Aug. 6, 1929. L. L. RUGGLES 1,723,209

AUTOMATIC TELEPHONE SYSTEM

Original Filed June 6, 1925 6 Sheets-Sheet 1

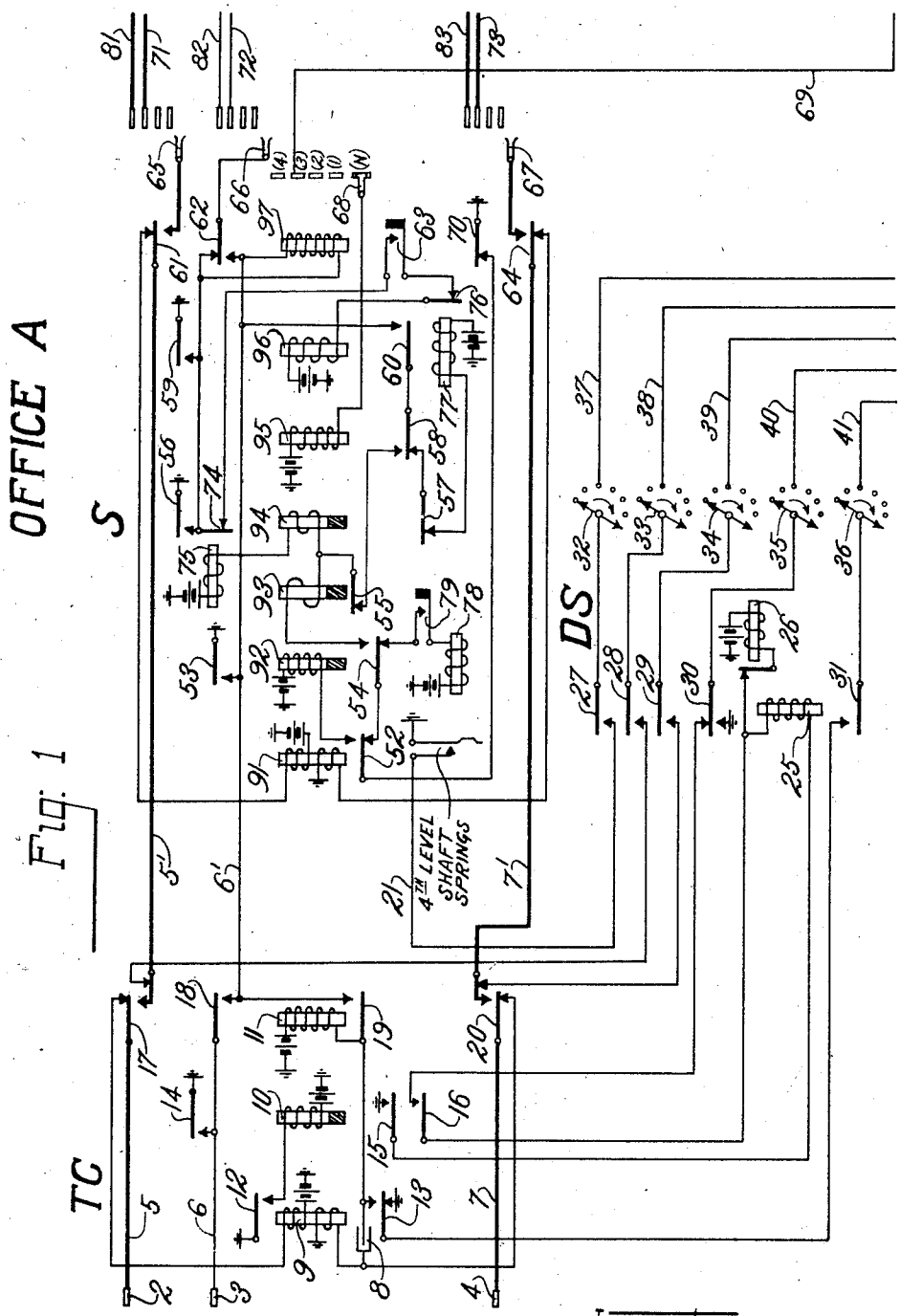

Fig. 1

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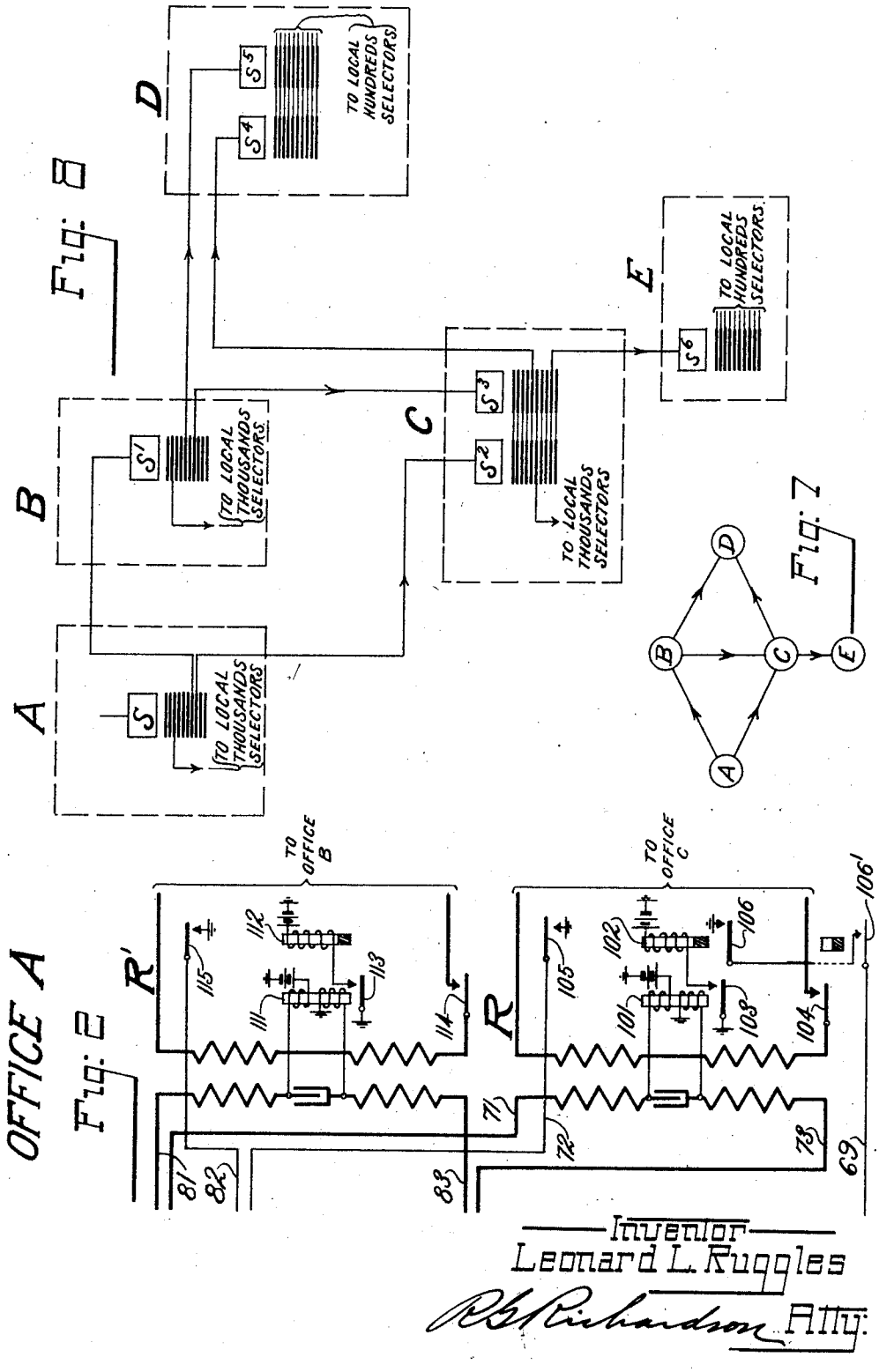
Original Filed June 6, 1925 6 Sheets-Sheet 2



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AUTOMATIC TELEPHONE SYSTEM

Original Filed June 6, 1925 6 Sheets-Sheet 3

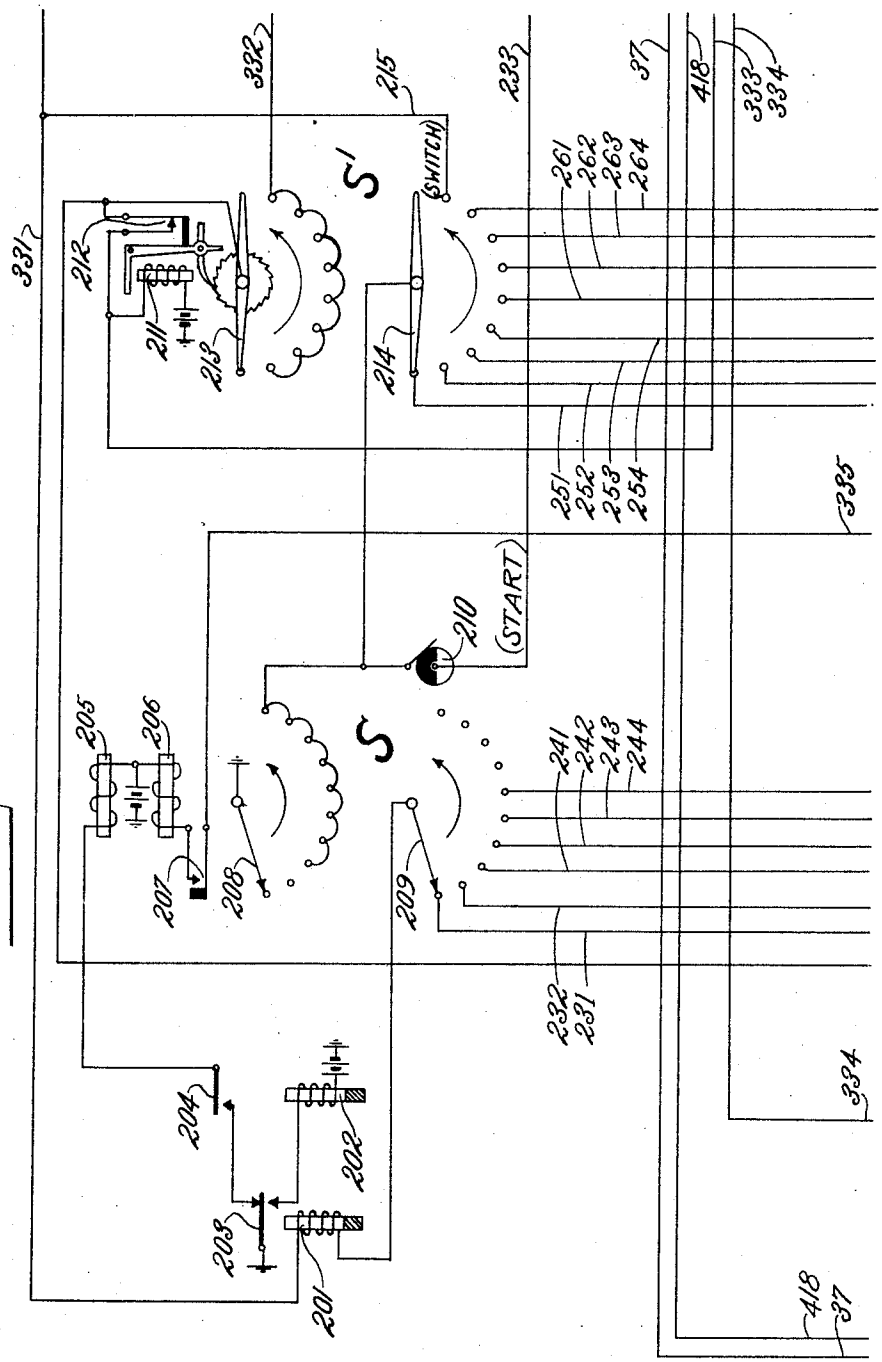

FIG. 3

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AUTOMATIC TELEPHONE SYSTEM

Original Filed June 6, 1925 6 Sheets-Sheet 4

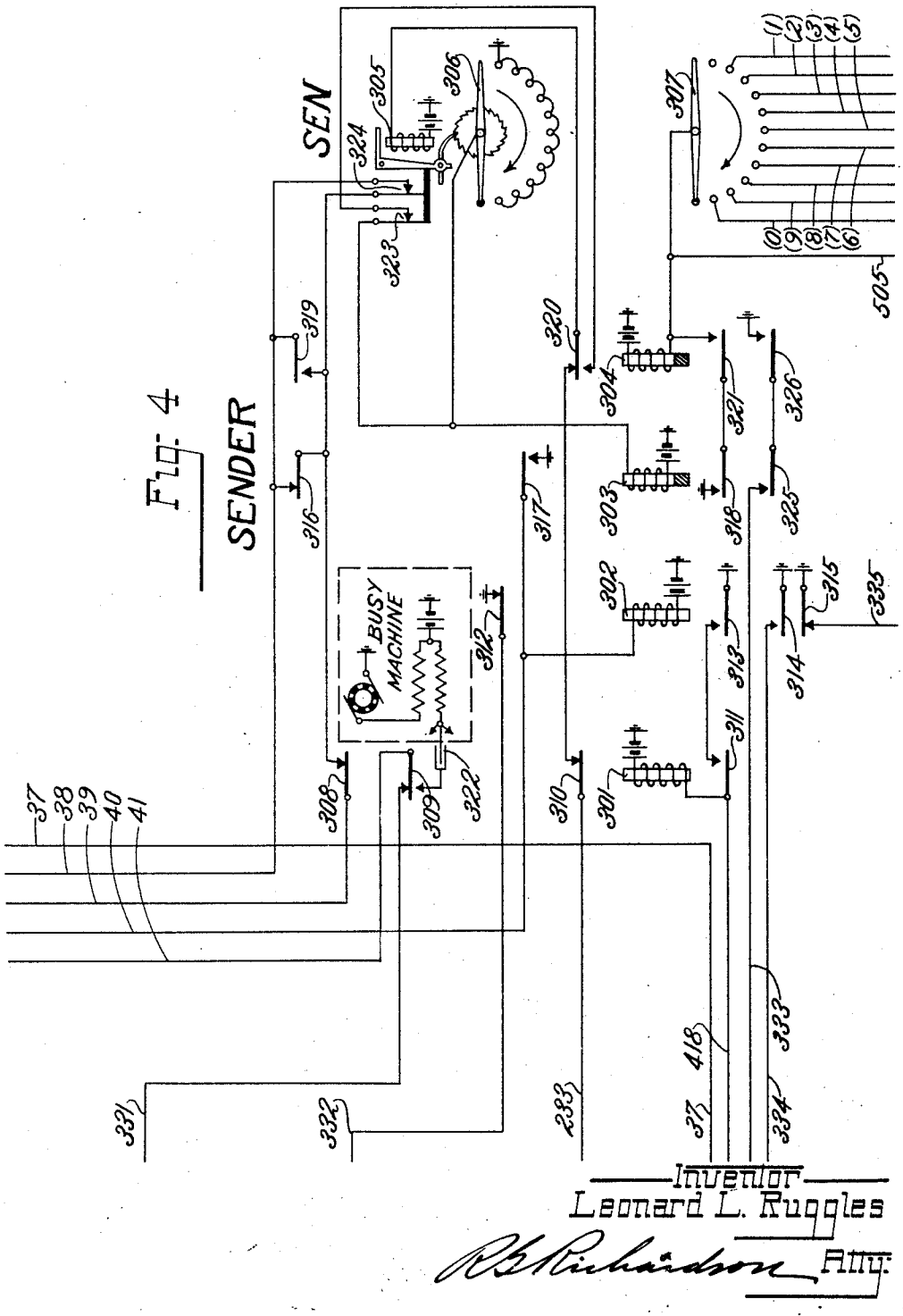

Fig. 4

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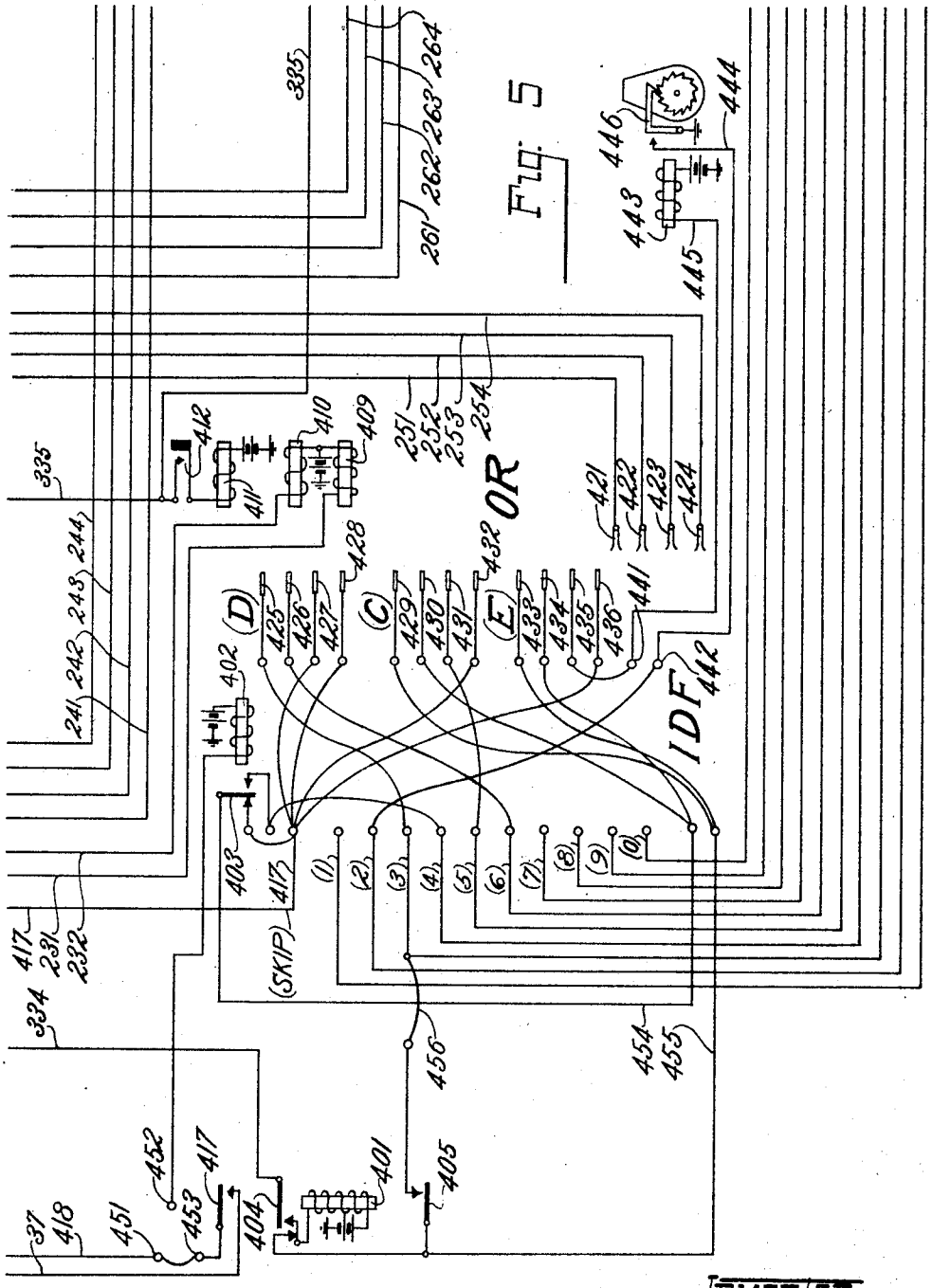
AUTOMATIC TELEPHONE SYSTEM

Original Filed June 6, 1925 6 Sheets-Sheet 5



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AUTOMATIC TELEPHONE SYSTEM

Original Filed June 6, 1925 6 Sheets-Sheet 6

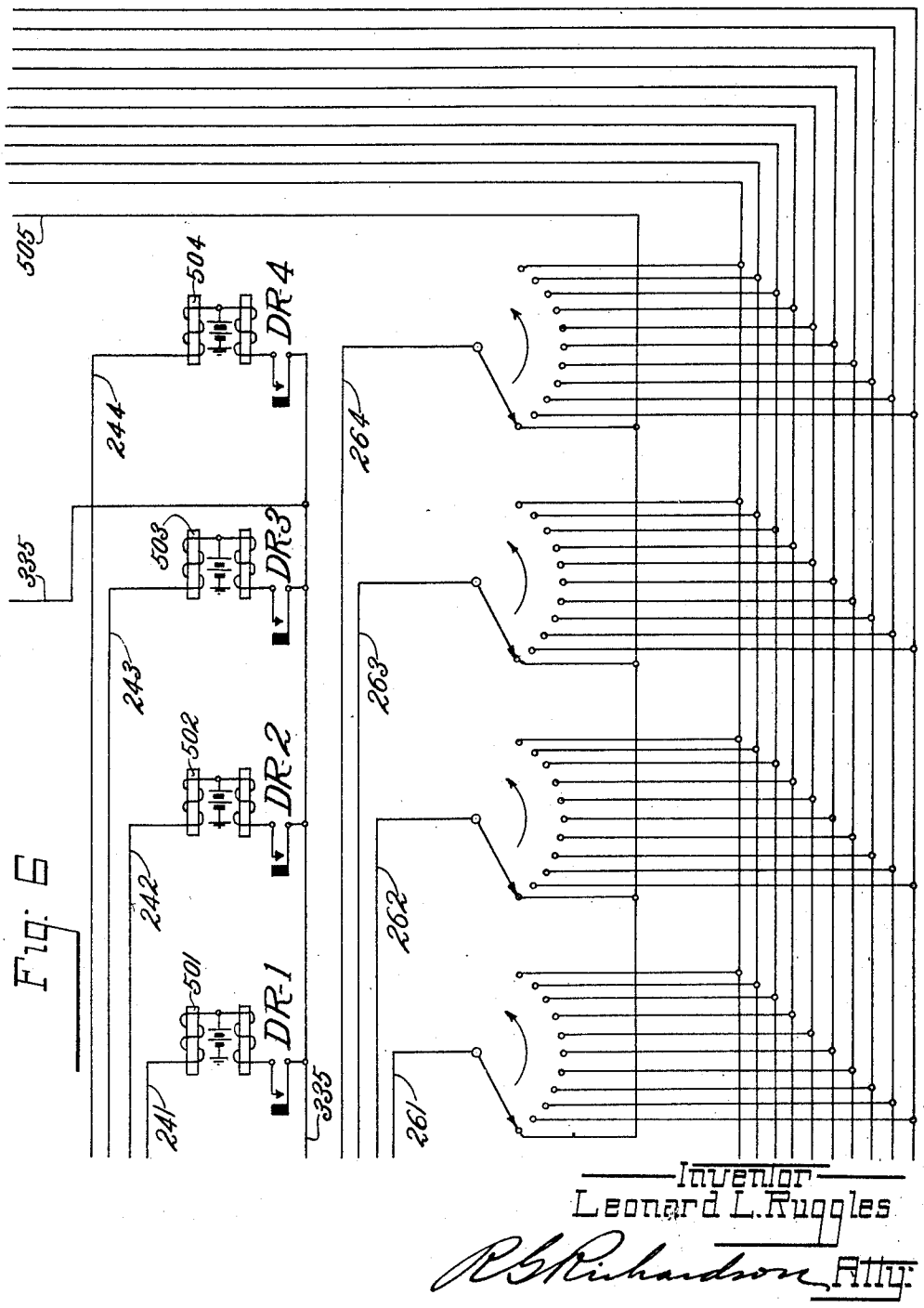

FIG. 6

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UNITED STATES PATENT OFFICE.

LEONARD L. RUGGLES, OF WHEATON, ILLINOIS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO AUTOMATIC ELECTRIC INC., OF CHICAGO, ILLINOIS, A CORPORATION OF DELAWARE.

AUTOMATIC TELEPHONE SYSTEM.

Application filed June 6, 1925, Serial No. 35,280. Renewed November 30, 1928.

The present invention relates to automatic telephone systems in general, but is concerned more particularly with automatic telephone systems in which directors are employed to translate the office digits of the telephone numbers into the codes necessary to effect the trunking of the various calls to the desired offices by way of the most suitable paths; and the principal object is the provision of novel circuit arrangements whereby, in case the group of trunk lines ordinarily used is found to be busy, the calls directed to a certain office may be re-routed and sent to the desired office over a trunk line path not ordinarily used for trunking such calls.

The above statement of the main object of the invention, of course, sets that object forth only broadly, and for a clearer understanding of the scope of the invention reference may be had to the outline of the system hereinafter given.

Referring now to the accompanying drawings, comprising Figs. 1–8, Figs. 1–6 show by means of the usual circuit diagrams a certain amount of apparatus employed in a telephone system embodying the principles of the invention; Fig. 7 shows five 10,000 line (ultimate capacity) offices interconnected by trunk lines, and it purports to show the relative geographical positions of the offices shown; and Fig. 8 is a trunking diagram showing how calls originated in office A are completed in the other offices shown in Fig. 7. It will be understood that the offices shown in Fig. 7 may represent only a small part of a large multi-office network.

It will be noted that there are two ways to trunk calls to the office D from the office A, that is, calls may go from A to C and from C to D, or from A to B and from B to D. Calls from A to E go by way of C as may be seen.

The outgoing trunk lines from A to C and from A to B are taken from the first selector bank as may be seen from Figs. 1 and 2. The first selectors of which the selector S, Fig. 1, is typical are of the automatic vertical type, that is, two levels can be combined in such a way that, when the lower level is busy the wipers are automatically raised to the upper level and are then rotated to find an idle trunk in that level. The calls from A to D are normally trunked by way of C, but when the trunks to C become busy the calls are automatically sent to B and then when the next digit is transmitted the seized selector in B extends the call over to D just as though a selector in C had been seized, the trunks to C coming from the same selector level in both offices. On calls from A to C and from A to E, however, the situation is not the same because the call is not automatically trunked to the destination by merely permitting the selector S, Fig. 1, to raise its wipers to the next higher level. Two methods of handling the calls destined for C and E from A, when the trunks from A to C are busy, are available.

In case the trunk group from B to C is a small group intended merely to handle calls from B to C this group will probably not handle the extra amount of traffic that would be imposed by arranging the director to reroute the traffic from A to C so that it goes from A through B and then to C over the B-to-C trunks. When this is the case, arrangements are provided so that not attempt is made to use the trunks from B to C to handle calls originating at A. Instead, the connection is denied at the director in these cases and the busy tone is given to the calling subscriber. However, the arrangement of the directors is such that, in case the trunk group from B to C is large enough to handle extra traffic the calls may be rerouted to C through B when the trunks from A to C are all busy.

In order for the drawings to be understood best, Figs. 1 and 2 should be placed together with Fig. 2 at the right of Fig. 1, and with the interconnecting lines in alignment, Figs. 3 and 4 should be placed with Fig. 4 to the right of Fig. 3 and with Fig. 4 under Fig. 1. Figs. 5 and 6 should be placed under Figs. 3 and 4, respectively.

Fig. 1 shows the trunk circuit TC interposed in the trunk line extending from the line switch bank contacts 2—4 to the selector S, together with the director selector DS associated with the trunk circuit TC.

Fig. 2 shows the repeaters R and R′ accessible from the third and fourth levels, respectively, of the selector S, Fig. 1. The outgoing trunk associated with the repeater R extends to office C, while the outgoing trunk associated with the repeater R′ extends to office B.

Regarding the director shown in Figs. 3–6, inclusive, the portion of the director shown in Fig. 3 comprises the sequence switches S

and S′, together with the relays 201 and 202. The function of the sequence switch S is to distribute the various series of impulses incoming from the trunk circuit TC to the various operating magnets of the director. The function of the sequence switch S′ is to ground the various register wipers, one after the other, as the digits are transmitted, and to effect the switch-through operation after the last digit is transmitted.

The portion of the director shown in Fig. 4 comprises the sender, made up of the sending switch SEN and relays 303 and 304; together with the special relay 301 and the release relay 302.

The portion of the director shown in Fig. 5 comprises the office register OR, the intermediate distributing frame IDF at which the control of the code digits is effected and the special relays 402 and 401.

The portion of the director shown in Fig. 6 comprises the digit registers DR—1—DR—4, which are the registers that record the subscriber digits.

Call from office A to office D.

The layout having been thus described generally, the detailed description of the operation will now be given. For this purpose it will be assumed that a subscriber in office A desires to converse with a subscriber in office D. That being the case, the aforesaid subscriber in office A removes his receiver and dials the number of the subscriber in office D.

It will be assumed that, when the subscriber removes his receiver, his line switch selects the trunk line extending through the trunk circuit TC to the selector S at the terminals 2, 3, and 4. Accordingly, line relay 9 pulls up over conductors 5 and 7 and over the calling line and closes at armature 12 a circuit for release relay 10. Release relay 10 energizes and places ground upon release trunk conductor 6 at armature 14. At armature 16 relay 10 connects test wiper 35 of the director selector DS through armature 30 and its resting contact, to the stepping magnet 26 of the director selector DS through the local interrupter contacts of the said stepping magnet. At armature 15 relay 10 places ground on the lower terminal of switching relay 25 of the director selector DS, thereby closing a circuit through switching relay 25 and stepping magnet 26 in series.

The further operation depends upon whether or not the director upon which the wipers of the director selector DS are standing is idle. If this director is idle, the test contact on which the test wiper 35 is standing is ungrounded and the stepping magnet 26 is not operated. That being the case, the circuit through relay 25 is effective, and switching relay 25 energizes, seizing the director.

Assuming, on the other hand, that the director upon which the wipers of the switch DS are standing is busy, wiper 35 encounters a ground potential on the busy test contact, thereby closing a circuit for stepping magnet 26. This ground potential, accordingly, short circuits relay 25 and prevents it from energizing at this time. Stepping magnet 26 is energized and, being self-interrupting, advances the wipers 32—36 step by step in search of an idle director.

When an idle director is reached, for example, the one shown in Figs. 3–6, test wiper 35 encounters an ungrounded test contact whereupon the operation of said magnet 26 ceases. Accordingly, relay 25, being no longer short circuited, energizes in series with stepping magnet 26. Stepping magnet 26 does not energize at this time on account of the relatively high resistance of relay 25. Upon energizing, relay 25 opens a point in the test circuit and places ground on test wiper 35, thereby making the seized director busy; at armature 27 relay 25 closes through the special control lead 21; it prepares the impulse circuit at armature 31; and at armatures 28 and 29 it connects the conductors 5′ and 7′ of the selector S to a closed loop in the director over wipers 33 and 34. This closed loop includes conductors 38 and 39, and the resting contact and armature 316 of relay 303, in multiple with contacts 324 of magnet 305. Accordingly line relay 91 of the selector S pulls up over this closed loop and closes at armature 52 a circuit for release relay 92. Release relay 92 thereupon energizes and at armatures 53 and 54 prepares the switch for operation in the usual manner.

In the seized director, release relay 302 pulls up over release trunk conductor 40 responsive to the grounding of test wiper 35 of the director selector DS as above pointed out. At armature 315 release relay 302 removes ground from release conductor 335 so as to prevent the premature operation of the various release magnets of the director; at armature 312 relay 302 removes ground from the restoring conductor 332 of the sequence switch S′; at armature 314 relay 302 grounds the locking conductor 334; and at armature 313 it prepares a circuit for locking up relay 301.

The seizure of the director is now complete and, as the impulse circuit is closed through from the trunk circuit TC to the director, the calling subscriber may now dial the various digits in the desired number.

When the calling subscriber manipulates his calling device in accordance with the first office digit, line relay 9 of the trunk circuit TC falls back a corresponding number of times and, each time it falls back it grounds the impulse circuit at armature 13, thereby closing a circuit through the working contact and armature 31, wiper 36, impulse conductor 41, armature 309 of relay 301 and its resting

contact conductor 331, series relay 201, sequence switch wiper 209 in its first position, conductor 231, and vertical magnet 409 of the office register OR to battery. Vertical magnet 409 operates over the above circuit to raise the wipers of the office register OR step by step until they come to rest opposite the desired level of bank contacts.

Relay 201, Fig. 3, is energized in series with the vertical magnet of the office register and, being slow acting, maintains its armature 203 attracted throughout the series of impulses. Upon operating, relay 201 closes a circuit for relay 202, whereupon relay 202 pulls up and prepares a circuit for magnet 205 at armature 204.

At the end of the series of impulses, relay 201 falls back and closes a circuit for magnet 205, also opening the circuit of relay 202. A moment later relay 202 falls back and opens the circuit of magnet 205. By the operation of magnet 205 the wipers 208 and 209 are advanced one step. Wiper 209 shifts the impulsing circuit from the vertical magnet conductor 231 to the rotary magnet conductor 232.

When the calling subscriber dials the second office digit, the resulting series of impulses is transmitted by the line relay of the trunk circuit TC, Fig. 1, to the director over the above traced path as far as wiper 209 of the sequence switch S, Fig. 3, and thence over conductor 232 to rotary magnet 410 of the office register OR, Fig. 5. By the operation of rotary magnet 410 the wipers of the office register are rotated step by step and come to rest in engagement with the set of bank contacts individual to the office D. These contacts are indicated on the drawings as (D).

Responsive to the above digit, relays 201 and 202 operate as above described to control magnet 205 to advance the wipers of the sequence switch S another step. Wiper 209 shifts the operating circuit from the rotary magnet conductor 232 of the office register OR to conductor 241 extending to stepping magnet 501 of the digit register DR—1, Fig. 6. Wiper 208 of the sequence switch S grounds wiper 214 of the sequence switch S′ and also grounds the conductor 233 through the interrupter 210, thereby starting the sending operation in a manner to be pointed out later.

Responsive to the dialling of the first subscriber digit in the number, a corresponding number of impulses is transmitted over the impulse circuit as above traced to wiper 209 of the sequence switch S and thence by way of conductor 241, to magnet 501 of the digit register DR—1. Accordingly the wiper of this digit register is advanced a number of steps corresponding to the digit dialled, thereby registering the digit.

Similarly the digit register DR—2′ is operated by means of stepping magnet 502, receiving current over conductor 242 when the second subscriber digit is dialled.

Accordingly, responsive to the third and fourth subscriber digits, the digit registers DR—3 and DR—4 are operated by current transmitted over conductors 243 and 244, respectively, and register the said third and fourth subscriber digits.

It is understood, of course, that the sequence switch S moved one contact after each of the above series of impulses so as to distribute the impulses to the various magnets concerned, and that the wipers 208 and 209 advance one more step at the termination of the fourth and last subscriber digit, and wiper 209 encounters a dead contact. Accordingly, the wipers of the sequence switch S remain in this position until the director is subsequently freed, at which time the component switches thereof are released. Returning now to the operation of the sender, which is started upon the connection of ground through the interrupter 210 to the start conductor 233 at the end of the second office digit, an impulse of current is transmitted over conductor 233 upon the first subsequent closure of the interrupter 210. This impulse of current is transmitted through armature 310 and its resting contact, and resting contact and armature 320, to the stepping magnet 305 of the sending switch SEN. When this occurs, magnet 305 pulls up and moves the associated pawl into engagement with the next notch in the wiper driving ratchet wheel, but does not move the wipers 306 and 307.

Upon the following opening of the interrupter 210, magnet 305 falls back and advances the wipers 306 and 307 one step. Pick-up wiper 306 encounters a grounded contact with the result that pick-up relay 303 pulls up. At armature 316, relay 303 removes the shunt from around the sending contacts 324 of the magnet 305; it grounds the release trunk conductor 40 at armature 317 so as to prevent the premature release of the director in case the calling subscriber should hang up while a digit is being transmitted; and at armature 318 it prepares a locking circuit for stop relay 304.

The shunt has now been removed from around the sending contacts 324 at armature 316 as above pointed out. Consequently, upon each of the following energizations of magnet 305, the outgoing control circuit is opened at armature 324, the wipers 306 and 307 being advanced as above pointed out upon each deenergization of magnet 305.

The advance of the wipers 306 and 307, and the sending of impulses, continues until three interruptions have been produced in the outgoing control circuit. When magnet 305 falls back at the end of the third interruption and closes the outgoing control circuit at the same time advancing the wipers 306 and 307 one

step, wiper 307 comes into engagement with the bank contact in which the third impulse stop conductor terminates, thereby closing a circuit for stop relay 304 as follows: From the ground by way of the grounded stop-conductor-control wiper 214 of the sequence switch S′, the first code-digit stop conductor 251, first wiper 421 of the office register OR, bank contact 425; the associated jumper on the intermediate distributing frame IDF, the sixth impulse conductor, stop wiper 307 of the sending switch SEN, and stop relay 304 to battery. Stop relay 304 energizes over this circuit and at armature 321 closes a locking circuit for itself; places a shunt around the sending contacts 324 at armature 319 and at armature 326 completes the circuit of stepping magnet 211 of the sequence switch S′. Stepping magnet 211 pulls up and moves the associated pawl into engagement with the next notch in the wiper driving ratchet wheel preparatory to advancing the wipers 213 and 214. At armature 320 relay 304 disconnects magnet 305 from the start wire and connects it through the interrupter contacts 323 to the combined pick-up and restoring wiper 306. Accordingly, magnet 305 is now operated under the control of wiper 306 and its self-interrupting contacts 323 to bring the wipers 306 and 307 around to their normal position. When the normal position is reached the operation of magnet 305 ceases and the circuit of the slow acting pick-up relay 303 is opened. This relay, however, does not fall back now on account of the fact that it is slow acting.

In the selector S, Fig. 1 line relay 91 falls back responsive to each of the three above mentioned interruptions produced in its circuit by the sending apparatus of the director. Upon each deenergization, line relay 91 completes at armature 52 a circuit through armature 54 and its working contact, series relay 93, series relay 94, and vertical magnet 75 to battery. By the operation of vertical magnet 75 the wipers 65—67 are raised step by step until they come to rest opposite the third level of bank contacts, and the vertical test wiper 68 is raised and brought into engagement with the third level test contact (3). Relays 93 and 94 are energized in series with each other and in series with the vertical magnet 75, and, being slow acting, they maintain their respective armatures attracted throughout the vertical operation. At armature 55 relay 93 opens a point in the automatic stepping circuit of vertical magnet 75. Relay 94, upon operating prepares a circuit for stepping relay 96 at armature 56, and at armature 57 opens a point in the circuit of rotary magnet 77.

Just before the vertical step of the switch shaft is completed, the off normal contacts 79 and 63 close, and contact 63 completes a circuit of the stepping relay 96 which includes armature 56 and its working contact, vertical interrupter contacts 74, off normal contacts 63; and the rotary interrupter contacts 76. Relay 96 energizes and locks itself at armature 59, and at armature 60 prepares the automatic stepping circuit.

At the end of the vertical movement, relays 93 and 94 fall back. Relay 94 closes at armature 57 a point in the circuit of rotary magnet 77, and at armature 56 opens the initial circuit of stepping relay 96, leaving this relay energized through its locking circuit which includes armature 59 and its working contact. Relay 93, upon falling back, closes at armature 55 a point in the automatic vertical stepping circuit.

From this point the operation depends upon whether the trunk line group terminating in the third level of bank contacts of the selector S is busy or idle. If the entire group of trunk lines is busy, there is a ground potential on the chain conductor 69 through contacts such as 106 and 106′, Fig. 2, and this ground potential is extended through the vertical test wiper 68 to relay 95. Relay 95 is, accordingly, energized and the stepping circuit is shifted from the rotary magnet 77 to the vertical magnet 75 through the series relay 94. That being the case, vertical magnet 75 energizes from ground on the grounded release trunk conductor 6′, through the working contact and armature 60, armature 58 and its working contact, and series relay 94. The slow acting series relay 94 energizes again in series with vertical magnet 75 and closes at armature 56 a shunt around the locking armature 59 and its working contact of the stepping relay 96, and at armature 57 opens a point in the circuit of rotary magnet 77 so as to prevent the premature operation of rotary magnet 77 at the end of the vertical stepping movement. By the operation of vertical magnet 75, the wipers 65—67 are raised from their position opposite the third level bank contacts to a position opposite the fourth level bank contacts. Near the end of its stroke vertical magnet 75 opens the circuit of stepping relay 96 at the interrupter contacts 74, whereupon stepping relay 96 falls back and opens the circuit of vertical magnet 75 and the slow acting relay 94 at armature 60. When this occurs, vertical magnet 75 falls back and at contacts 74 again completes the circuit of relay 96 from ground through armature 56 and its working contact. Relay 96, accordingly, energizes again but it does not close the vertical magnet circuit again at this time on account of the fact that the vertical test wiper 68 is now in engagement with an ungrounded test contact, namely the test contact associated with the fourth level, and relay 95 has, therefore, fallen back. Accordingly, the vertical stepping circuit is opened at armature 58 and the rotary stepping circuit is prepared.

After a slight interval the slow acting re-

lay 94 falls back; removes the shunt from around the locking armature 59 and its working contact at armature 56; and at armature 57 completes the circuit of rotary magnet 77. When this occurs rotary magnet 77 pulls up and advances the wipers 65—67 into engagement with the first set of contacts in the fourth level, and, near the end of its stroke, opens the circuit of stepping relay 96 at the interrupter contacts 76. When this occurs, relay 96 falls back and opens a further point in its locking circuit at armature 59, and at armature 60 opens the circuit of rotary magnet 77. Rotary magnet 77 thereupon falls back and closes its interrupter contacts 62 again.

From this point the operation depends upon whether the trunk terminating in the first set of bank contacts in the fourth level is busy or idle. If it is idle, the test contact engaged by test wiper 66 is ungrounded and switching relay 97 energizes, seizing the trunk. Assuming, however, that the first trunk is busy, ground is encountered on the test contact thereof by test wiper 66, short circuiting the switching relay 97 and again energizing stepping relay 96. Relay 96 again completes its locking circuit at armature 59, and at armature 60 again completes the circuit of rotary magnet 77, whereupon the wipers 65—67 are advanced another step. This alternate operation of relay 96 and magnet 77 continues as described until an idle trunk is reached, which trunk, it will be assumed is the one comprising conductors 81—83.

When this idle trunk is reached, switching relay 97 being no longer short circuited pulls up in series with stepping relay 96. Stepping relay 96, however, does not operate at this time on account of the relatively high resistance of switching relay 97. Upon energizing, switching relay 97 removes ground at armature 70 from the line relay armature 52; it opens the test circuit and prepares the holding circuit at armature 62, thereby grounding the test wiper 66 to make the seized trunk busy immediately; and at armatures 61 and 64 it disconnects conductors 5′ and 7′ from line relay 91 and extends them by way of wipers 65 and 67 and conductors 81 and 83 to the line relay 111 of the repeater R′. Relay 111 now energizes over conductors 81 and 83 and closes at armature 113 a circuit for the release relay 112, which thereupon energizes and grounds the release trunk conductor 82 at armature 115. As a further result of its energization, relay 111 closes at armature 114 a bridge across the outgoing trunk conductors, whereupon the distant selector S′ in the office B is prepared for operation in the usual manner.

In the director, the slow acting pick-up relay 303 falls back after a slight interval responsive to the return to its normal position of wiper 306, as above pointed out. At armature 318 relay 303 opens the locking circuit of the slow acting stop relay 304, and at armature 325 it opens the circuit of magnet 211 of the sequence switch S′, whereupon the wipers 213 and 214 are advanced one step.

Stop relay 304 falls back after a slight interval and again connects the stepping magnet 305 of the sending switch SEN to the start wire 233 at armature 320. Accordingly, the second code digit 6 is transmitted in the same manner as the first code digit 3. In this case the transmission of impulses continues until the end of the sixth interruption in the outgoing control circuit at the sending contacts 324 of magnet 305. At this time the wipers 306 and 307 advance another step and wiper 307 encounters a ground potential on the bank contact in which the sixth impulse stop conductor terminates. The circuit for stop relay 304 at this time is as follows: From ground by way of wiper 214 of the sequence switch S′, the second bank contact, the second code digit stop conductor 252, the second wiper 422 of the office register OR, bank contact 426, the associated jumper on the intermediate distributing frame IDF, the sixth impulse stop conductor, stop wiper 307 of the sending switch SEN, and stop relay 304 to battery. Responsive to the energization of stop relay 304 the second code digit 6 is terminated in the same manner as the first code digit 3 and the wipers 213 and 214 of the switch S′ are again advanced one step in the manner heretofore described. Wiper 214 grounds the third code-digit stop conductor 253. In the present case two code digits are enough. Accordingly, the third and fourth bank contacts in the office register OR associated with the office D are not wired to any of the impulse stop conductors but are instead jumpered over to the skip conductor 417. That being the case when the third wiper 423 of the office register OR is grounded over conductor 253, ground potential is transmitted by way of bank contact 427, and the self-interrupting contacts 212 to the stepping magnet 211 of the sequence switch S′. Stepping magnet 211 energizes and, being self interrupting, again falls back, thereby advancing wipers 213 and 214 another step. Wiper 214 grounds the fourth code digit stop conductor 254 with the result that a circuit is closed through the fourth wiper 424 of the office register OR, bank contact 428, the associated IDF jumper, and the skip conductor 417 for stepping magnet 211 again. Accordingly, the wipers 213 and 214 are automatically advanced another step, and wiper 214 shifts the ground potential from the fourth code-digit stop conductor 254 to the first subscriber-digit stop conductor 261.

In the office B, Fig. 8, the selector S′ raises its wipers opposite the sixth level responsive to the transmission of the second code digit 6

by the director, as above pointed out, and selects an idle trunk extending to the office D, for example the trunk extending to the selector S^5.

Returning now to the director, as the first subscriber-digit stop conductor 261, which leads to the wiper of the digit register DR—1, Fig. 6, is now grounded, the next digit to be transmitted is the first subscriber digit. This digit is transmitted in the hereinbefore described manner and is terminated upon the energization of stop relay 304 over the particular impulse stop conductor on which the wiper of the digit register DR—1 is standing. Upon the termination of this digit, wipers 213 and 214 of the sequence switch S′ advance again with the result that ground potential is shifted from the first subscriber digit stop conductor to the second subscriber digit stop conductor 262. Accordingly, the second subscriber digit, which is registered on the digit register DR—2 is transmitted in the usual manner. Similarly, the third and fourth subscriber digits, which are registered on the digit registers DR—3 and DR—4 are transmitted in the hereinbefore described manner.

At the end of the transmission of the fourth subscriber digit, wipers 213 and 214 of the sequence switch S′ are advanced another step with the result that wiper 214 removes ground from the fourth subscriber-digit step conductor 264 and connects it instead to the switching branch 215 of the impulse conductor 331. The impulse conductor 331 is open at this time in the director on account of the fact that the wiper 209 of the sequence switch S is standing on a dead contact. The impulse circuit is connected at its origin, however, to the switching relay 11 of the trunk circuit TC through armature 13 and its working contact of line relay 9. Accordingly, switching relay 11 energizes over the impulse conductor and locks itself to the grounded release trunk conductor 6′ at armature 19; it connects the release trunk conductor 6 with the release trunk conductor 6′ at armature 18; and at armatures 17 and 20 it disconnects conductors 5 and 7 from line relay 9 and connects them to the conductors 5′ and 7′ of the selector S, at the same time disconnecting conductors 5′ and 7′ from the closed loop of the director. The established connection is now held up by the current flow over the calling line through the line relay of the repeater R′, Fig. 2.

Line relay 9 at the trunk circuit TC now falls back and opens the circuit of release relay 10 at armature 12. Accordingly, release relay 10 falls back after an interval and removes ground from release trunk conductor 6 at armature 14, leaving this conductor grounded, however, from the release trunk conductor 6′. At armature 15 relay 10 opens the circuit of switching relay 25 of the director selector DS, whereupon relay 25 falls back, freeing the director.

In the director, release relay 302 falls back responsive to the removal of the ground potential from release trunk conductor 40 when the director is freed. Upon falling back, relay 302 grounds at armature 312 the restoring conductor 332 of the sequence switch S′. When this takes place, a circuit is closed through wiper 213 and the interrupter contacts 212 for stepping magnet 211, with the result that the wipers 213 and 214 are advanced the remaining step to their normal position. At armature 315 relay 302 grounds the release conductor 335, thereby closing parallel circuits through the various off normal contacts of the home position switches of the director. For example, a circuit is closed through off normal contacts 412 for the release magnet 411 of the office register OR, and a circuit is closed through off normal contacts 207 for release magnet 206 of the sequence switch S, similar circuits being closed for the release magnets of the digit registers DR—1—DR—4. The result is that the various release magnets energize, and the respective wipers are restored to their normal positions, the circuits of the release magnets being then opened at the respective off normal contacts.

In the office D, the selector S^5 is operated opposite the desired level in accordance with the transmission of the first subscriber digit which was previously registered on the digit register DR—1, Fig. 6; the hundreds selector seized by the selector S^5 is operated in accordance with the digit registered on the digit register DR—2 and transmitted as hereinbefore pointed out; and the connector switch seized by the hundred selector in use is operated in accordance with the digits registered on and retransmitted from digit registers DR—3 and DR—4 to finally extend the connection to the desired line in the office D.

When the calling subscriber replaces his receiver at the termination of the conversation, the circuit of line relay 111 of the repeater R′ is opened. Line relay 111 falls back and at armature 114 opens the bridge across the outgoing trunk conductors with the result that the connection extending through the office D to the office B is released in the usual manner. At armature 113 relay 111 opens the circuit of the slow acting release relay 112, which deenergizes after an interval and removes ground from the release trunk conductor 82 at armature 115. When this occurs, switching relay 97 of the selector S and switching relay 11 of the trunk circuit TC fall back and the calling line switch is released in the usual manner. Upon the deenergization of relay 97 of the selector S, a circuit is completed at armature 70 through armatures 52 and 54 at the off normal con-

tacts 79 for release magnet 78, whereupon release magnet 78 restores the wipers 65—67 to their normal position in the usual manner. The circuit of release magnet 78 is opened at off normal contacts 79.

The foregoing example serves to illustrate how the calls which are normally trunked from office A to office D by way of the C office are automatically rerouted through the office B by the group hunting selector S′, Fig. 1. It will be understood, of course, that in case the entire group of trunk lines accessible to the third level of the selector S is not busy, then there is no ground potential on the chain conductor 69 with the result that relay 95 is not energized at the end of the vertical movement. Accordingly, no automatic vertical operation takes place, but, instead, the regular rotary magnet circuit is completed right away upon the falling back of relays 93 and 94. In this case the selector S selects an idle trunk in the third level, leading to the office C. For example, the trunk leading to the selector S^2. Accordingly, when the second code digit 6 is transmitted by the director as hereinbefore pointed out, the selector S^2 raises its wipers opposite the sixth level and selects an idle trunk extending to the office D, for example the trunk extending to the selector S^4.

Call from office A to office C.

Assuming now that a calling subscriber in the office A desires to converse with a subscriber whose line terminates in office C and that, upon the removal of the receiver at the calling substation, the connection is extended through to the selector S, as hereinbefore described, and that the director selector DS seizes the director shown in Figs. 3–6, the calling subscriber now dials the office digits assigned to the office C, followed by the four subscriber digits in the number, with the result that the office register OR, Fig. 5, brings its wipers 421—424 into engagement with the C office bank contacts 429—432, and that the digit registers DR—1—DR—4 are operated to register the subscriber digits of the number.

It will be noted that the first bank contact 429 of the set allocated to the C office is cross connected on the intermediate distributing frame IDF to the special conductor 455. Accordingly, when the stop-conductor-control wiper 214 of the sequence switch S′ is grounded at the end of the rotary movement of the office register OR, upon the sequence switch S passing into third position, a circuit is closed over the first code digit stop conductor 251, wiper 421, bank contact 429, the associated jumper, special conductor 455, and the normally closed contacts controlled by armature 404 for the special relay 401. This relay thereupon pulls up and locks itself to the grounded conductor 334 at armature 404, at the same time opening its initial circuit so as to prevent the locking ground potential from remaining permanently on the special conductor 455; extends the special conductor 455 at armature 405 through the jumper 456 to the third impulse stop conductor to control the sending out of the first code digit 3; and at armature 417 prepares a circuit for the special cut-off relay 301, Fig. 4, which latter circuit is closed only in case the selector S, Fig. 1, is automatically raised to the fourth level responsive to a busy condition of all the third level trunks as will hereinafter appear.

From the foregoing it may be seen that as the first code digit stop conductor 251 is now connected through the circuit above traced, including the special conductor 455 and armature 405 and its working contact to the third impulse stop conductor, the first code digit to be transmitted is the code digit 3. When this transmisison takes place the selector S, Fig. 1 raises its wipers opposite the third level of contacts in the manner hereinbefore described. Assuming now that there is at least one idle trunk in the third level, the vertical test relay 95 of the selector S is not energized at the end of the vertical movement and the rotary movement commences as soon as relays 93 and 94 fall back. Assuming that the trunk comprising conductors 71—73 is the one selected, the connection is extended through to the repeater R upon the energization of switching relay 97 which takes place when the idle trunk is reached. Accordingly, line relay 101 of the repeater R pulls up and closes a bridge across the outgoing trunk conductors at armature 104, with the result that the selector S^2, Fig. 8 is prepared for operation in the usual manner. At armature 103, line relay 101 closes a circuit for release relay 102 which thereupon energizes and places ground on the release trunk conductor 72 at armature 105. At armature 106, relay 102 closes a point in the chain circuit for supplying ground to the vertical-test chain conductor 69.

In the director, the sequence switch S′ is advanced one step in the usual manner at the end of the transmission of the first code digit 3, and wiper 214 removes ground from the first code digit stop conductor 251 and extends it instead to the second code digit stop conductor 252. The second code digit stop conductor 252 is connected through the second wiper 422 of the office register OR, bank contact 430, the associated IDF jumper, special conductor 454, armature 403 and its resting contact, and the associated jumper to the skip conductor 417. The result is that the wipers of the sequence switch S′ are automatically advanced in the hereinbefore described manner and the ground potential

is removed from the second code digit stop conductor 252 and placed on the third code digit stop conductor 253.

As the second code digit position is skipped in the above manner, the third code digit stop conductor 253 is the one over which the transmission of the second code digit is controlled. Accordingly, when the said conductor 253 is grounded, the ground connection is extended through wiper 423 of the office register OR, bank contact 431, and the associated IDF jumper to the fifth impulse stop conductor. Accordingly, the second digit transmitted is the digit 5.

In the office C, Fig. 8, the incoming selector S^2 raises its wiper opposite the fifth level responsive to the transmission of the second code digit 5 and selects an idle local thousands selector.

In the director, when the wipers of the sequence switch S′ are advanced one step at the end of the transmission of the second code digit 5, the fourth code digit stop conductor 254 is grounded whereupon a circuit is closed through wiper 424 of the office register OR, bank contact 432, the associated IDF jumper, and the skip conductor 417 for the stepping magnet 211 of the sequence switch S′, with the result that the wipers 213 and 214 are automatically advanced one step and ground is extended to the first subscriber digit stop conductor 261.

From this point on the operation of the apparatus is the same as described hereinbefore. Accordingly, the director transmits the subscriber digits in the number in the usual manner after which it switches through and is released. The established talking connection is released in the usual manner when the calling subscriber replaces his receiver.

Assuming now that, when the aforesaid subscriber in office A desires to call the subscriber in office C, all the trunks accessible to the selector S, Fig. 1, on the third level are busy the selector S is first operated from the director and is then automatically operated to raise the wipers 65—67 from their operated position opposite the third level of contacts to a position opposite the fourth level of bank contacts in the hereinbefore described manner. In this case, as before, the selector S starts rotating and selects an idle trunk in the fourth level.

When the fourth level of bank contacts is reached, the fourth level shaft springs place ground on the special conductor 21, and since the special relay 401 in the director, Fig. 5, is operated, a circuit is closed for the special cut-off relay 301, Fig. 4, as follows: From the ground by way of the fourth level shaft springs of selector S, Fig. 1, conductor 21, working contact and armature 27, wiper 32 conductor 37, working contact and armature 417 of relay 401, Fig. 5, the jumper connected between terminals 453 and 451, conductor 418, and the special cut-off relay 301 to battery. Responsive to the closure of this circuit, relay 301 operates and locks itself to ground at armature 311 through the working contact and armature 313 of release relay 302. At armature 310 relay 301 opens the start conductor so as to prevent further sending operations from taking place; it opens the outgoing control circuit at armature 308, thereby releasing the partly established connection including the selector S and the selector on the distant end of the trunk line seized by the selector S; and at armature 309 relay 301 disconnects the impulse conductor 41 from the branch leading to the wiper 209 of the sequence switch S and connects it through the small condenser 322 to the common busy signalling lead associated with the busy machine. Accordingly, busy tone current is transmitted back over conductor 41 to armature 13 and its working contact of the trunk circuit TC and is there placed on the calling line through the small condenser 8 and the resting contact and armature 20. When the calling subscriber hears this busy tone he is expected to replace his receiver, whereupon the line and release relays of the trunk circuit TC fall back with the result that the seizing line switch is freed and the switching relay 25 of the director selector DS falls back and frees the director with the hereinbefore described results that the component parts of the director are restored to normal in the usual manner.

The foregoing arrangement is the preferred one to dispose of "A" to "C" calls when the "A" to "C" trunks are busy in case the group of trunks from the B office to the C office is a relatively small group of trunks, and cannot therefore carry any appreciable additional load. It will now be assumed, however, that the group of trunks is a comparatively large group of trunks and it can carry, in adidtion to the regular B to C traffic, extra traffic directed to the C office from the A office at such times as all the trunks running directly from the A office to the C office are all busy. This situation may arise in case extra trunks are actually installed between the B and C offices to take care of the above contingency, or it may be, as is often the case, that the peak load from the A office to the C office occurs at a time when the trunks from B to C (which at the time of their peak load are all in use) are carrying a light load and that the trunks can carry some extra load on this account. In any event, in case the B to C trunk group, can handle A to C traffic, the jumper between the terminals 451 and 453, Fig. 5, is out and a new jumper is run between the terminals 453 and 452. Accordingly, when the C office is called from the A office when the A

to C trunks are busy, the partially established connection is not released by the special cut-off relay 301, Fig. 4, in this case as in the one described. Instead of this, when the selector S, Fig. 1 is automatically raised from the third level to the fourth level in response to the condition of all trunks busy on the third level, a circuit is closed by the fourth level shaft springs which extends as previously traced as far as contact 453, Fig. 5 from which point it now extends through the new jumper between terminals 453 and 452 to battery through the special code control relay 402. Relay 402 now pulls up and disconnects conductor 454 from the skip conductor and connects it instead through the working contact of armature 403 to the fourth impulse stop conductor. Accordingly, when the sequence switch S′ advances responsive to the falling back of the slow acting pick-up relay 303, (which it does in the manner pointed out hereinbefore) and places ground on the second code digit conductor 252, the second code digit position is not skipped as in the preceding case, but instead the fourth impulse stop conductor is grounded to predetermine that the next code digit is transmitted, that is, when, after the sending operations have again started, the wiper 307 of the sending switch SEN lands on the bank contact in which the fourth impulse stop conductor terminates, stop relay 304 energizes over the following circuit: From ground by way of the grounded wiper 214 of the sequence switch S′, the second bank contact, the second code digit stop conductor 252, wiper 422 of the office register OR, bank contact 430, the associated IDF jumper, special conductor 454, armature 403 and its working contact, the associated IDF jumper, the fourth impulse stop conductor, and thence by way of wiper 307 of the sending switch SEN and stop relay 304 to battery. This energization of the stop relay results in the termination of the digit being transmitted. After the usual time interval, the sequence switch S′ is again advanced and shortly thereafter the sending of the next digit commences.

In the office B, Fig. 8, the selector S′ responds to the second code digit 4 to raise its wipers opposite the fourth level and to select an idle trunk therein. For example, the trunk extending to the C office and terminating in the selector S^3.

In the director, the next code digit 5 is now transmitted in the manner hereinbefore described as the sequence switch S′ is now in its third position. Accordingly, the selector S^3 in the C office, Fig. 8, raises its wipers to the fifth level and selects a local thousands selector in the hereinbefore described manner.

Obviously the transmission of the registered thousands digit now takes place in the same manner as described hereinbefore.

Call from office A to office E.

Considering now the manner in which a call originated in the A office and intended for a subscriber in the E office is handled, it may be seen upon reference to Fig. 8 that the same number of code digits is required in this case as when the C office is called. It will be noted that the only difference between the codes of the C office and the E office is that whereas the final code digit on calls to the C office is the digit 5, the final code digit when the E office is called is the code digit 2. It will be seen further that since the calls from the A office to the E office are all handled through the C office and that the thousands selectors in the E office are accessible to the same office selectors S^2 and S^3, to which the thousands selectors in the C office are accessible, the special arrangement hereinbefore described with reference to handling calls to the C office are applicable to the E office. For example, when the director transmits the first digit 3 in the code 32 necessary to trunk the call to the office E, the selector S raises its wipers opposite the third level of bank contacts and completes the connection to a selector in the C office, such as the selector S^2, provided there is an idle trunk in the third level. In this case, it is obvious that the transmission of the next and last code digit 2 completes the call to the E office. However, in case all the third level trunks are busy, the selector S in the A office is automatically operated to the fourth level and it selects an idle trunk to the B office, for example, the trunk extending to the selector S′. In this case, as in the case of a call to the C office, the connection must be denied in case the trunk lines from B to C cannot be used. On the other hand, an extra digit must be introduced to trunk the call from the B to C office in case it is permissible to use the B to C trunk for calls directed to C from A.

It may be seen from the diagram, Figs. 7 and 8, that the office E is more or less an outlying office. Accordingly it may be readily supposed that this is a relatively new office and one in which the traffic is increasing at a fairly rapid rate owing to the building up of the territory which it serves. That being the case, it is desirable to have a ready means for ascertaining the traffic directed to the E office in order that the trunking facilities may be changed from time to time as the traffic conditions change. This situation has been taken care of by providing in the director shown in Figs. 3–6 suitable metering arrangements, later described, for registering the number of calls directed to the E office. It will be understood, of course, that the other directors are similarly equipped.

Referring now to Fig. 5, it will be noted

that the first bank contact 433 associated with the E office position of the office register OR is cross connected on the intermediate distributing frame IDF to the same special conductor 455 to which the first bank contact 429 of the set belonging to the C office is cross connected. Therefore, on calls to the E office relay 401 pulls up and operates armature 417 just as described hereinbefore on calls to the C office. It will be noted further that the second bank contact 424 of the set belonging to the E office is cross connected on the intermediate distributing frame in the same manner as the second bank contact 430 of the set belonging to the C office. Accordingly, the second code digit position on calls to the E office is skipped or is used to transmit the extra digit 4 necessary to trunk from B to C, subject to the same conditions as described in connection with calls from the A office to the B office.

From the above it may be seen that the same special arrangements provided to take care of one office may be used to take care of as many offices as desired that are reached through the first mentioned office.

It will be noted that Fig. 5 shows a meter M. This meter is used to register the number of calls directed to the E office. It is for this purpose associated with the special terminals 441 and 442. It will be noted that the third contact 435 in the group assigned to the office E is jumpered on the intermediate distributing frame IDF to the special terminal 441. Accordingly when the third wiper 423 of the office register OR is grounded by the sequence switch S′ on a call to the E office, the ground potential is extended over conductor 445 to energize the magnet 443 of the meter M. When magnet 443 energizes it operates the associated armature 446 to turn the number-wheel registering mechanism to register the call, and it also places ground on conductor 444, which is extended to the special terminal 442 and from then by way of the associated IDF jumper to the second impulse stop conductor so as to terminate the last digit 2 in the usual manner.

What is claimed is:

1. In a multi-office telephone system, four offices, trunk lines from the first office to the second office, trunk lines from the second office to the third office, trunk lines from the first office to the fourth office, trunk lines from the fourth office to the third office, switching mechanism in the first office responsive to a predetermined digit for extending a connection over one of said trunk lines to the second office, switching mechanism in the second office responsive to a second predetermined digit for extending the connection by way of one of said trunk lines from the second office to the third office, means associated with the said switching mechanism in the first office, operative responsive to a busy condition of the said trunk lines from the first office to the second office to extend the said connection to the fourth office by way of one of said trunk lines instead of to the second office, switching mechanism in the fourth office responsive to said second predetermined digit for further extending the said connection from the fourth office to the third office by way of one of said trunk lines, and a register sender in the first office for transmitting the digits to operate said switching mechanism.

2. In a telephone system, a plurality of offices, trunk lines interconnecting said offices, switching mechanism in the first of said offices responsive to a predetermined digit for extending a connection from the first office to the second office by way of one of said trunk lines in case one is idle, means associated with said mechanism responsive to a busy condition of the trunk lines connecting the first office with the second office for extending the said connection by way of one of said trunk lines to the third office, and a register sender in said first office for controlling said switching mechanism.

3. In a telephone system, a plurality of offices, trunk lines interconnecting said offices, switching mechanism in the first office responsive to a predetermined digit to extend a connection to the second office, means, associated with said mechanism, responsive to a busy condition of the trunk lines connecting the first office with the second office to extend the said connection by way of a trunk line to the third office, and means responsive to the operation of the last named means, controlled in accordance with the final destination of the call, operative to give the calling subscriber a busy signal and to release the connection to said third office.

4. In a multi-office telephone system, a register-transmitter for registering a telephone number and for transmitting digits to trunk the call to its destination, and means in said register-transmitter responsive to a busy condition of one of the inter-office trunk groups encountered for altering the untransmitted part of the digit combination to route the call to its destination over a new inter-office trunk path by way of a different intermediate office.

5. In a telephone system, a plurality of offices interconnected by trunk lines, sending mechanisms, switching mechanism in the first office controlled by said sending mechanism to extend a connection to the second office in case there is an idle trunk, means associated with said mechanism responsive to a busy condition of the trunk lines from the first to the second office to extend the said connection by way of a trunk line from the first office to the third office, and means responsive to the last named operation of said

switching mechanism for causing said sending mechanism to transmit an extra digit to trunk the call from the third office to the second office.

6. In a call director, registering mechanism, sending mechanism controllable thereby to transmit a plurality of digits, means for canceling one of said digits, and a relay energized responsive to the transmission of a preceding digit for rendering said canceling means ineffective to cancel said one digit.

7. In a telephone system, a selector having a group hunting movement effective if a selected group is busy, a director for controlling said selector and other selectors in accordance with a predetermined code, and means effective to alter the code in case said group hunting movement takes place.

8. In a telephone system, a selector having a group hunting movement effective if a selected group is busy, a director for controlling said selector and other selectors in accordance with a predetermined code, and means for automatically increasing the number of digits in the code in case said group hunting movement takes place.

9. In a telephone system, an automatic switch for trunking a call from a first office to a second office over a particular group of trunks, a director for controlling said switch and other switches in accordance with a predetermined code, means responsive if all trunks in said group are busy for causing said first switch to automatically select another group of trunks, and means responsive only in case the said first switch selects the second group of trunks for causing the director to continue the trunking control in accordance with a revised code.

10. In a telephone system, an automatic switch for trunking a call from a first office to a second office over a particular group of trunks, a director for controlling said switch and other switches in accordance with a predetermined code, means responsive if all trunks in said group are busy for causing said first switch to automatically select another group of trunks, and means responsive only in case the said first switch selects the second group of trunks for causing the director to insert an extra digit in the code.

11. In a telephone system, a selector, a director for controlling said selector and other selectors in accordance with a predetermined code, and means for revising the code during transmission in case said selector is operated to select a busy group of trunks.

12. In a telephone system, a selector, a director for controlling said selector and other selectors in accordance with a predetermined code, means in said selector for causing the same to select another group of trunks in case the code digit received corresponds to a busy group, and means effective in such case for revising the remaining portion of the code before transmission.

13. In a telephone system, a selector, a director for controlling said selector and other selectors in accordance with a predetermined code, means normally effective to cause said director to skip a possible code digit, a non-skip relay, and means in said selector for controlling said relay.

14. In a telephone system, a selector, a director for controlling said selector and other selectors in accordance with a predetermined code, means normally effective to cause said director to skip a possible code digit, a non-skip relay, and means for operating said relay in case said selector is operated to select a busy group of trunks.

15. In a telephone system, a plurality of offices, trunk lines interconnecting said offices, switching mechanisms in said offices, a director for registering and transmitting digits to trunk the call to its destination, the switching mechanism in the first office being responsive to a digit set up on said director for extending a connection from the first to the second office by way of one of said trunk lines if one is idle, means associated with said first mechanism responsive to a busy condition of the trunk lines connecting the first office with the second office for extending the connection by way of one of said trunk lines connecting the first office with the third office, and means in said director for altering or not altering the untransmitted part of the digit combination dependent upon the destination of the call to control the switching mechanism in the third office to route the call over the proper trunk lines to its destination.

16. In a telephone system, a first office, a second office, two tandem offices, means including a director normally effective for routing calls from the first office to the second office by way of the first of said tandem offices, but effective if all the trunks connecting the first office with the first tandem office are busy for routing calls from the first office to the second office by way of said second tandem office, and equivalent trunking connections between the two tandem offices and said second office, whereby calls can be routed via either tandem office as set forth with the same setting in said director.

17. In a telephone system, groups of trunks, a director for registering and for transmitting digits to trunk the call to its destination, and discriminating means in said director responsive to a busy condition of one of the trunk groups for altering or for not altering the untransmitted part of the digit combination dependent upon the destination of the call.

18. In a telephone system, a selector, a director for controlling said selector and other selectors in accordance with codes corre-

sponding to different exchanges, and means in said selector for causing said director to change one of said codes.

19. In a telephone system, a register sender for registering a designation and retransmitting in accordance therewith a predetermined digit combination, and means for altering said combination of digits after the transmission of the first digit.

20. In a telephone system, a first office, a second office, a third office, trunks connecting each office with the other two, a register sender in the first office normally effective for routing calls from the first office to the second office by way of the trunk connecting the two offices, means effective independent of control from said sender when all of the trunks connecting the first office with the second office are found unavailable to route calls intended for the second office to the third office, and means in the sender thereafter operable to control the routing of such calls from the third office to the second office.

21. In a multi-office telephone system, a register sender for registering a telephone number and for transmitting digit impulses to trunk the call to its destination, and means effective when all the trunks leading directly to the desired office are busy for altering said sending apparatus after it has transmitted the first code digit so that it will transmit impulses to route the call to its destination over a different inter-office trunk by way of an intermediate office.

22. In a telephone system, a register sender, means for registering groups of digit impulses in said sender, means in the sender for transmitting groups of impulses corresponding to the impulses registered, and means in said sender effective responsive to the transmission of the first registered digit under predetermined conditions for automatically changing the remaining number of digits to be transmitted.

23. In an automatic telephone system including a number of exchanges interconnected by trunks, a register sender, a device directively controlled by the sender, and means independent of said sender for controlling said device after its operation by the sender to automatically deviate calls between two exchanges through a third exchange in case all of the trunks connecting the two exchanges are busy, and means controlled by said device responsive to its automatic deviation for revising the remainder of the code to be transmitted by the sender.

24. In a telephone system, a register sender for registering and retransmitting in accordance therewith a predetermined digit combination, a selector directively controlled by said sender to select a predetermined trunk group in accordance with the first digit of said combination, and means in said sender effective in case said selector automatically selects a different trunk group responsive to the transmission of the first digit of said combination for altering the said digit combination.

In witness whereof, I hereunto subscribe my name this third day of June, A. D. 1925.

LEONARD L. RUGGLES.