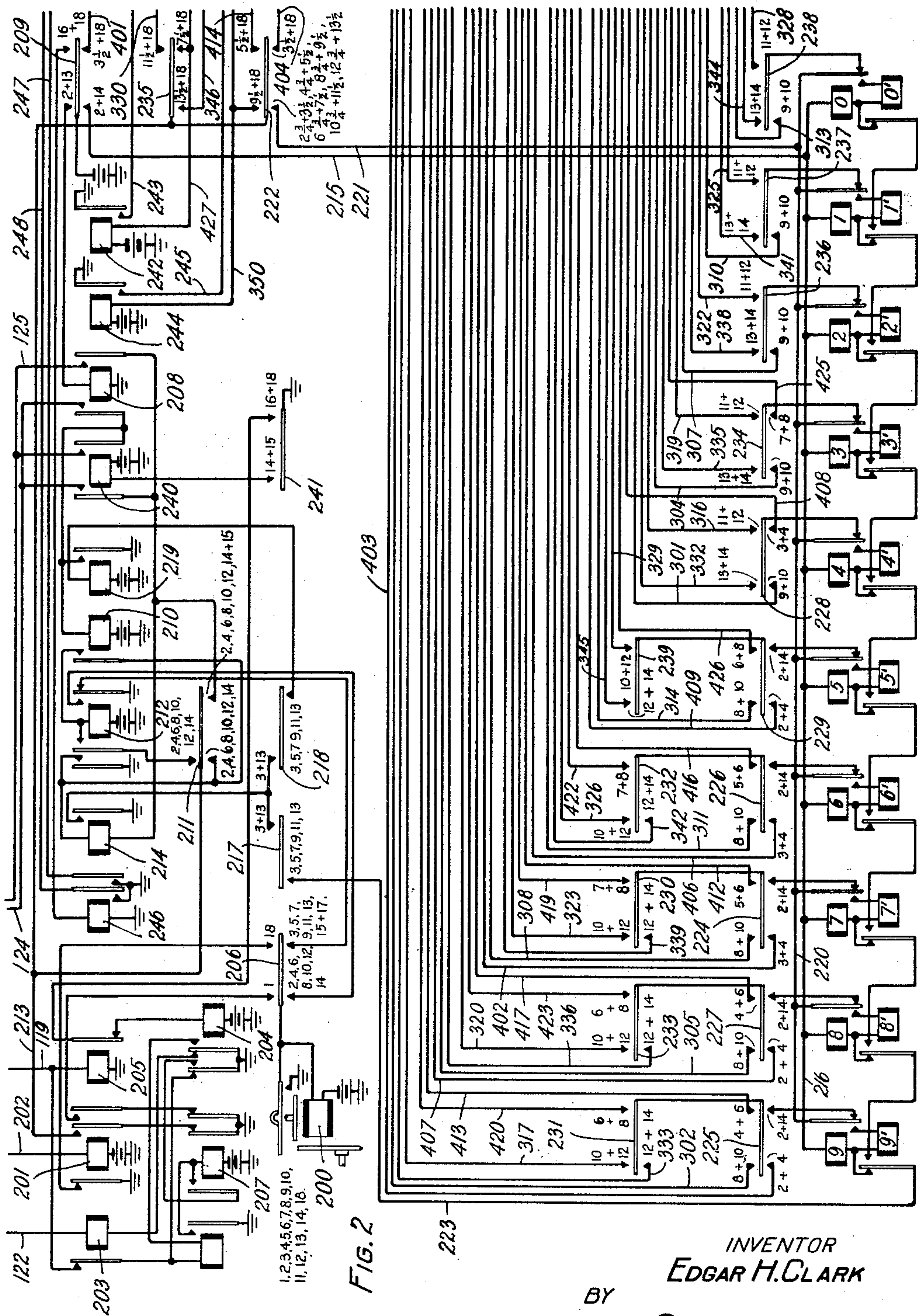
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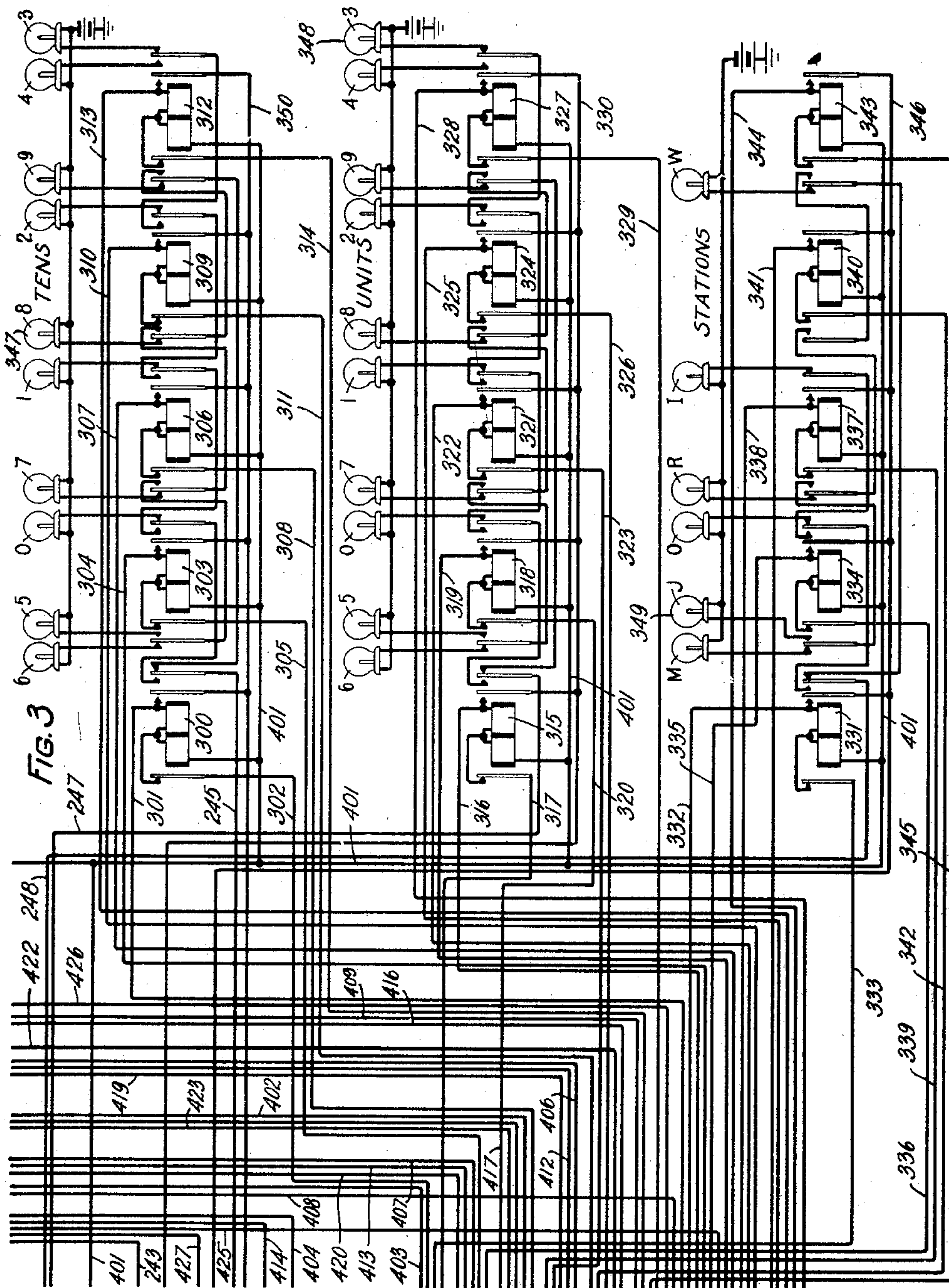
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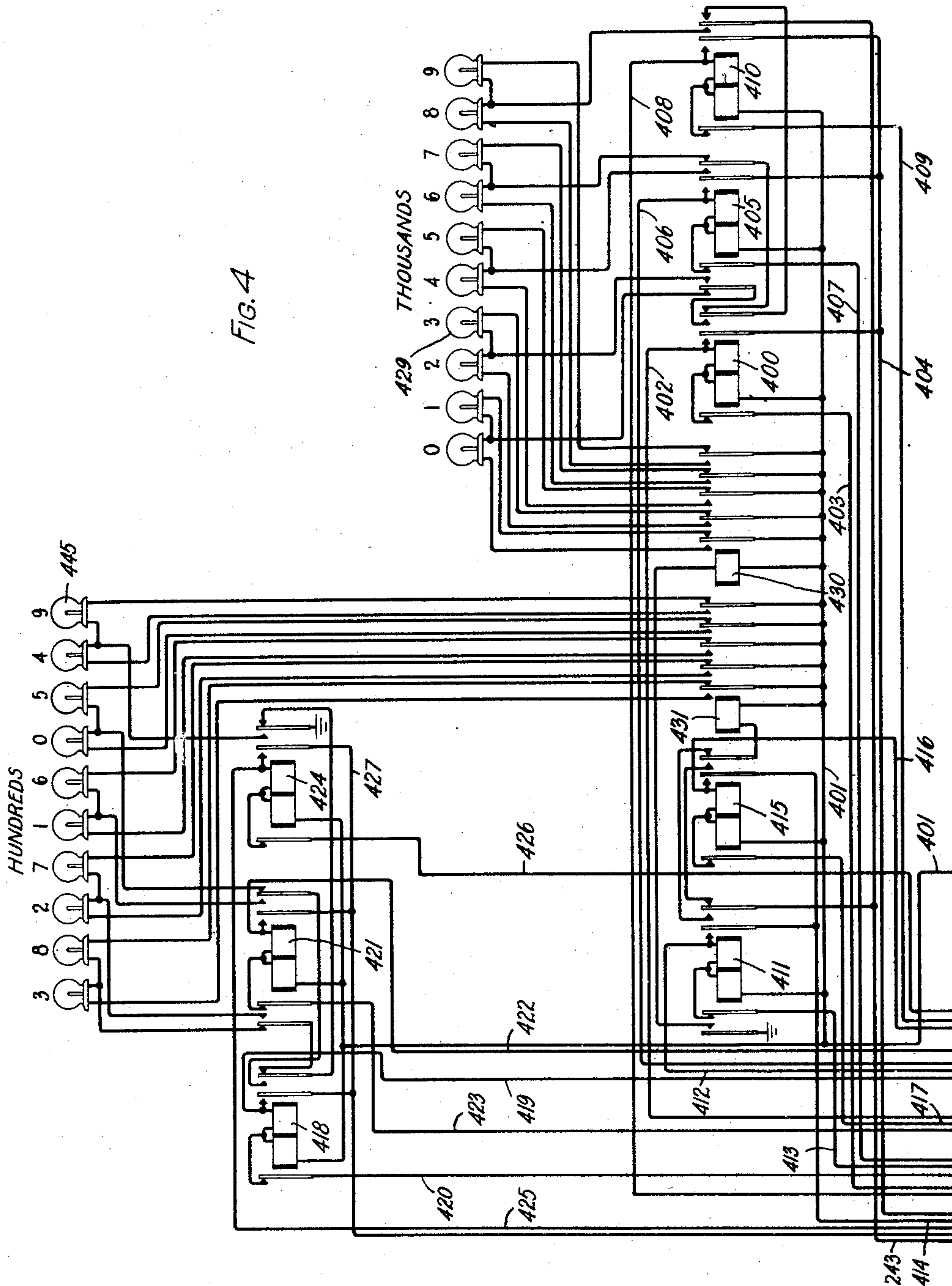
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TELEPHONE EXCHANGE SYSTEM

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4 Sheets-Sheet 4



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TELEPHONE-EXCHANGE SYSTEM

Application filed June 27, 1928. Serial No. 288,607.

This invention relates to telephone exchange systems and more particularly to an indicating arrangement for the purpose of indicating to an operator the number of a telephone line. The object of the invention is to economize in the apparatus required, and to enable such indications to be transmitted over long cable loops.

In telephone exchanges of a machine switching character, especially during the period in which the exchanges are being converted from a manual operation basis to a machine switching basis, there are certain offices which operate on a manual basis while others are equipped with selector switches and operate on a full machine switching basis. For establishing calls from lines in a machine switching office of such an exchange to lines in a manual office, it is the common practice for the subscriber to set registers in a common sender in his office in accordance with the office and line designation of the wanted line. Thereupon the sender operates selector switches to extend a connection over an interoffice trunk from the calling line to the office in which the wanted line terminates in accordance with the office designation of the wanted line number. The interoffice trunk extending to the manual office terminates in a manual connection plug. Common line number indicating apparatus is associable at the manual office with any one of the trunks incoming to the office. As soon as the manual operator has associated the indicating apparatus with the trunk upon which a call is incoming the sender in the machine switching office proceeds to send codes of impulses to the indicating apparatus to set registers therein to record the numerical designation of the wanted line. When the registers have been set lamps are lighted to display the line number registered thereon. The patent to A. E. Lundell and E. H. Clark No. 1,464,084, issued August 7, 1923, shows a system of the character above described.

In accordance with the present invention the registrations on the registers of the machine switching sender are transferred to the relay registers of the call indicator in

the manual office by trains of impulses transmitted revertively from the indicator apparatus over the interoffice trunk to the sender. This is accomplished by impulsing relays in much the same manner in which the revertive impulses are transmitted by the commutators of selector switches to measure their selective movements. When, for example, the impulsing relays have sent a train of impulses corresponding to a digit of a wanted line number such as satisfies the particular register setting in the sender for such digit, the impulsing or fundamental circuit is opened at the sender and impulsing for such digit ceases. The number of impulses in each train thus sent is counted by a series of counting relays in the indicating apparatus, the counting relays in turn controlling the setting of the proper combinations of register relays of the indicating apparatus.

By thus transmitting trains of impulses revertively from the indicating apparatus to the sender instead of transmitting codes of impulses of special character from the sender to the indicating apparatus as heretofore done, since the impulses thus revertively sent are of the same character and cause the sender to function in the same manner as in controlling selector switches, it is possible to eliminate from each sender the special code impulsing switch and associated circuits, thereby effecting a considerable economy in the senders. Thus not only is an economy of apparatus attained, but also due to the character of impulses used it is possible to accurately operate over long interoffice cable loops.

The drawings with Fig. 1 placed above Fig. 2, Fig. 3 at the right of Fig. 2 and Fig. 4 above Fig. 3 diagrammatically represent a portion of a telephone system employing the present invention. Fig. 1 shows a calling subscriber's substation and line, the diagrammatic representation of the brushes of a line switch, district selector, office selector and central office sender, an interoffice trunk terminating in a plug at the B operator's position of a terminating manual office, and the substation and line of a called subscriber. Fig. 2 shows the control apparatus of a line

number indicating mechanism common to the interoffice trunks incoming to the B operator's position. Fig. 3 shows the lamps and controlling relays for indicating the tens, units and stations digits of wanted line numbers. Fig. 4 shows the lamps and controlling relays for indicating the thousands and hundreds digits of line numbers.

For the purpose of this disclosure the apparatus of the originating dial switching office of Fig. 1 has been abbreviated, but it may be of the character fully disclosed in the patent to F. A. Stearn No. 1,505,171, granted August 19, 1924. The trunk circuit terminating at the manual office disclosed in the right portion of Fig. 1 and the number indicating apparatus disclosed in Figs. 2, 3 and 4 is in general of the same character as disclosed in the patent to A. E. Lundell and E. H. Clark No. 1,464,084, granted August 7, 1923, modified, however, in accordance with the present invention.

It is believed that the invention will be best understood through a detailed description of the manner in which a connection is established from the line of the calling substation 100 terminating in the originating dial switching office to the line of substation 150 terminating in a manual office. When the calling subscriber removes his receiver from the switchhook, the line switch 101 in which his line terminates hunts for and connects with an idle district selector trunk 102 which, in turn, becomes connected in the well-known manner with an idle register sender 103. As soon as an idle sender is selected the calling subscriber receives a dialing tone and commences to dial the office code and numerical digits of the wanted line number, thereby setting registers of the sender to record those digits. After the office code digits have been recorded, the sender 103 proceeds to operate the district selector 104 and the office selector 105 to extend the calling line to an idle interoffice trunk 106 terminating in a connection plug 107 before a B operator's position in the terminating office in which the desired line terminates.

Upon the seizure of trunk 106 a circuit is established from battery through the lower winding of relay 108, the right normal contacts of relay 109, the upper back contact of relay 110, the tip brushes of selectors 105 and 104, the lower contact of cam 112 to the sender 103, returning over the upper contact of cam 111, the ring brushes of selectors 104 and 105, the lower back contact of relay 110, the left normal contacts of relay 109 to ground through the upper winding of relay 108. Relay 108 operates and closes a circuit for relay 113 extending from ground at the contact of relay 108, the left back contact of relay 114, winding of relay 113 to battery at the inner back contact of relay 115. Relay 113 operates and at its inner right front contact

closes a locking circuit for itself directly to battery independent of relay 115, and at its outer right front contact closes an obvious circuit for the lamp 116, the illumination of which notifies the operator that a connection has been extended to the trunk 106 from a distant dial switching office.

In response to the illumination of lamp 116 the operator actuates the assignment key 117 individual to the trunk 106 for the purpose of associating with the trunk, call indicator mechanism shown on Figs. 2, 3 and 4 to receive the transfer of the wanted line designation from the sender 103. The depression of key 117 closes a circuit from battery through the winding of relay 201, conductor 202, the lowermost back contact of relay 120, the right winding of relay 118, the left front contact of relay 113, the right contact of key 117, conductor 119, back contact of relay 203 to ground at the outer back contact of relay 204. A branch of this circuit extends through the winding of relay 205 to ground, but due to the direct path to ground relay 205 cannot operate. Relays 201 and 118 become energized and a new circuit for these relays is established from battery through the winding of relay 201, conductor 202, the lowermost back contact of relay 120, both windings of relay 118 in series, inner left contact of relay 118 to ground. Relay 118 establishes a circuit from ground through its right front contact, the winding of relay 115 to battery at the intermediate lower back contact of relay 120. Relay 115 operates and a circuit is closed from battery through the inner right front contact of relay 113, the left front contact of relay 115 to ground through the winding of relay 121. Relay 121 energizes and closes a circuit from battery through the winding of relay 114, the right front contact of relay 121 to ground through the winding of relay 121. Relay 114 does not energize since its winding is shunted by the circuit from battery through the inner right front contact of relay 113 and the left front contact of relay 115. Relay 121 also closes a circuit from battery over its left contact, the winding of relay 110, outer left contact of relay 118, conductor 122, winding of relay 203 to ground at the inner back contact of relay 204. Relays 110 and 203 become energized. Relay 203 opens the shunt around the winding of relay 205, previously mentioned, but relay 205 remains deenergized since the circuit thereof is opened at the right contacts of key 117 as soon as the operator releases such key.

When relay 110 energizes it opens the circuit extending to the sender 103 through the windings of relay 108. Relay 108 opens the circuit of relay 113 which thereupon deenergizes and removes the short circuit from around the winding of relay 114. Relay 114 now becomes energized in series with relay 121 over the circuit previously traced. The

release of relay 113 completes a circuit from battery through the lamp 116, the right back contact of relay 113, the right front contact of relay 115 to ground through the interrupter 123. The lamp 116 ceases to burn steadily and instead is intermittently flashed by the constantly rotating interrupter 123. This flashing signal will continue throughout the period in which the relay call indicator is being operated. Relay 110 at its front contacts extends the incoming conductors of the trunk 106 over conductors 124 and 125 toward the call indicator. At the sender the circuits are prepared for transferring the numerical designation of the desired line to the registers of the call indicator.

Relay 201, upon energizing, also closes a circuit for advancing sequence switch 200 out of normal position 1 into position 2, which may be traced from battery, winding of magnet 200, the upper left contact of cam 206, the outer right contact of relay 201 to ground at the outer right back contact of relay 207. With sequence switch 200 in position 2 a circuit is closed for relay 208 extending from ground, winding of relay 208, the upper left contact of cam 209 to battery. Conductor 124 is now extended over the left contact of relay 208 to battery through the winding of relay 210 and conductor 125 is extended over the right contact of relay 208, the lower right contact of cam 211, conductor 213, the inner right front contact of relay 201 to ground at the inner right back contact of relay 207. Relay 210 and the stepping relay of the sender 103 energize in this circuit preparatory to transferring the thousands registration from a register of the sender 103 to a relay register of the call indicator. Relay 210, upon energizing, closes a circuit for relay 212 extending from ground on conductor 213 over the lower left contact of cam 211, the front contact of relay 210 to battery through the winding of relay 212. Relay 212 locks to ground on conductor 213 over its inner left front contact, the upper contact of cam 211, and also in a circuit through its winding, the front contact of relay 210 to ground at the outer left contact of relay 212. Relay 212 also closes a circuit for advancing sequence switch 200 into position 3 extending from battery through the magnet 200, the lower left contact of cam 206 to ground at the right front contact of relay 212. As soon as sequence switch 200 leaves position 2, the shunt which in position 2 extended around the winding of relay 214 over the lower contacts of cam 211 is removed and relay 214 energizes over the pulsing circuit extending to the sender 103 previously traced. Relays 210 and 214 are now both energized over the pulsing circuit in series with the stepping relay of the sender 103.

Two circuits are now closed in parallel, one extending from battery at the lower left

contact of cam 209, over conductors 215 and 216, the winding of the No. 9 counting relay, the back contact of the No. 9' counting relay, conductor 223, contacts of cam 217 to ground at the front contact of pulsing relay 214, and the second extending from ground at the front contact of relay 214, over the contacts of cam 218 to battery through the winding of relay 219. Relay 219 and the No. 9 counting relay both energize, the No. 9 counting relay closing a locking circuit for itself from battery on conductor 216, through its own winding and the winding of the No. 9' counting relay, the front contact of the No. 9 counting relay, conductors 220 and 221, the lower left contact of cam 222 to ground on conductor 213. The No. 9' counting relay, however, does not energize in this locking circuit as its winding is shunted by ground on the front contact of relay 214 as long as relay 214 remains energized. Relay 219, upon energizing, connects ground at its front contact to the winding of relay 210 and to conductor 124 and, since conductor 125 is also connected to ground through the winding of relay 214 and the outer left front contact of relay 212, the stepping relay of the sender 103 and the pulsing relay 214 become deenergized.

Relay 214 upon deenergizing removes the shunt from the winding of the No. 9' counting relay, whereupon such relay energizes extending the counting relay control conductor 223 over its front contact, the back contact of the No. 8' counting relay to battery through the No. 8 counting relay upon the next energization of the pulsing relay 214. Relay 214, upon deenergizing, also opens the circuit of relay 219, which in turn deenergizes removing the shunting ground at its front contact from the windings of pulsing relay 214 and the stepping relay of sender 103. These latter relays again energize and relay 214 now causes the operation of the No. 8 counting relay and the reoperation of relay 219. The No. 8 counting relay now locks through the winding of the No. 8' counting relay. In the manner just described, successive counting relays are operated until the sender 103 is satisfied as to its thousands registration when the pulsing circuit will be opened in the well-known manner at the sender 103, opening the circuits of relays 214 and 210. Since one locking circuit of relay 212 was opened at the upper contact of cam 211 when sequence switch 200 advanced into position 3, the relay 212 now deenergizes when its other locking circuit is opened at the contact of relay 210. Relay 212 thereupon closes a circuit for advancing sequence switch 200 into position 4, extending from battery through the winding of magnet 200, the lower right contact of cam 206 to ground at the right back contact of relay 212. At the sender 103 circuits are prepared for trans-

ferring the remainder of the thousands and a portion of the hundreds registration from registers therein to the call indicator. With sequence switch 200 in position 4, the previously traced pulsing circuit extending to the sender 103 through the stepping relay thereof, and through the winding of relay 210 is again established.

It will be assumed that the number of the wanted subscriber is 3983-J. The originating sender 103 is not aware of the fact that the control which it is to exercise in accordance with the registered designation is to be over a call indicator mechanism rather than over panel type selector switches and therefore it proceeds as though six series of reverte impulses are to be received thereby from selective switches, i. e., an incoming brush series and incoming group series to satisfy the thousands digit registration and to partially satisfy the hundreds digit registration in the sender, final brush, tens, and units series to further satisfy the hundreds registration and the tens and units registrations, and a stations series to satisfy the stations registration. Thus in response to the first series of reverte impulses transmitted to the sender 103 from the call indicator two pairs of counting relays No. 9 and No. 9' and No. 8 and No. 8' have been operated and locked.

The manner in which a record of this first series of impulses is made on the register relays 400, 405 and 410 will now be described. When sequence switch 200 passes into position 3½ a circuit is extended from battery, over the lower right contact of cam 209, conductor 401, both windings of register relay 400, conductor 402, the lower contacts of cam 224, the back contact of the No. 7 counting relay, over conductor 221, the lower left contact of cam 222 to ground on conductor 213. Until the No. 9 counting relay energizes a shunt around the right winding of relay 400 exists which may be traced from the junction of the two windings of relay 400, over the left back contact of relay 400, conductor 403, the lower contacts of cam 225, the back contact of the No. 9 counting relay to ground on conductor 221. As soon as the No. 9 counting relay energizes relay 400 energizes.

A circuit is also established for relay 405 extending from battery on conductor 401 through both windings of relay 405, conductor 406, the lower contacts of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. Until the No. 8 counting relay energizes there is a shunt around the right winding of relay 405 which may be traced from the junction of the two windings of relay 405, over its left back contact, conductor 407, the lower contacts of cam 227, the back contact of the No. 8 counting relay, to ground on conductor 221. This shunt is opened at the back contact of

the No. 8 counting relay when that relay is energized and relay 405 thereupon energizes.

A circuit is also established for relay 410 extending from battery on conductor 401, through both windings of relay 410, conductor 408, the lower right contact of cam 228, the back contact of the No. 4 counting relay, to ground on conductor 221. This relay, however, does not energize since its right winding is shunted over its outer left back contact, conductor 409, the lower contacts of cam 229, the back contact of the No. 5 counting relay to ground on conductor 221. Since the No. 5 counting relay has not been energized relay 410 cannot operate. Thus in response to the operation of the counting relays two register relays 400 and 405 have been operated. When sequence switch 200 advances into position 4 locking circuits therefor are established. The locking circuit of relay 400 may be traced from battery on conductor 401, through both windings and the inner right contact of relay 400, conductor 404, the lower right contact of cam 222 to ground on conductor 213. The locking circuit of relay 405 may be traced from battery on conductor 401, through both windings and the inner right contact of relay 405, conductor 404 to ground on conductor 213.

It will be recalled that upon the termination of the first series of impulses, sequence switch 200 advanced into position 4 again establishing the pulsing circuit between the sender 103 and the call indicator causing the energization of relay 210. Relay 214 is at this time shunted at the contacts of cam 211. Relay 210 upon energizing over the pulsing circuit again operates relay 212 which locks in the manner before described and closes the previously traced circuit for advancing sequence switch 200 into position 5. The operated counting relays are at this time released as their locking circuits were opened at the lower left contact of cam 222 when sequence switch 200 passed out of position 3½. With sequence switch 200 in position 5 the shunt around the winding of relay 214 is removed and this relay energizes over the pulsing circuit closing the previously traced parallel circuits through the winding of relay 219 and the winding of the No. 9 counting relay.

In the manner previously described relays 214 and 219 cooperate to successively operate and lock pairs of counting relays until the counting relays of the sender 103 have been operated to satisfy the combined thousands and hundreds registrations therein when the fundamental circuit will be opened at the sender 103 releasing relays 210 and 214. The release of relay 210 in the manner previously described opens the holding circuit of relay 212 which releases and causes the advance of sequence switch 200 into position 6. Since it is assumed that the subscriber's line number

is 3983-J, the second series of impulses transmitted revertively to the sender 103 will have caused the operation of pairs of counting relays No. 9, No. 9' to No. 6, No. 6' inclusive.

5 As the sequence switch 200 passes into position 5 operating circuits will be established for operating relays of the register group comprising relays 411 and 415. The first circuit extends from battery on conductor 401, through both windings of relay 411, conductor 412, the right contacts of cam 224, the back contact of the No. 7 counting relay to ground on conductor 221. Until the No. 9 counting relay energizes the right winding of relay 411 is shunted over a circuit from the junction between the windings thereof, over its left contact, conductor 413, the right contacts of cam 225, the back contact of the No. 9 counting relay, to ground on conductor 221. As soon as the No. 9 counting relay energizes this shunt is opened and relay 411 operates. A second circuit is also closed from battery on conductor 401, through both windings of relay 415, conductor 416, the right contacts of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. Until the No. 8 counting relay energizes relay 415 is shunted in a circuit extending from the junction point between the windings of relay 415, over the left back contact thereof, conductor 417, the right contacts of cam 227, the back contact of the No. 8 counting relay to ground on conductor 221. As soon as the No. 8 counting relay energizes this shunt is opened and relay 415 operates. When the No. 7 counting relay operates the operating circuit of relay 411 is opened at its back contact and relay 411 deenergizes. As soon as the No. 6 counting relay energizes the circuit of relay 415 is opened at its back contact. Thus when the sequence switch 200 advances into position 6 at the end of the transmission of the second series of impulses no relays of the register group 411 and 415 remain operated.

As sequence switch 200 leaves position 5½ the locking circuits of the operated counting relays are opened at the lower left contact of cam 222 and as the sequence switch arrives in position 6 relay 210 is again operated over the pulsing circuit in series with the stepping relay of the sender 103. In the manner previously described relay 212 operates and locks following the operation of relay 210, advancing sequence switch 200 into position 7 and thereby including relay 214 in the fundamental circuit. Counting relays of the call indicator and of the sender 103 are thereupon operated and locked in the manner previously described until the sender 103 is satisfied as to its hundreds registration when the fundamental circuit is opened at the sender 103 in the usual manner. Thereupon relays 210 and 214 are deenergized, relay 210 unlocking relay 212 which in turn deenergizes

advancing sequence switch 200 into position 8. Since it has been assumed that the hundreds digit of the wanted subscriber's number is nine, the transfer of the registration from the sender 103 to the call indicator will have operated five pairs of counting relays No. 9, No. 9' to No. 5, No. 5' inclusive for the purpose of operating register relays of the groups 418, 421 and 424.

Prior to the advance of sequence switch 200 out of position 7 a circuit will be effective from battery on conductor 401, through both windings of register relay 418, conductor 419, the right contact of cam 230, the lower right contact of cam 224, the back contact of the No. 7 counting relay to ground on conductor 221. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 418 extending from the junction between the windings thereof, over its left back contact, conductor 420, the right contact of cam 231, the lower right contact of cam 225, the back contact of the No. 9 counting relay, to ground on conductor 221. As soon as the No. 9 counting relay operates this shunt is opened and relay 418 operates. A circuit is also closed from battery on conductor 401, through both windings of relay 421, conductor 422, the right contact of cam 232, the lower right contact of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 421 extending from the junction point between its windings, over the inner left back contact thereof, conductor 423, the right contact of cam 233, the lower right contact of cam 227, the back contact of the No. 8 counting relay to ground on conductor 221. As soon as the No. 8 counting relay operates this shunt is opened and relay 421 operates. A circuit is also established from battery on conductor 401, through both windings of relay 424, conductor 425, the lower right contact of cam 234, the back contact of the No. 3 counting relay, to ground on conductor 221, and a shunt around the right winding of relay 424 exists from the junction of its windings, over its left back contact, conductor 426, the right contacts of cam 229, the back contact of the No. 5 counting relay, to ground over conductor 221. This shunt is removed when the No. 5 counting relay energizes and relay 424 thereupon operates.

As soon as the No. 7 counting relay energizes the operating circuit of relay 418 is opened at the back contact of this counting relay and relay 418 releases. The operation of the No. 6 counting relay also opens the operating circuit of relay 421 and the latter relay releases. Thus at the end of the third series of impulses relay 424 is the only register relay of the group 418, 421 and 424 which remains operated. This relay locks over its inner right front contact, conductor 427, the

lower right contact of cam 235, to ground on conductor 213 as soon as sequence switch 200 advances into position $7\frac{1}{2}$.

When sequence switch 200 leaves position $7\frac{1}{2}$ the locking circuits for the operated counting relays are opened at the lower left contact of cam 222, and as the sequence switch arrives in position 8 relay 210 is again operated over the pulsing circuit in series with the stepping relay of sender 103. In the manner previously described relay 212 operates and locks following the operation of relay 210, advancing sequence switch 200 into position 9 and thereby including relay 214 in the pulsing circuit. Counting relays of the call indicator and of the sender 103 are thereupon operated and locked in the manner previously described until the sender 103 is satisfied as to its tens digit registration when the pulsing circuit is opened at the sender 103. Thereupon relays 210 and 214 deenergize, relay 210 unlocking relay 212 which in turn deenergizes advancing sequence switch 200 into position 10. Since it has been assumed that the tens digit of the wanted line number is eight all of the pairs of counting relays from No. 9, No. 9' to No. 1, No. 1' inclusive will have been operated.

Prior to the advance of sequence switch 200 out of position 9 a circuit will be effective from battery on conductor 401, through both windings of relay 300, conductor 301, the lower left contact of cam 228, the back contact of the No. 4 counting relay, to ground on conductor 221. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 300 extending from the junction between its windings, the left back contact of relay 300, conductor 302, upper left and lower right contacts of cam 225, the back contact of the No. 9 counting relay, to ground over conductor 221. As soon as the No. 9 counting relay operates this shunt is opened and relay 300 energizes. A circuit is also closed from battery on conductor 401, through both windings of relay 303, conductor 304, the lower left contact of cam 234, the back contact of the No. 3 counting relay, to ground on conductor 221. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 303 extending from the junction between its windings, over its inner left back contact, conductor 305, the upper left and lower right contacts of cam 227, the back contact of the No. 8 counting relay, to ground on conductor 221. As soon as the No. 8 counting relay operates this shunt is opened and relay 303 operates.

A circuit is also established from battery on conductor 401, through both windings of relay 306, conductor 307, the lower left contact of cam 236, the back contact of the No. 2 counting relay, to ground on conductor 221. Until the No. 7 counting relay operates a shunt exists around the right winding of

relay 306 extending from the junction between the windings thereof, over its inner left back contact, conductor 308, the upper left and lower right contacts of cam 224, the back contact of the No. 7 counting relay, to ground on conductor 221. As soon as the No. 7 counting relay operates this shunt is opened and relay 306 operates. A circuit may also be traced from battery on conductor 401, through both windings of relay 309, conductor 310, the lower left contact of cam 237, the back contact of the No. 1 counting relay to ground on conductor 221. Until the No. 6 counting relay operates a shunt exists around the right winding of relay 309 extending from the junction between the windings thereof, over its inner left back contact, conductor 311, the upper left and lower right contacts of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. As soon as the No. 6 counting relay operates this shunt is opened and relay 309 energizes. Still another circuit may be traced from battery on conductor 401, through both windings of relay 312, conductor 313, the lower left contact of cam 238, the back contact of the No. 0 counting relay to ground on conductor 221. Until the No. 5 counting relay operates the right winding of relay 312 is shunted in a circuit extending from the junction point between its windings, over its inner left back contact, conductor 314, the upper left and lower right contacts of cam 229, the back contact of the No. 5 counting relay to ground on conductor 221. As soon as the No. 5 counting relay operates this shunt is removed and relay 312 operates.

When the No. 4, No. 3, No. 2 and No. 1 counting relays operated the previously traced operating circuits for relays 300, 303, 306 and 309 were opened at the back contacts of such counting relays and therefore at the time sequence switch 200 advances out of position 9 into position 10 only one register relay, 312, of the tens register remains operated. This relay locks from battery on conductor 401, through both of its windings and its inner right front contact, conductor 350, the upper left contact of cam 222 to ground on conductor 213 as soon as sequence switch 200 reaches position $9\frac{1}{2}$. Upon leaving position $9\frac{1}{2}$ the locking circuits of all the operated counting relays are opened at the lower left contact of cam 222 in readiness for the registration of the units digit.

With sequence switch 200 in position 10 relay 210 is again energized over the pulsing circuit in series with the stepping relay of the sender 103. In the manner previously described relay 212 operates and locks following the operation of relay 210, advancing sequence switch 200 into position 11 thereby including relay 214 in the pulsing circuit. Counting relays of the call indicator and of the sender 103 are thereupon operated and

locked in the manner previously described until the sender 103 is satisfied as to its units registration when the pulsing circuit is opened at the sender 103. Thereupon relays 210 and 214 deenergize, relay 210 in turn unlocking relay 212 which deenergizes advancing sequence switch 200 into position 12. Since it has been assumed that the units digit of the wanted line is three the pairs of counting relays No. 9 No. 9' to No. 6, No. 6' inclusive will have been operated.

Prior to the advance of sequence switch 200 out of position 11 a circuit will be effective from battery on conductor 401, through both windings of relay 315, conductor 316, the upper right contact of cam 228, the back contact of the No. 4 counting relay, to ground on conductor 221. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 315 from the junction between its windings, over its left back contact, conductor 317, the upper left contact of cam 231, the lower right contact of cam 225, the back contact of the No. 9 counting relay, to ground on conductor 221. As soon as the No. 9 counting relay operates this shunt is opened and relay 315 energizes. A circuit is also closed from battery on conductor 401, through both windings of relay 318, conductor 319, the upper right contact of cam 234, the back contact of the No. 3 counting relay, to ground on conductor 221. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 318 extending from the junction between its windings, over its inner left back contact, conductor 320, the upper left contact of cam 233, the lower right contact of cam 227, the back contact of the No. 8 counting relay to ground on conductor 221. As soon as the No. 8 counting relay operates this shunt is opened and relay 318 operates.

A circuit is also established from battery on conductor 401, through both windings of relay 321, conductor 322, the right contact of cam 236, the back contact of the No. 2 counting relay to ground on conductor 221. Until the No. 7 counting relay operates a shunt exists around the right winding of relay 321 extending from the junction between the windings thereof, over its inner left back contact, conductor 323, the upper left contact of cam 230, the lower right contact of cam 224, the back contact of the No. 7 counting relay, to ground on conductor 221. As soon as the No. 7 counting relay operates this shunt is opened and relay 321 operates. A circuit is also extended from battery, over conductor 401, through both windings of relay 324, conductor 325, the right contact of cam 237, the back contact of the No. 1 counting relay, to ground on conductor 221. Until the No. 6 counting relay operates a shunt exists around the right winding of relay 324 extending from the junction of the windings

thereof, over its inner left back contact, conductor 326, the upper left contact of cam 232, the lower right contact of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. As soon as the No. 6 counting relay operates this shunt is opened and relay 324 operates. Still another circuit may be traced from battery on conductor 401, over both windings of relay 327, conductor 328, the right contact of cam 238, the back contact of the No. 0 counting relay, to ground on conductor 221. Until the No. 5 counting relay operates the right winding of relay 327 is shunted in a circuit extending from the junction between the windings thereof, over its inner left back contact, conductor 329, the right contact of cam 239, the lower right contact of cam 229, the back contact of the No. 5 counting relay, to ground on conductor 221. Since it has been assumed that the No. 5 counting relay is not energized this shunt is not opened and relay 327 does not operate. When therefore sequence switch 200 advances out of position 11 into position 12 only register relays 315, 318, 321 and 324 of the units register remain operated. These relays then lock as soon as sequence switch 200 reaches position 11½ from battery on conductor 401, over both windings of these relays, the inner right front contact of each, conductor 330, the upper contact of cam 235, to ground on conductor 313. Upon leaving position 11½ the locking circuits of all operated counting relays are opened at the lower left contact of cam 222 and these relays deenergize.

With sequence switch 200 in position 12 relay 210 is again energized over the pulsing circuit in series with the stepping relay of the sender 103. In the manner previously described relay 212 operates and locks, advancing sequence switch 200 into position 13 thereby including relay 214 in the fundamental circuit. Counting relays of the call indicator and of the sender 103 are thereupon operated and locked in the manner previously described. For the purpose of this description it will be assumed that the stations register of the sender 103 is connected with the train of counting relays of such sender in a manner similar to the connection of the other registers of the sender. When therefore the sender 103 is satisfied as to its stations registrations, which has been assumed to be for the stations letter J, relays 210 and 214 deenergize, relay 210 in turn unlocking relay 212 which deenergizes, advancing sequence switch 200 into position 14. At this time the pairs of counting relays No. 9, No. 9' to No. 4, No. 4' inclusive will have been operated and locked.

Prior to the advance of sequence switch 200 out of position 13 a circuit will be effective from battery on conductor 401, through both windings of relay 331, conductor 332, the upper left contact of cam 228, the back contact

of the No. 4 counting relay, to ground on conductor 221. Until the No. 9 counting relay operates a shunt exists around the right winding of relay 331 extending from the junction between its windings, its left back contact, conductor 333, the lower contact of cam 231, the lower right contact of cam 225, the back contact of the No. 9 counting relay to ground on conductor 221. As soon as the No. 9 counting relay operates this shunt is removed and relay 331 operates. A circuit is also closed from battery on conductor 401, through both windings of relay 334, conductor 335, the upper left contact of cam 234, the back contact of the No. 3 counting relay, to ground on conductor 221. Until the No. 8 counting relay operates a shunt exists around the right winding of relay 334 extending from the junction between its windings, over its inner left front contact, conductor 336, the lower contact of cam 233, the lower right contact of cam 227, the back contact of the No. 8 counting relay, to ground on conductor 221. As soon as the No. 8 counting relay operates this shunt is opened and relay 334 operates.

A circuit is also established from battery on conductor 401, through both windings of relay 337, conductor 338, the upper left contact of cam 236, the back contact of the No. 2 counting relay to ground on conductor 221. Until the No. 7 counting relay operates a shunt exists around the right winding of relay 337 extending from the junction between its windings, its inner left back contact, conductor 339, the lower contact of cam 230, the lower right contact of cam 224, the back contact of the No. 7 counting relay to ground on conductor 221. As soon as the No. 7 counting relay operates this shunt is opened and relay 337 operates. A circuit may also be traced from battery on conductor 401, through both windings of relay 340, conductor 341, the upper left contact of cam 237, the back contact of the No. 1 counting relay, to ground on conductor 221. Until the No. 6 counting relay operates a shunt exists around the right winding of relay 340 extending from the junction between its windings, over its inner left back contact, conductor 342, the lower contact of cam 232, the lower right contact of cam 226, the back contact of the No. 6 counting relay, to ground on conductor 221. As soon as the No. 6 counting relay operates this shunt is removed and relay 340 energizes. Still another circuit may be traced from battery on conductor 401, through both windings of relay 343, conductor 344, the upper left contact of cam 238, the back contact of the No. 0 counting relay to ground on conductor 221. Until the No. 5 counting relay operates a shunt exists around the right winding of relay 343 extending from the junction between its windings, over its inner left back contact, conductor 345, the left contact of cam 239, the

lower right contact of cam 229, the back contact of the No. 5 counting relay to ground on conductor 221. As soon as the No. 5 counting relay operates this shunt is opened and relay 342 operates.

When the No. 4 counting relay operates the energizing circuit of relay 331 is opened and that relay releases. When therefore sequence switch 200 advances out of position 13 into position 14, register relays 334, 337, 340 and 343 of the stations register remain operated. These relays then lock as soon as sequence switch 200 reaches position 13½ from battery on conductor 401, over both windings of each of these relays, the inner right front contact of each relay, conductor 346, to ground on conductor 213, over the lower left contact of cam 235. Upon leaving position 13½ the locking circuits of all operated counting relays are opened at the lower left contact of cam 222 and these relays deenergize.

When sequence switch 200 reaches position 14 a circuit is established for relay 240 extending from battery, through the winding of relay 240 to ground over the left contact of cam 241. The previously traced circuit for relay 208 is opened at the upper left contact of cam 209 and relay 208 releases as soon as sequence switch 200 leaves position 13. The previously traced circuit between the sender 103 and the call indicator is now established but battery is now connected through the winding of relay 210 and the right contact of relay 240 to conductor 125 rather than over the left contact of relay 208 to conductor 124, and ground is connected from conductor 213, over the lower right contact of cam 211 and the left contact of relay 240 to conductor 124 rather than over the right contact of relay 208 to conductor 125. This reversal of the connection of battery and ground to the pulsing circuit now operates in the well-known manner to advance the sender 103 into the talking selection position whereupon the district selector circuit is prepared for talking and the sender 103 becomes dismissed. The talking circuit at the district selector 104 is now established from the tip brush over the upper contact of cam 112, upper right winding of the repeating coil, the winding of polarized relay 127, the lower right winding of the repeating coil, lower contact of cam 111 to the ring brush of the district selector.

At the call indicator, relay 210 energizes over the pulsing circuit in turn operating relay 212 which locks as before over its inner left front contact and the upper contact of cam 211 and also over its outer left front contact and the front contact of relay 210. Relay 212 upon operating closes at its right front contact a circuit extending over the lower left contact of cam 206 for advancing sequence switch 200 into position 15. As soon as the sender 103 has become advanced and the pulsing circuit is open thereat, relay

210 deenergizes in turn releasing relay 212 which, upon deenergizing, closes a circuit from ground at its right back contact, over the lower left contact of cam 206 for advancing sequence switch 200 into position 18.

At the time sequence switch 200 reached position 7½ a circuit was established for relay 242, over the lower right contact of cam 235 in parallel with the locking circuit of the register relay 424. A circuit is thereupon effective for lighting the No. 3 thousands lamp 429 extending from ground at the contact of relay 242, conductor 243, the right back contact of register relay 410, the outer right front contact of register relay 400, the outer left front contact of relay 405, the No. 3 thousands lamp 429, the next to innermost back contact of relay 430 to battery on conductor 401. A circuit is also established from ground at the outer right front contact of register relay 424, through the No. 9 hundreds lamp 445, the outer right back contact of relay 431 to battery on conductor 401. When sequence switch 200 arrived in position 9½ a circuit was established for relay 244, over the upper left contact of cam 222 in parallel with the locking circuit of register relay 312. A circuit is thereupon effective for lighting the No. 8 tens lamp 347 which may be traced from ground at the contact of relay 244, conductor 245, the outer right back contact of register relay 300, the outer left front contact of relay 312, outer left back contact of relay 309 to battery, through the lamp 347. As soon as sequence switch 200 arrives in position 16 a circuit is established for relay 246 extending from ground through the winding of that relay to battery over the upper right contact of cam 209. With relay 246 operated circuits are established for lighting the No. 3 units lamp 348 and the J stations lamp 349. The circuit of lamp 348 may be traced from ground at the outer contact of relay 246, conductor 247, the outer right front contact of register relay 315, the outer right front contact of relay 318, the outer right front contact of relay 321, the outer right front contact of relay 324, the outer right back contact of relay 327 to battery, through lamp 348. The circuit of lamp 349 may be traced from ground at the inner contact of relay 246, over conductor 248, the outer right back contact of register relay 331, the outer left front contact of relay 343, the outer left front contact of relay 340, the outer left front contact of relay 337, the outer left front contact of relay 334 to battery through lamp 349. Lamps 445, 429, 347, 348 and 349 have now lighted to display the number of the wanted line 3983-J.

At this point it will be advantageous to explain how translation is effected between the register relays of Fig. 4 to light the other thousands and hundreds lamps to display thousands and hundreds digits dialed by a

calling subscriber. In the setting of the register relays 400, 405, and 410 in accordance with the thousands digit registered by the calling subscriber in the sender 103, five registration combinations may be effected by these register relays as follows: For digits 0 and 1 relay 400 is energized alone, for digits 2 and 3 relays 400 and 405 are both energized, for digits 4 and 5 relay 405 is energized alone, for digits 6 and 7 no relays are operated, and for digits 8 and 9 relay 410 is operated alone. The thousands lamps are arranged in pairs, the No. 0 and No. 1 lamps, the No. 2 and No. 3 lamps, etc. being paired, and conductors being extended from the junction between the lamps of each pair to contacts of the register relays in such a manner that each of the registration conditions above enumerated is effective to extend an operating circuit to either one of a particular pair of lamps.

Register relays 411 and 415 are operated in accordance with the thousands digit dialed and also in accordance with the hundreds digit dialed. For example, if the thousands digit is even and the hundreds digit is less than 5, register relay 411 only will be operated. If the thousands digit is even and the hundreds digit is greater than 4, register relays 411 and 415 will both be operated. If the thousands digit is odd and the hundreds digit is less than 5, only register relay 415 will be operated and if the thousands digit is odd and the hundreds digit is greater than 4, both relays 411 and 415 will be unoperated. By an inspection of Fig. 4 of the drawings it will be noted that whenever a registration condition is set up on relays 411 and 415, denoting an even thousands digit, relay 430 operates but that this relay does not operate if the thousands digit is odd. Also if the registration condition indicates that the hundreds digit is less than 5, relay 431 operates but that this latter relay does not operate if the hundreds digit is greater than 4. Thus when the thousands digit is even and relay 430 is operated the even numbered lamp of a pair selected by the register relays 400, 405 and 410 is selected over a front contact of relay 430 and when the thousands digit is odd and relay 430 is not operated the odd numbered lamp of a pair is selected over a back contact of relay 430.

In the setting of the register relays of the group 418, 421 and 424 in accordance with the hundreds digit registered in the sender 103, five registration combinations may be effected. For digits 0 and 5 relay 418 only is operated. For digits 1 and 6 relays 418 and 421 are operated together, for digits 2 and 7 only relay 421 is operated, and for digits 4 and 9 relay 424 only is operated. The hundreds lamps are arranged in pairs, the No. 0 and No. 5 lamps, the No. 1 and No. 6 lamps, etc., being paired and conductors being extended from the junction between the lamps

of each pair to contacts of the register relays in such a manner that each of the registration conditions, just enumerated, is effective to extend an operating circuit to either one of a particular pair of lamps. As previously stated relay 431 always operates when the hundreds digit is less than 5, and it therefore follows that when relay 431 operates the lamp of a pair selected by the register relays 418, 421 and 424, which bears a number less than 5, is selected over the front contact of relay 431, and that with relay 431 unoperated the lamp of the pair selected by relays 418, 421 and 424, which bears a number greater than 4, is selected.

Resuming the description of the operation of the circuits for the assumed call to the wanted line 150, when sequence switch 200 reached position 16 following the completion of the registration, a circuit was established for relay 204, from battery, through the winding of that relay, the back contact of relay 205, to ground at the right contact of cam 241. Relay 204 becomes energized and opens the circuit of relay 110 which in turn deenergizes and disconnects the incoming conductors of trunk 106 from conductors 124 and 125 and extends such incoming conductors, through the windings of relay 108. If at this time the talking circuit has been completed at the district selector 104 then relay 108 energizes in series with the polarized relay 127, but relay 127 does not energize. Relay 108 upon energizing now closes a holding circuit for relay 114 and shunts down relay 121.

The operator at the manual office, noting the display of the wanted line number, plugs into the jack of the wanted line completing a circuit from ground on the sleeve of jack 128, over the sleeve of plug 107, through the winding of relay 120, outer right back contact of relay 121, the outer right front contact of relay 114, the back contact of relay 129, the back contact of relay 130, to battery through the winding of relay 131. Relays 120 and 131 energize in this circuit. Relay 120 at its intermediate lower back contact opens the circuit of relay 115 which deenergizes and in turn opens the interrupting circuit of lamp 116. At its lowermost back contact relay 120 opens the circuit of relays 118 and 201. Relay 201 deenergizes removing ground from conductor 213 thereby releasing all operated register relays of the call indicator and extinguishing the lamps lighted thereby. At its left back contact relay 201 closes a circuit extending from ground thereat, over the upper right contact of cam 206 to battery, through the winding of sequence switch 200 for advancing such sequence switch into normal position. Operated control relays of the call indicator are thereupon released and the call indicator is restored for use on another call.

With relays 120 and 131 energized a circuit is completed for the application of signaling current to signal the called subscriber. This circuit may be traced from the ringing source 132, through the winding of relay 129, the lower front contact of relay 121, rings of plug 107 and jack 128, through the substation call bell 133, returning over the tips of jack 128 and plug 107, the upper front contact of relay 120, the upper front contact of relay 131 to ground. As soon as the called subscriber responds relay 129 operates, removing at its back contact the shunt around the winding of relay 130, which thereupon becomes energized. Relay 130 now closes a circuit from battery, through its right front contact, through its winding, thence through the winding of relay 120 to ground on the sleeve of jack 128 as previously traced, thus shunting relay 131 which thereupon deenergizes disconnecting ground and the ringing current source from the tip and ring of plug 107, and connecting the right windings of repeating coil 135 to the plug. Supervisory relay 134 now energizes over the called line and closes a circuit for reversing relay 109, extending from battery, through the winding of such relay, the front contact of relay 134, to ground at the left front contact of relay 130. Relay 109 upon energizing reverses the direction of current flowing over the connection extending back to the district trunk 102 for supervisory or call charging purposes. The subscribers are now connected into a talking connection, the calling subscriber receiving talking battery from the left windings of the repeating coil in the district trunk and the called subscriber receiving talking current through the right winding of repeating coil 135.

Upon the termination of the conversation the subscribers restore their receivers to the switchhooks, the restoration of the calling subscriber's receiver restoring the selectors in the originating office in the well known manner, and the restoration of the called subscriber's receiver restoring relays 134 and 109. Following the release of the office selector 105 the circuit of relay 108 is opened, which in turn releases relay 114. The release of relay 114 now opens the shunt around the disconnect lamp 136 which now lights in series with relay 120. The operator, noting the illumination of lamp 136, withdraws plug 107 from jack 128 whereupon the remaining operated relays of the incoming trunk 106 release.

What is claimed is:

1. In a telephone exchange system, a sending device having registers associated therewith for registering the designation of a wanted line, mechanism for displaying the number of a wanted line, means for controlling said mechanism comprising a plurality of registers, and means for transferring said

designation from the registers of said sending device to the registers of said controlling means by means of impulses revertively transmitted from said controlling means to said sending device.

2. In a telephone exchange system, a sending device having registers associated therewith for registering the designation of a wanted line, lamps for displaying the number of a wanted line, means for controlling said lamps comprising a plurality of registers, and means for transferring said designation from the registers of said sending device to the registers of said controlling means by means of impulses revertively transmitted from said controlling means to said sending means.

3. In a telephone exchange system, a sending device having registers associated therewith for registering the designation of a wanted line, lamps for displaying the number of a wanted line, means for controlling said lamps comprising a plurality of registers and means for transferring said designation from the registers of said sending device to the registers of said controlling means comprising means for revertively transmitting trains of impulses to said sending device from said controlling means, means for counting the impulses in each train so transmitted, and means for operating the registers of said controlling means in accordance with the operation of said counting means.

4. In a multi-office telephone exchange system, calling and called lines, an operator's position, a trunk line, means including said trunk line for extending a calling line to said position, means for automatically indicating the number of a called line at said position, means for revertively sending trains of impulses over the trunk line, and means responsive to said impulses to control said indicating means.

5. In a telephone system, a sending device having registers associated therewith for registering the designation of a wanted line, a call indicator comprising a bank of lamps for displaying each digit of the wanted line number, a greater number of registers than there are banks of lamps, and translating means for selectively lighting lamps of said banks under the control of said latter registers, and means for transferring said designation from the registers of said sending device to the registers of said call indicator by means of impulses revertively transmitted from said call indicator to said sending device.

6. In a telephone system, a sending device having registers associated therewith for registering the designation of a wanted line, there being a register for registering each digit of a designation, a call indicator comprising a bank of lamps for displaying each digit of a wanted line number, a greater number of registers than there are banks of lamps

and translating means for selectively lighting lamps of said banks under the control of said latter registers, and means for transferring said designation from the registers of said sending device to the registers of said call indicator comprising means for revertively transmitting a number of trains of impulses to said sending device from said call indicator equal to the number of registers in said call indicator and greater than the number of registers in said sending device.

7. In a telephone system, a sending device having registers associated therewith for registering the digits of a wanted line designation, there being a register for registering each digit, a call indicator comprising a bank of lamps for displaying each digit of a wanted line number, a greater number of registers than there are digits to be registered, and translating means for lighting certain of said banks of lamps under the joint control of a plurality of said latter registers, and means for transferring said designation from the registers of said sending device to the registers of said call indicator comprising means for revertively transmitting a number of trains of impulses to said sending device from said call indicator.

In witness whereof, I hereunto subscribe my name, this 25th day of June, 1928.

EDGAR H. CLARK.