Sept. 22, 1936. S. F. NELSON ET AL 2,054,910

TELEPHONE SYSTEM

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FIG. 1

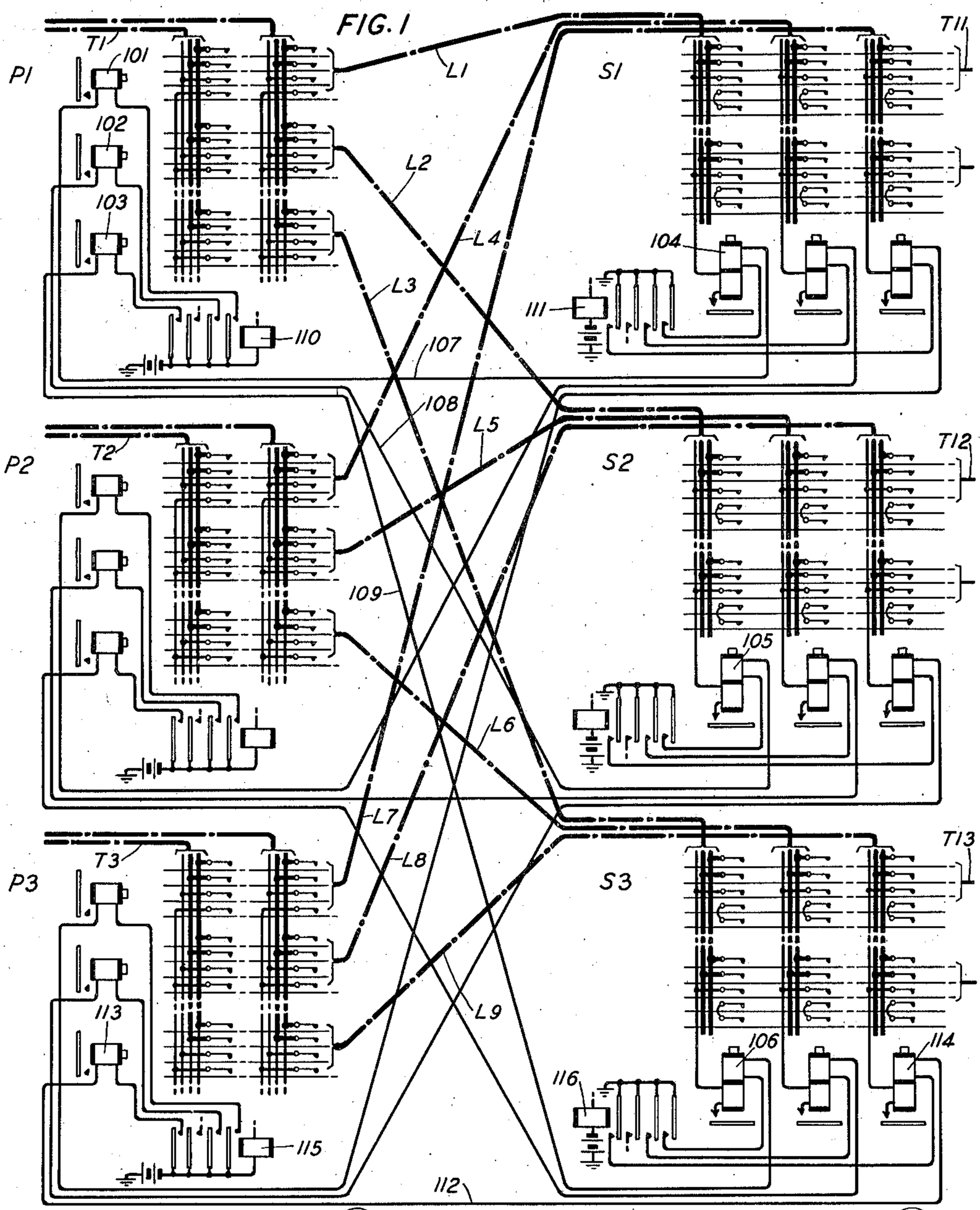
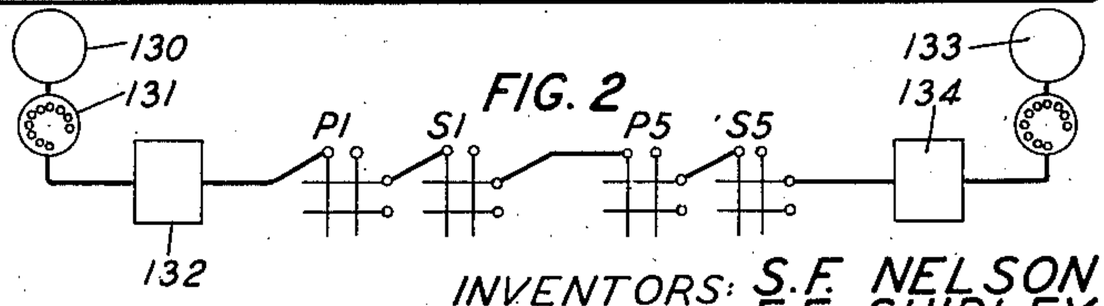


FIG. 9

FIG. 3	FIG. 5	FIG. 7
FIG. 4	FIG. 6	FIG. 8

FIG. 2



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TELEPHONE SYSTEM

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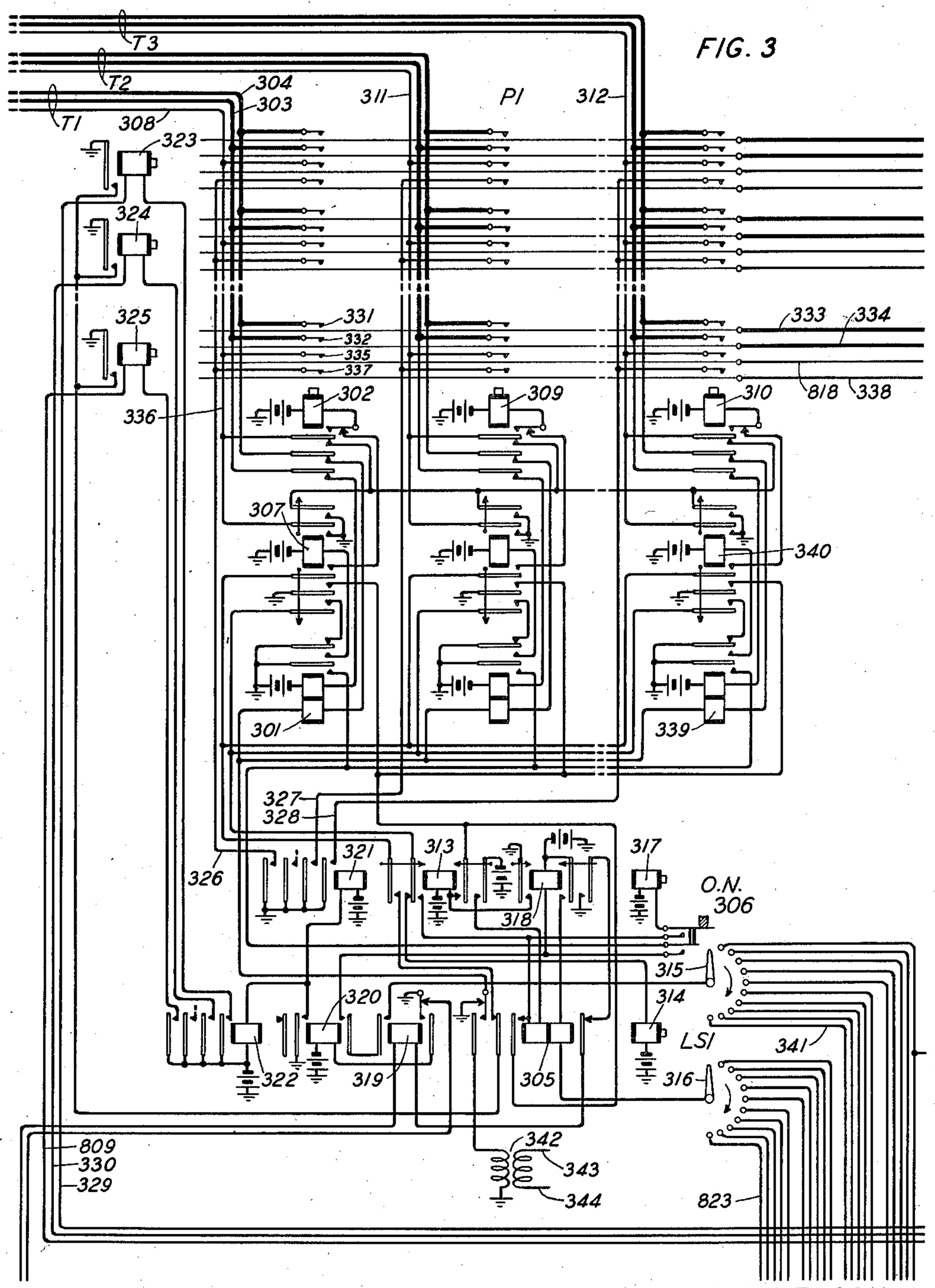
FIG. 3



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TELEPHONE SYSTEM

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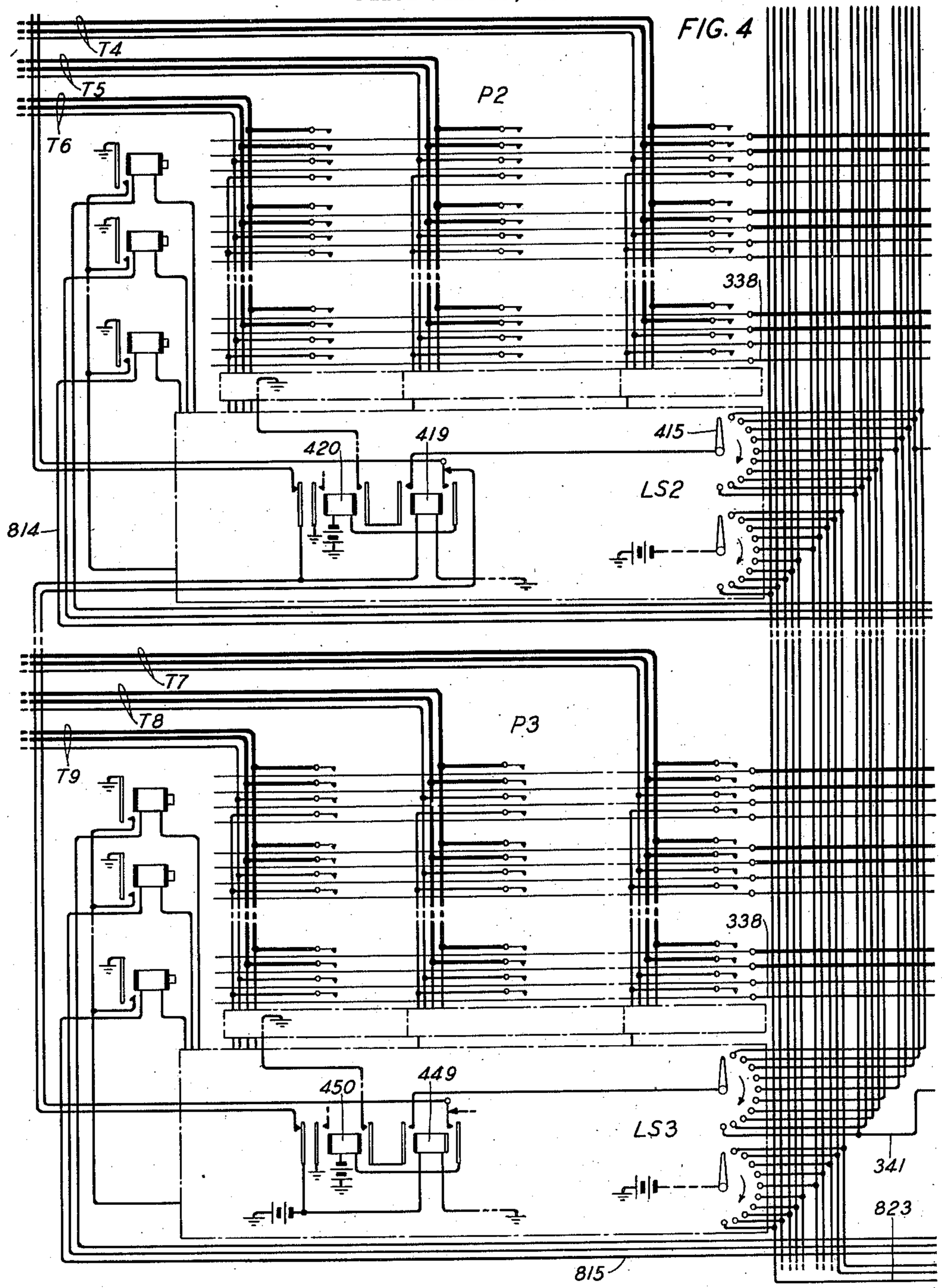
FIG. 4



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TELEPHONE SYSTEM

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FIG. 5

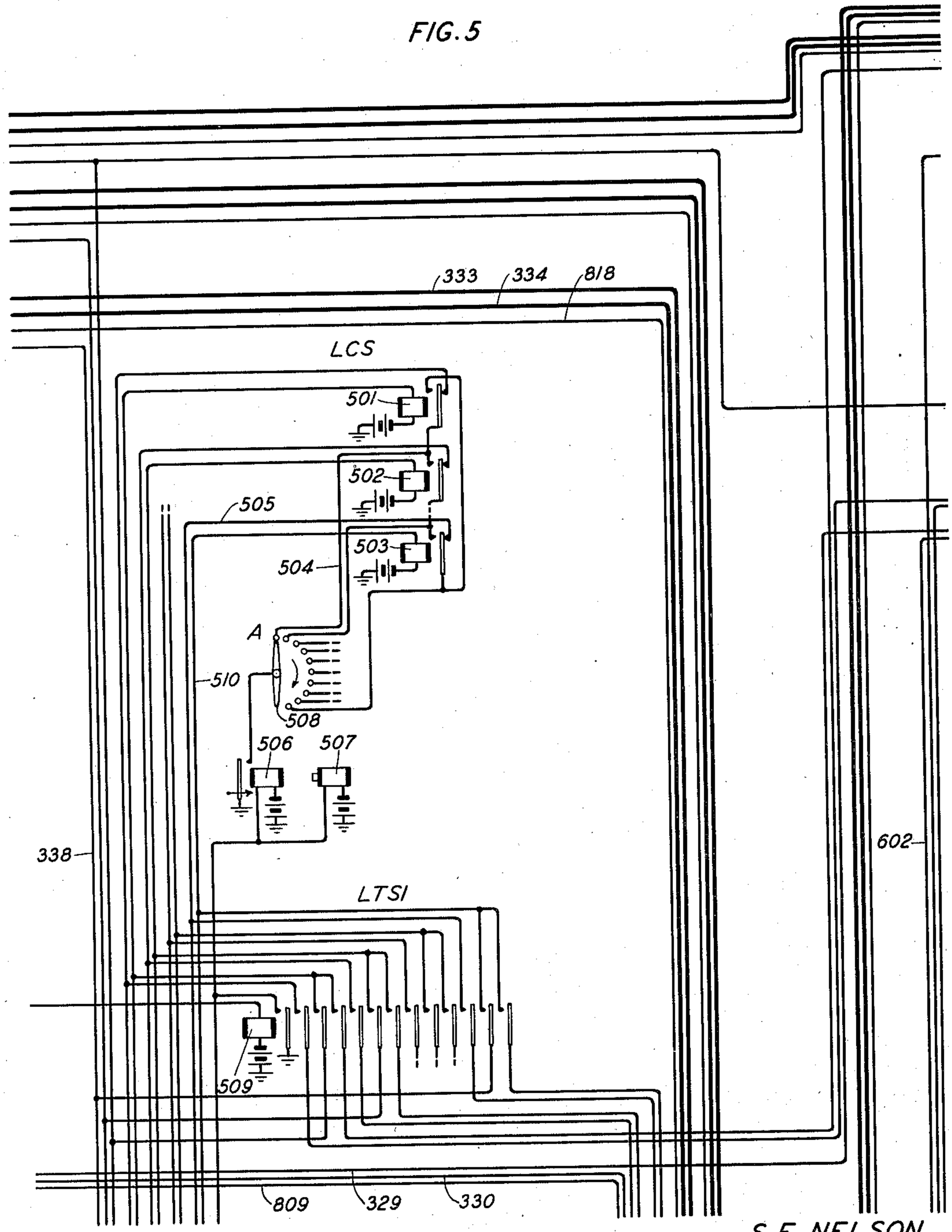

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FIG. 6

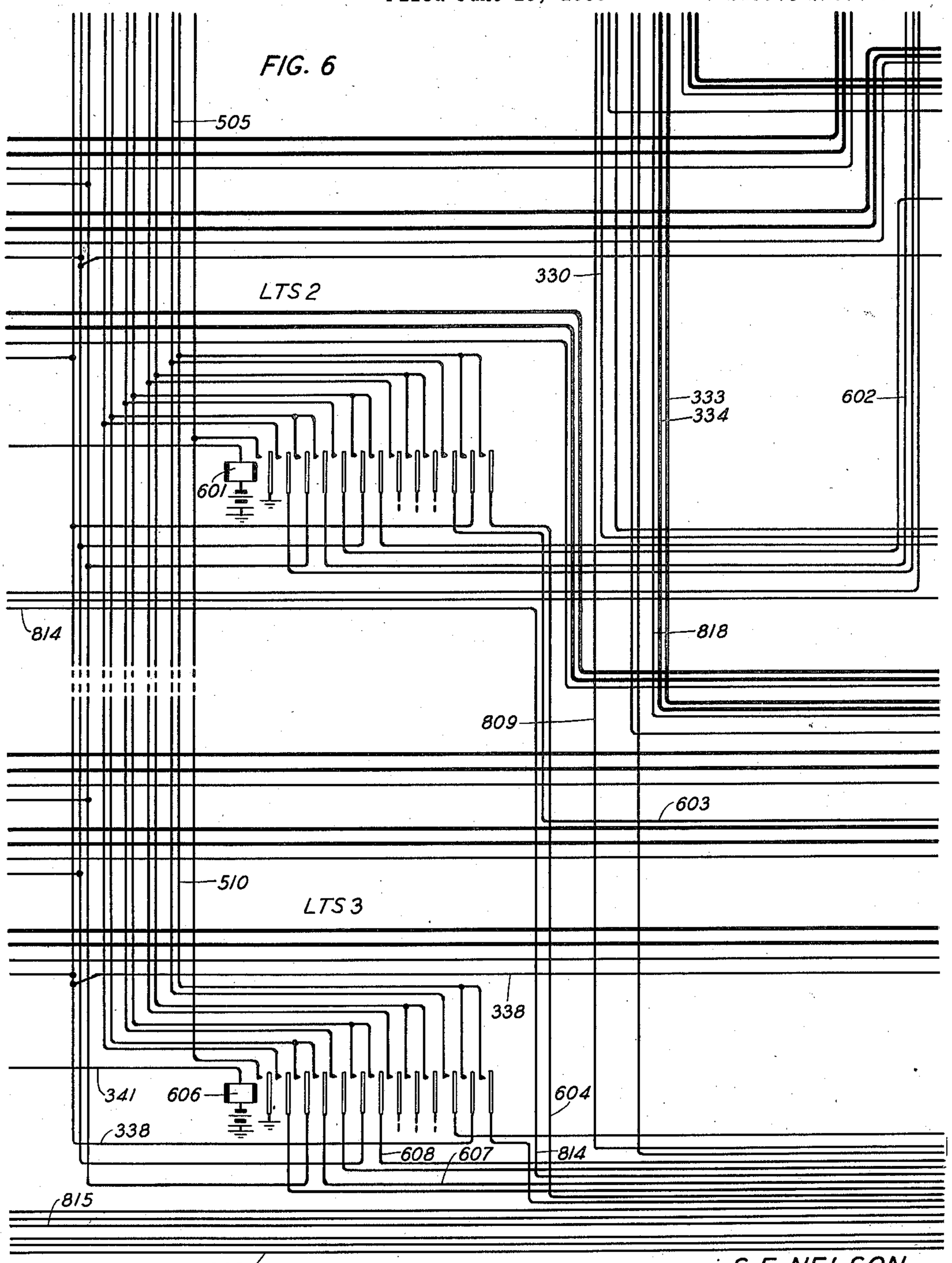

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FIG. 7

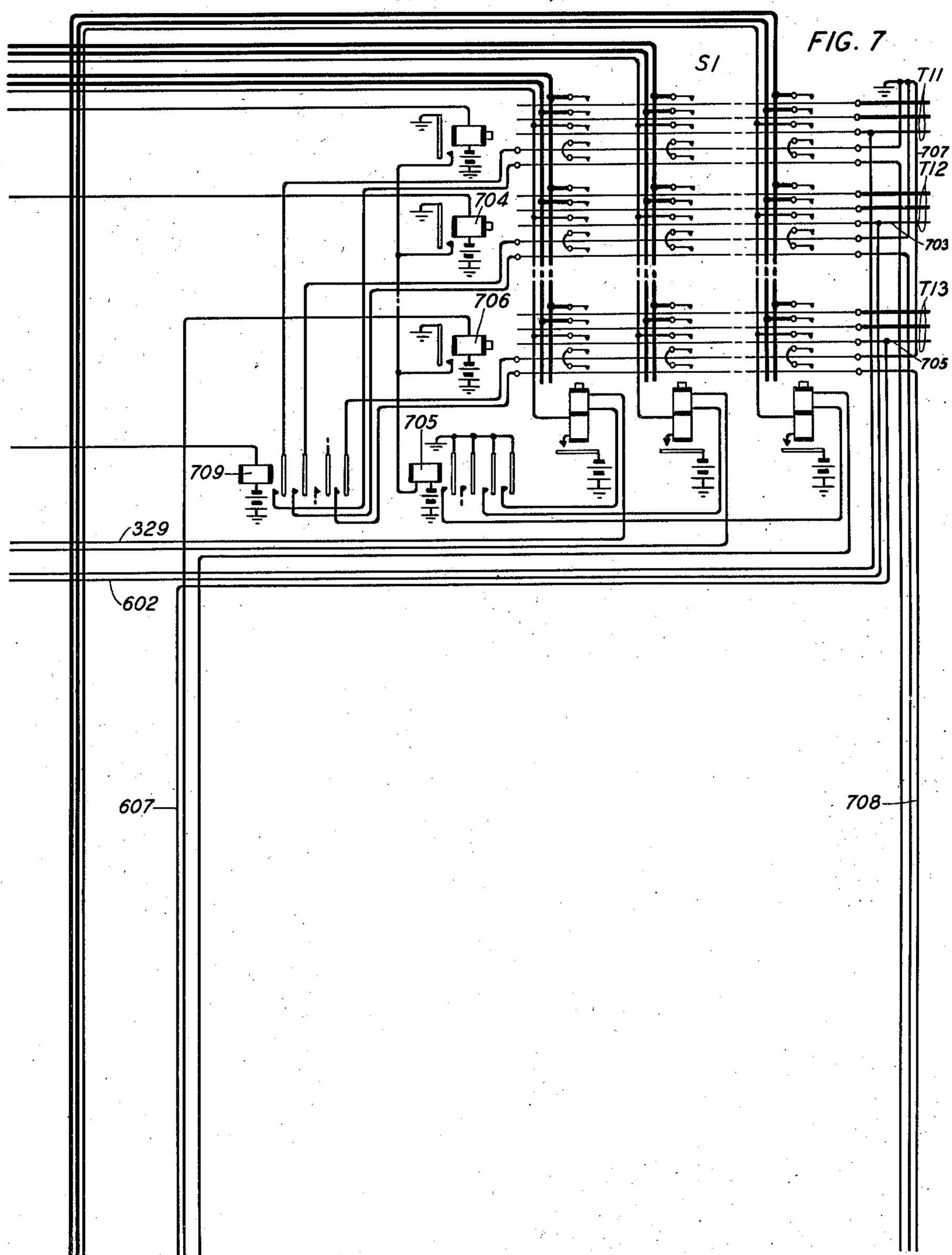

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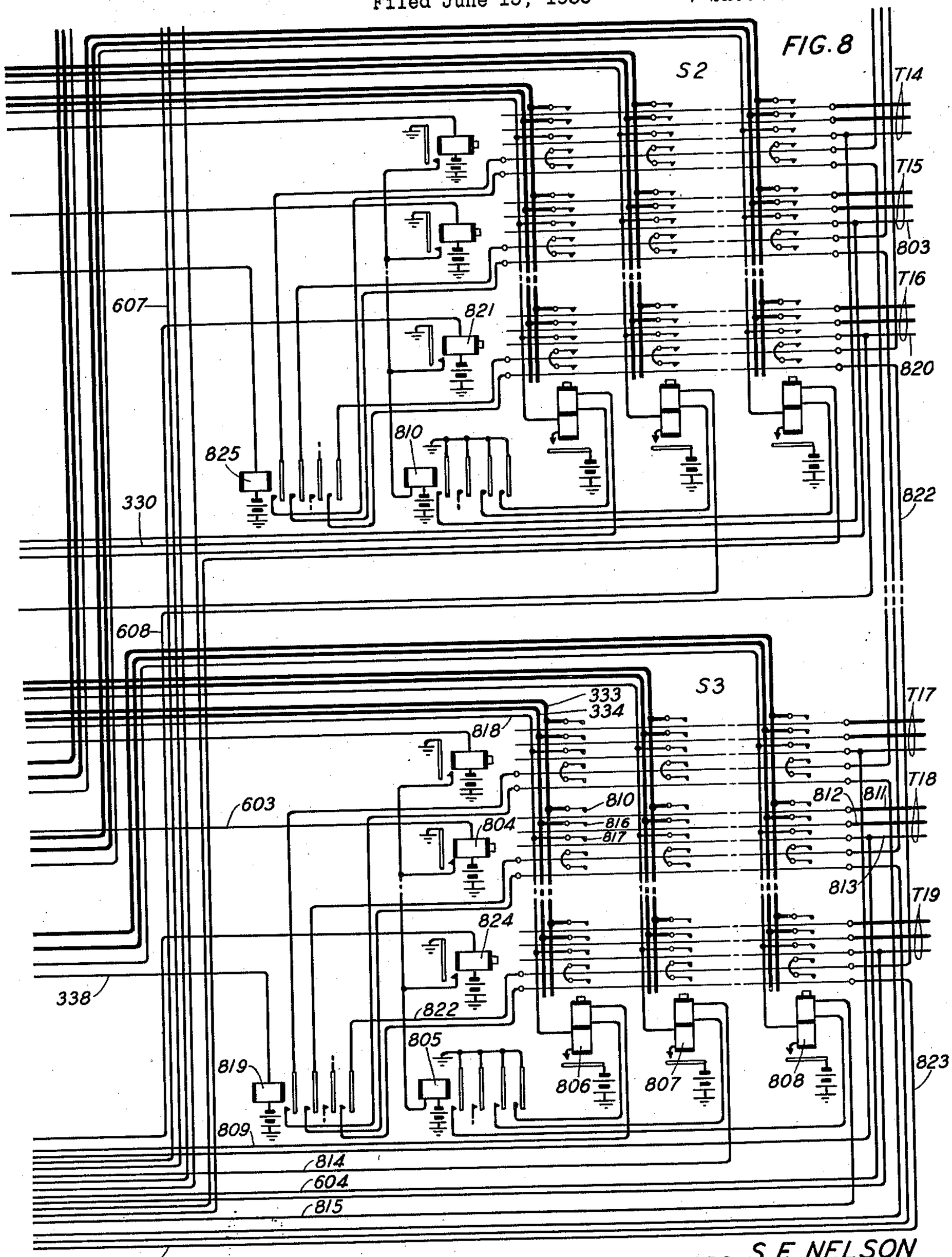
FIG. 8



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Patented Sept. 22, 1936 2,054,910

UNITED STATES PATENT OFFICE

2,054,910

TELEPHONE SYSTEM

Stanley Foushee Nelson, Brooklyn, N. Y., and Frank Foster Shipley, Teaneck, N. J., assignors to American Telephone and Telegraph Company, a corporation of New York

Application June 15, 1935, Serial No. 28,860

11 Claims. (Cl. 179—18)

This invention relates to telephone systems and particularly to systems of the character in which automatic switching apparatus is employed for establishing connections.

The object of the invention is to enable a more efficient and economical use of the switching and controlling equipment in the establishment of connections through group-selecting stages comprising switches of the cross-bar type which receive the successive series of designation impulses directly from the subscriber's dial or other sending device.

It has been suggested heretofore to control group-selecting switches of the cross-bar type by sending the digital impulses directly to the switches at the successive stages as distinguished from recording the whole designation in a sender or marker which in turn controls the successive switches. Such an arrangement is disclosed in the patent to Clark, No. 1,567,242 of December 29, 1925.

The present invention secures advantages over these prior systems by the use of a more efficient connecting arrangement in which an incoming circuit is selectively connected to an outgoing circuit through primary and secondary switches, these switches being interconnected by link circuits and controlled and operated by associated equipment that receives the digit impulses directly from the dial.

Another feature of the invention is a system in which each group-selecting stage comprises a plurality of primary and a plurality of secondary cross-bar switches interconnected by links, a plurality of incoming circuits or trunks appearing in each of the primary switches, the successive digital series being sent directly to the controlling apparatus associated with each successive stage as the connection progresses from stage to stage, and in which all of the trunks incoming to a particular primary switch are served by the same digit receiving mechanism forming a part of the controlling apparatus associated with that stage.

Another feature of the invention is a circuit arrangement such that if a plurality of calls reach a group-selecting stage simultaneously they are disposed of one at a time. This prevents interference between two incoming calls seeking trunks in the same outgoing group, and it also enables an incoming call at one primary switch to reach any idle outgoing trunk through any available link without interference from an incoming call at some other primary switch that may be seeking connection to a trunk in either the same or another outgoing trunk group.

Another feature is an arrangement for testing the outgoing trunks of a group and the interconnecting link circuits in which each outgoing trunk is tested in conjunction with the link circuit that interconnects the secondary switch in which such outgoing trunk appears and the particular primary switch in which appears the calling incoming trunk, and in which the busy condition of the link is determined by the fact that the test circuit therefor is completed through the closed contacts of the link at the primary selector switch. The test relay that tests a particular outgoing trunk is also applied to all links extending from the respective primary switches to the secondary switch in which the outgoing trunk appears, but since only one call can be in progress at a time a complete circuit for the testing relay can be closed only through the primary switch in which appears the call that is in progress.

A further feature is a circuit arrangement for operating the magnets of the switches in which a battery potential is applied to the magnets of all link circuits incoming to the particular secondary switch in which appear the idle outgoing trunk to be selected for use at the same time that the opposite potential of the battery is applied to the magnets of all links outgoing from the calling primary switch to the several respective secondary switches. Since one of these links interconnects the primary and secondary switches involved, their magnets are operated in series to complete the connection through the stage to the group-selecting stage beyond.

These and other features of the invention will be explained more fully in the following detailed description, which should be taken in connection with the accompanying drawings.

The following description will cover only the operation of an intermediate group-selecting stage of a telephone system embodying this invention since other intermediate stages are practically identical, differing only in the quantities of apparatus required. The initial or line-finder stage, as well as the final or connector stage, may be assumed to be of whatever type is best suited to perform the particular functions of these said stages and may consist of any combination of crossbar switches, Strowger switches, Keith line switches or any other suitable equipment, the functions and operation of which are well known to the art.

Figure 1 of the accompanying drawings illustrates diagrammatically the manner in which the groups of primary and secondary switches of any group-selecting stage are interconnected.

Fig. 2 shows the invention applied to a plurality of group-selecting stages.

Fig. 3 illustrates, in part, one switch of the primary switch group in which appear three trunks T1, T2 and T3 incoming from the preceding stage. Associated with this primary switch P1 is shown the level selector LS1 which, under control of dial impulses, selects a link-trunk selector corresponding to the dialed digit.

Fig. 4 illustrates, in part, two other primary switches P2 and P3 together with their associated level selectors LS2 and LS3 respectively. Appearing in switch P2 are trunks T4, T5 and T6 incoming from the preceding stage. In switch P3 appear incoming trunks T7, T8 and T9. The individual trunk relays for trunks T4 to T9, inclusive, as well as the relays for switches P2 and P3 and the magnets and springs for controlling level selectors LS2 and LS3 are not shown since these trunks, switches and level selectors are identical with, and function in the same manner as trunks T1 to T3 inclusive, switch P1, and level selector LS1 respectively.

Fig. 5 illustrates the link-trunk selector LTS1 associated with the trunks outgoing from the upper level of the secondary switches to the succeeding stage. Fig. 5 also shows a link circuit selector LCS, common to all link-trunk selectors, which selects an idle outgoing trunk in the proper level on a secondary switch to which there is an idle link from the primary switch.

Fig. 6 illustrates two other link-trunk selectors LTS2 and LTS3 which are respectively associated with the trunks outgoing from the middle and lower levels of the secondary switches.

Fig. 7 illustrates, in part, one switch of the secondary switch group, in which appear the trunks T11, T12, and T13 outgoing to the succeeding stage.

Fig. 8 illustrates, in part, two other switches of the secondary switch group, in which appear outgoing trunks T14 to T19, inclusive.

Fig. 9 shows how Figs. 3, 4, 5, 6, 7, and 8 are to be arranged with respect to each other in disclosing the switches and associated equipment which comprise an intermediate group-selecting stage.

Switches P1, P2, P3, P5, S1, S2, S3, and S5 shown in Figs. 1, 2, 3, 4, 7, and 8 are of the crossbar type and consist briefly of a plurality of sets of contacts arranged in horizontal and vertical rows or units. Associated with each horizontal row of contact sets is a horizontal operating magnet under control of which the said horizontal contact sets are prepared for operation. Associated with each vertical row of contact sets is a vertical magnet under control of which any set of contacts in that vertical row, after being prepared by the operation of its respective horizontal magnet, is operated and held in that position until the release of the vertical magnet takes place. For a more detailed explanation of the construction and operation of these crossbar switches reference may be made to the application of J. N. Reynolds Serial No. 702,453, filed December 15,, 1933, granted as Patent 2,021,329, Nov. 19, 1935.

Referring now to Fig. 1, for the purpose of simplicity only such portions of three of the primary and secondary switches are shown as is required to illustrate, in general, the manner in which a connection is extended through a group-selecting stage. It will be apparent, however, that the system is applicable to any number of primary and secondary switches and that these said switches may be comprised of any number of horizontal and vertical rows or units of contact sets.

Appearing in the vertical row or units of contact sets of the primary switches P1, P2 and P3 are trunks such as T1, T2 and T3, incoming from the preceding stage. The horizontal rows of contacts of primary switch P1 connect to the first vertical rows of contacts on the secondary switches S1, S2 and S3 over links L1, L2 and L3, respectively. Similarly, the horizontal contact rows of primary switch P2 connect to the second rows of vertical contacts on the secondary switches over links L4, L5 and L6, and the horizontal contacts of primary switch P3 connect to the third vertical rows of contacts on secondary switches S1, S2 and S3 over links L7, L8 and L9. Each incoming trunk, such as trunks T1, T2 and T3, therefore has access to each secondary switch and, through the secondary switches, may be extended to the succeeding stage over outgoing trunks such as trunks T11, T12 and T13. While a single link is shown from a primary to a secondary switch, it will be understood that the invention is not so limited and that more than one link could be used if desired.

Associated with each horizontal row of sets of contacts on the primary switches P1, P2 and P3 is a horizontal operating magnet, such as magnets 101, 102 and 103, under control of which, in conjunction with the operation of a vertical operating magnet (not shown), a particular set of contacts is operated. Associated with each vertical row of contact sets on the secondary switches S1, S2 and S3 is a vertical operating magnet, such as magnets 104, 105 and 106, under control of which, in conjunction with the operation of a horizontal magnet (not shown), a particular set of contacts of the secondary switch is operated.

Each primary switch horizontal magnet connects to a vertical magnet of a secondary switch over a conductor such as conductors 107, 108, 109 and 112. Associated with each primary switch is a relay, such as relay 110 of switch P1, which connects battery to the windings of all horizontal magnets of a particular primary switch. Similarly, associated with each secondary switch is a relay, such as relay 111 of switch S1, which connects ground to the windings of all vertical magnets of a particular secondary switch. Selection of an idle outgoing trunk in the proper level of a secondary switch to which there is an idle link from the primary switch is made under control of a link-trunk selector and a link selector (not shown in this figure), the functions and operation of which will later be set forth in detail.

A call extended to this stage over incoming trunk T1 may be extended to the succeeding stage over trunks T11, T12 or T13 outgoing from the secondary switches S1, S2 or S3 respectively, depending upon the selection made by the link-trunk selector which is associated with primary switch P1 at that time. Assuming, for example, that idle trunk T11 is selected, horizontal magnet 101 of the primary switch P1 energizes in series with vertical magnet 104 of the secondary switch S1, over conductor 107, upon the operation of relays 110 and 111. In energizing, magnet 101, in conjunction with the operation of a vertical magnet (not shown), causes the upper set of contacts in the first vertical row of switch P1 to operate. Similarly, magnet 104, in conjunction with a horizontal magnet (not shown), causes the upper set of contacts in the first vertical row

of switch S1 to operate. The connection incoming over trunk T1 is therefore extended to the succeeding stage over outgoing trunk T11, over the aforementioned operated sets of contacts of switches P1 and S1. Should idle trunk T12 be selected, magnets 102 of switch P1 and 105 of switch S2 are energized over conductor 108, and the connection extends from trunk T1, over the middle set of contacts of the first vertical row of switch P1, link L2, and the upper set of contacts of the first vertical row of switch S2 to the succeeding stage over outgoing trunk T12. As a further illustration, assume that a call is extended to this stage over the incoming trunk T3 and that the link-trunk selector (not shown) associated with switch P3 at this time selects idle trunk T13. Horizontal magnet 113 of switch P3 and vertical magnet 114 of switch S3 are energized in series, over conductor 112, upon the operation of relays 115 and 116, and the call is extended to the succeeding stage over the lower set of contacts of the first vertical row of contacts of switch P3, link L9, over the upper set of contacts of the third vertical row of contacts of switch S3, and over the outgoing trunk T13. It will be noted that, although battery is connected simultaneously to all horizontal magnets of a particular primary switch at the same time that ground is connected to all vertical magnets of a secondary switch, only one primary switch horizontal magnet and one secondary switch vertical magnet can operate, in series, since each link from any primary switch horizontal magnet leads to a separate secondary switch.

In Fig. 2 a calling line 130 having a dial 131 is shown terminating in a line switch 132 and a called line 133 terminating in a connector 134. For the purpose of illustration only two intermediate group stages are shown. The first of these comprises primary switches P1 and secondary switch S1, and the second stage includes primary and secondary switches P5 and S5. There may, of course, be other stages.

Referring now to Figs. 3 to 8 inclusive, the manner in which a call is extended through the group-selecting stage illustrated therein will be considered in detail. As hereinbefore set forth, a stage may consist of any desired number of primary and secondary switches and each switch, in turn, may be composed of any convenient number of horizontal and vertical rows or units of contact sets. The group-selecting stage herein disclosed is assumed to consist of ten primary and ten secondary switches, each switch having ten horizontal and ten vertical rows or units of contacts. For clarity of illustration and description, only the first, second and tenth switch of each of the group of ten primary and ten second switches are shown. In addition, only the first, second and tenth rows of horizontal and vertical sets of contacts for each of the switches illustrated are shown. Three link-trunk selectors are illustrated, one being associated with the trunks outgoing from each level of the secondary switches shown. It should be understood however that, since it is assumed that there are ten horizontal rows or levels on each switch, there are also ten link-trunk selectors, one being associated with the trunks outgoing from each of the ten levels of the secondary switches.

Assume now that a call is extended to this group-selecting stage over the incoming trunk T1 of Fig. 3. As soon as connection is established through the preceding stage, relay 301 operates in a circuit from battery through its upper winding, over the lower back contact of vertical magnet 302, ring conductor 303 of trunk T1, ring conductor of the preceding stages, over the subscriber's station loop (not shown), tip conductor of the preceding stages, tip conductor 304 of trunk T1, middle armature and back contact of magnet 302, lower winding of relay 301, normally closed make-before-break contacts of relay 305 to ground. In the first group-selecting stage, the operating ground for relay 301, instead of being connected directly to the back contact of the make-before-break contacts of relay 305 as in this case for an intermediate stage, is supplied through one winding of a coil through which a dial tone is induced to provide the calling subscriber with an indication that the circuit is ready for dialing. Relay 301, in operating connects ground over its inner front contact to the lower armature of the off-normal springs 306 associated with the level selector LS1, and also operates relay 307 in an obvious circuit. Relay 307, in operating, connects ground over its upper inner front contact to sleeve conductor 308 of trunk T1, and also connects ground over its upper outer front contact, over the next-to-inner back contacts of magnets 302, 309 and 310 to the respective sleeve conductors 308, 311 and 312 of the incoming trunks T1, T2 and T3. This ground on the sleeve conductors of all of the incoming trunks provides for making this primary switch busy so that no other call can be extended to it until the call which has come in over trunk T1 is extended to the succeeding stage. Relay 307, in operating, also partially closes the operating circuit for vertical magnet 302, partially closes the locking circuits for relays 305 and 313, and closes, in part, the operating circuit for rotary magnet 314 of switch LS1.

Assuming that the calling subscriber dials the digit 2, relay 301 releases and reoperates twice in response to the two corresponding open intervals in the subscriber's loop. Relay 307, being of the slow-to-release type, remains operated during the intervals in which the circuit through its winding is opened by the release of relay 301. Each release of relay 301 energizes rotary magnet 314 of the level selector LS1 in a circuit from ground over the back contact of relay 301, lower outer front contact of relay 307, left back contact of relay 313, to battery through the winding of magnet 314. Each operation of magnet 314 causes brushes 315 and 316 to advance one step over the contacts of their associated terminal banks. In response to the two releases of relay 301, corresponding to the open pulses of the digit 2, brushes 315 and 316 therefore contact the second terminal of their respective terminal banks. On the first operation of magnet 314 the off-normal springs 306 operate, partially closing the circuit for the level selector release magnet 317 over their upper front contact, and partially closing the operating circuit for relay 318 over their lower front contact. When relay 301 reoperates at the conclusion of the dial pulses, ground over its inner front contact completes the operating circuit for relay 318 which is of the slow-to-operate type to prevent its operation during the dialing interval. Relay 318, in operating, operates relay 313 in an obvious circuit, and connects ground over its right outer front contact and over the right back contact of relay 305 to the winding of relay 319. Relay 313, in operating, locks over its right inner front contact to ground over a previously traced circuit, and opens the circuit to the winding of magnet 314.

A pair of sequence relays, such as relays 319

and 320, 419 and 420, and 449 and 450, are associated with each primary switch of the group. The operating circuits for these relays extend over a chain circuit through the entire group of switches in such manner that only one pair of relays can operate at a time. Ground is connected over the normally closed right contacts of relay 319 of the first primary switch of the group, over the normally closed right contacts of relay 419 and of the corresponding relays of the other intermediate switches of the group (not shown) to the right front contact of relay 449 of the last switch of the group. The operation of only one relay, such as relay 319, is effective at any one time since, by its operation, relay 319 removes the ground from the chain circuit and from the right contacts of the corresponding relay of each succeeding switch of the group. Similarly, battery is connected to the winding of relay 449 of the last switch of the primary group and over the left back contact of relay 450 to the winding and left back contact of the corresponding relays of each preceding switch, finally connecting to the winding of relay 319 of the first primary switch of the group. The operation of relay 450, or of the corresponding relay of any intermediate switch, removes the battery from the windings of the relays corresponding to relay 319 and relay 419 in all switches preceding that switch on which relay 450, or its corresponding relay, operated.

With ground connected to the winding of relay 319 by the operation of relay 318, as hereinbefore set forth, and assuming that relays 420 and 450 are not operated at this time, relay 319 operates over the previously described chain circuit to battery on the left back contact and armature of relay 450. Relay 319, in operating, operates relay 320 in an obvious circuit, and removes the ground from the chain circuit extending over the right contacts of relay 419, corresponding relays of other intermediate switches, and right front contact of relay 449, thereby preventing the operation of relays 420 and 450 should a call be extended to switches P2 or P3 at this time. Relay 320, in operating, operates relays 321 and 322 locally, and operates relay 601 of the link-trunk selector LTS2 in a circuit from ground over the inner front contact of relay 301, lower contacts of the off-normal springs 306, right front contact of relay 320, left front contact of relay 319, brush 315 and second terminal of its associated bank, to battery through the winding of relay 601.

Relay 321, in operating, connects ground over its front contacts to conductors 326, 327 and 328, thereby grounding the lowest make contact of every set of contacts in the vertical and horizontal rows of switch P1. Relay 322, in operating, connects battery to the windings of horizontal magnets 323, 324 and 325. Relay 601, in operating, associates the trunks outgoing to the succeeding stage from the selected level of each secondary switch, in this case the second level since the digit 2 was dialed, with the link circuit selector LCS. Assuming that the trunk T12 is busy and has ground connected to its sleeve conductor 703 from the succeeding stage, the first link circuit selector relay 501 operates in a circuit from battery through its winding, over the fourth inner make contact of relay 601, conductor 602, to ground over sleeve conductor 703. Relay 501, in operating, opens the circuit over its back contact and the next-to-inner front contact of relay 601, to the winding of horizontal magnet 704 of switch S1, thereby preventing the operation of magnet 704 which would result in the subsequent connection to the busy trunk T12.

The winding of relay 503 is connected over the outer front contact of the previously operated relay 601, and over conductor 604, to the sleeve conductor 813 of trunk T18 of switch S3. Assuming that trunk T17 is idle, relay 503 does not operate since there is no ground on conductor 813. Upon the previous operation of relay 601, a circuit was closed from ground over the inner front contact of that relay to battery through the windings of the slow-to-operate relay 506 and the rotary magnet 507. The energizing of magnet 507 does not cause any operation since the mechanism of switch A is such that brush 508 does not step until its rotary magnet 507 is deenergized. Relay 506, operating after an interval, closes a circuit from ground over its front contact, brush 508, first terminal of its associated bank, conductor 504, armature and front contact of relay 501, armature and back contact of relay 503, conductor 505, third outer front contact of relay 601, conductor 603, to battery through the winding of horizontal magnet 804 of switch S3. Relay 506 is slow-to-operate to provide an interval sufficient for the selection of a link to a secondary switch having an idle trunk before ground is connected to conductor 504, thereby preventing the operation of the horizontal magnet of any other secondary switch.

Horizontal magnet 804, operating over the circuit previously traced, prepares the sets of contacts in the middle row of switch S3 for operation, and operates relay 805 in an obvious circuit. Relay 805, in operating, connects ground to the upper windings of vertical magnets 806, 807 and 808. As previously set forth, the operation of relay 322 associated with switch P1 connected battery to the windings of the horizontal magnets 323, 324 and 325 of that switch. With ground now connected to the windings of the vertical magnets of switch S3, a circuit is completed from ground through the upper winding of vertical magnet 806, over conductor 809, to battery through the winding of horizontal magnet 325 of switch P1, and these magnets operate in series. It will be obvious that, although battery is connected to the windings of horizontal magnets 323 and 324 of switch P1 at this time, these magnets cannot operate since they connect over conductors 329 and 330, to switches S1 and S2 respectively, and no ground is connected to the upper windings of vertical magnets of switches S1 and S2 at this time. Similarly, although the upper windings of all vertical magnets of switch S3 are grounded simultaneously, magnets 807 and 808 cannot operate since they connect to switches P2 and P3 respectively, over conductors 814 and 815, and no battery is connected to the horizontal magnets of switches P2 and P3 at this time.

The aforementioned operation of horizontal magnet 804 of switch S3, in addition to operating relay 805, also prepares the middle horizontal row of contact sets of that switch for operation. Therefore, upon the operation of vertical magnet 806, the middle set of contacts in the first vertical row of switch S3 operate. The operation of horizontal magnet 325 of switch P1 prepares the set of contacts in the lowest horizontal row in switch P1 for operation, and in addition, closes a circuit from ground over its front contact, left back contact of relay 305, left outer front contact of relay 313, lower inner front contact of relay 307, to battery over the inner back contact and through the winding of vertical magnet 302. Magnet 302,

in operating, locks over its inner front contact to ground over the upper inner front contact of relay 307 and, in addition, operates the lowest set of contacts in the first vertical row in switch P1, thereby extending the connection incoming to this stage over trunk T1 to the succeeding stage over outgoing trunk T18. The extended connection is traceable from the incoming tip conductor 304 and ring conductor 303 of trunk T1, over the cross-points 331 and 332, over conductors 333 and 334 respectively, over cross-points 810 and 816 of switch S3, to tip conductor 811 and ring conductor 812 respectively, of trunk T18.

Vertical magnet 302 of switch P1, in operating, also opens the circuit through the windings of relay 301 and causes that relay to release. Relay 301, in releasing, removes the ground over its inner front contact from the windings of relays 318 and 601, causing these relays to release. In addition, relay 301 in releasing removes the ground from the winding of slow-to-release relay 307, and energizes the level selector release magnet 317 in a circuit from battery through the winding of the magnet, upper make contact of springs 306, inner left front contact of relay 313, lower outer front contact of relay 307, to ground over the back contact of relay 301. Release magnet 317, in energizing, restores brushes 315 and 316 to their normal position and causes the off-normal contacts 306 to restore to the unoperated position. Relay 307, being slow-to-release, provides for holding vertical magnet 302 operated and for maintaining the busy ground on the sleeve conductor of trunk T1 until the selected trunk circuit of the succeeding stage has had time to function and return a ground for this purpose. This holding ground from the succeeding stage is traceable over sleeve conductor 813 of trunk T18, cross-point 817, conductor 818, cross-point 335 of switch P1, to sleeve conductor 308 to trunk T1, and over the inner front contact and through the winding of magnet 302 to battery. After an interval, relay 307 releases and removes the ground from conductor 336, this conductor having since been grounded from the succeeding stage as set forth above. Relay 307, in releasing, also opens the holding circuit for relay 313, opens the circuit through the winding of release magnet 317 of the level selector switch LS1, and removes the ground over its upper outer front contact and the next-to-inner back contacts of vertical magnets 309 and 310 from sleeve conductors 311 and 312 of trunks T2 and T3 thereby removing the busy condition from these trunks.

Relay 318, in releasing, opens the operating circuits for relays 313 and 319, causing these relays to release. Relay 319, in releasing, opens the circuit through the winding of relay 320 and again connects ground to the sequence relay chain circuit extending over the normally closed right contacts of relays, 319, 419 and 449. Relay 320, in releasing, releases relays 321 and 322. Relay 321, in releasing, removes the ground from conductors 326, 327 and 328. The purpose for which these conductors were grounded will be set forth in detail subsequently. Relay 322 in releasing, removes the battery from the windings of horizontal magnets 323, 324 and 325. Magnet 325 releases and the lowest set of contacts in the first vertical row of switch P1 are held in the operated position by vertical magnet 302 which is locked to ground from the succeeding stage.

Relay 601, releasing upon the release of relay 301 as previously described, opens the circuit through the windings of relays 501 and 506, winding of rotary magnet 507, and winding of horizontal magnet 804 of secondary switch S3. Relay 501 releases and closes, in part, the operating circuits for the horizontal magnets of switch S1. Magnet 804, in releasing, releases relay 805 which, in turn removes ground from the upper windings of vertical magnets 806, 807 and 808. The middle set of contacts in the first vertical row in switch S3 are now held operated under control of vertical magnet 806 which is locked through its lower winding to ground supplied over sleeve conductor 813 from the succeeding stage. Relay 506, in releasing, removes the ground from brush 508 of switch A. Rotary magnet 507, in deenergizing, causes brush 508 to step to the second contact of its associated terminal bank.

Allotter switch A which, together with the link circuit selector relays 501, 502 and 503, is common to the link-trunk selectors LTS1, LTS2 and LTS3. Each time a connection is extended through this stage, the release of the particular link-trunk selector relay used deenergizes rotary magnet 507 and the brush of switch A advances to the next lower terminal of its associated terminal bank. As it successively advances, one step for each extended connection, brush 508 perpares the operating circuits for the horizontal magnets of the first to tenth or last secondary switch consecutively, thereby changing the order of the first choice trunk in any group. In this foregoing manner, an even distribution of traffic through the groups of trunks outgoing from the various corresponding levels of the secondary switches is obtained.

Since only magnets 302 and 806 remain operated, the common equipment associated with the primary and secondary switches is ready to receive another incoming call. At the conclusion of the call extended through this stage from incoming trunk T1 over the outgoing trunk T18, ground is removed from sleeve conductor 813 by the succeeding stage thereby opening the locking circuits for magnets 302 and 806. Magnet 302, in releasing, restores the lowest set of contacts of the first vertical row in primary switch P1. Magnet 806, in releasing, restores the middle set of contacts of the first vertical row in secondary switch S3 and this group-selecting stage is thereby restored to normal. For calls incoming over trunks T4 to T6 inclusive, or over trunks T7 to T9 inclusive, primary switches P2 or P3, respectively, function in the same manner as set forth for switch P1. Similarly, secondary switches S1 and S2 function in the manner identical with the operation of switch S3. On a call incoming to switch P2 the operation of sequence relay 419 opens the chain circuit ground to prevent the operation of relay 449, on a simultaneous call incoming to switch P3, from operating relay 450. Similarly, the operation of relay 420 of switch P2 opens the operating circuit for relay 319, to prevent the operation of relays 319 and 320 on a simultaneous call incoming to switch P1. On a call incoming to switch P3, the operation of relay 450 opens the operating circuits for relays 319, 419 and corresponding relays of the other intermediate primary switches of the group (not shown).

As previously set forth, on a call being extended through this stage from primary switch P1, the operation of relay 319 opens the ground from the chain circuit extending over the nor-

mally closed right contacts of relays 319, 419 and 449. Assume another call, incoming to this stage over a trunk appearing in primary switch P2, before the call incoming to switch P1 is extended to the succeeding stage. In response to dial pulses over the trunk incoming to switch P2, level selector LS2 will step its brushes to the terminals of its associated bank, the number of steps taken corresponding to the dialed digit. Upon the first step of the brushes, the off-normal springs (not shown) of level selector LS2 operate and close the operating circuit for relay 419. Relay 419 operates but, since there is no ground on its right front contact, it does not cause relay 420 to operate. The call over switch P2 is not cut through to the link-trunk selector since ground over the right front contact of relay 420, and over brush 415, is required to complete the operating circuit for the link-trunk selector relay, such as relay 601. When the call incoming over switch P1 is extended to the succeeding stage, relay 319 releases and closes ground to the sequence chain circuit over its normally closed right contacts, thereby permitting relay 420 to operate. Relay 420, in operating, completes the operating circuit for the link-trunk selector relay associated with the particular level dialed, and the call incoming to switch P2 is extended in the manner identical with that hereinbefore described for the call incoming to switch P1.

On a call incoming over trunk T7, T8 or T9, the sequence relays 449 and 450 associated with switch P3 remain operated until the call has been extended to the succeeding stage. Relay 450, in operating, removes the battery over its left back contact from the chain circuit extending to the winding of relay 419, and over the left back contact of relay 420 to the winding of relay 319. Calls incoming at this time over trunks appearing in primary switches P1 and P2 are not connected through to a link-trunk selector circuit since relays 319 and 419 cannot operate. After the call incoming over switch P3 is extended to the succeeding stage, relays 449 and 450 release. Relay 450, in releasing, reconnects battery to the windings of relays 319 and 419. Relay 319 operates, in turn operating relay 320 thereby closing the operating circuit for the associated link-trunk selector relay over brush 315 of level selector LS1. The call incoming over switch P1 is now extended through the stage in the manner hereinbefore described. Relay 319, in operating, also removes ground from the chain circuit extending over the right contacts of relays 419 and 449. Therefore, following the release of relay 450, the operation of relay 419 does not operate relay 420. The call incoming over switch P2 now awaits the release of relay 319 before being connected to a link-trunk selector for extension through this stage.

When the lowest set of springs in the first vertical row in switch P1 operated during the extension of the call incoming over trunk T1 as hereinbefore set forth, a circuit was closed from the outer front contact of relay 321, over cross-point 337, conductor 338, to the next-to-outer armatures of link-trunk selector relays 509, 601 and 606, and to the winding of relay 819. However, since relay 321 released as soon as the connection incoming over trunk T1 was extended to the succeeding stage relay 819 did not operate. Assume now that with connection from trunk T1 to trunk T18 still established, another call, over trunk T3, is incoming to switch P1. Relay 339 operates over the circuit through the preceding stages and over the subscribers' loop in the same manner as previously described for relay 301. Relay 339, in operating, operates relay 340. Relay 340, in operating, connects ground over its upper inner front contact to the sleeve conductor 312 of trunk T3 and also connects ground over its upper outer front contact to sleeve conductor 311 of trunk T2, thereby making these trunks busy to the preceding stage. Trunk T1, which at this time is already in use, has its sleeve conductor 308 grounded from the succeeding stage over a previously traced circuit.

Assume that on this call incoming over trunk T3, the digit 0 is dialed into this stage. Relay 339 therefore releases and reoperates ten times in response to the ten dial pulses corresponding to the digit 0. Under control of ground pulses over the back contact of relay 339, over the lower outer front contact of relay 340 and left back contact of relay 313, rotary magnet 314 advances brushes 315 and 316 of the level selector LS1 to the tenth contacts of their associated terminal banks. Upon the operation of the off-normal springs 306, relay 318 operates in a circuit from battery through its winding, over the lower contacts of springs 306, to ground over the inner front contact of relay 339. Relay 318, in operating, operates relay 313 locally, and, providing that no other call is being extended through any other primary switch of the group, operates relay 319 over a previously traced chain circuit. Relay 319, in operating, operates relay 320 locally. Relay 320, in operating, operates relays 321 and 322 locally, and operates relay 606 of link-trunk selector circuit LTS3 in a circuit from ground over the inner front contact of relay 339, lower contacts of springs 306, right front contact of relay 320, left front contact of relay 319, brush 315 and tenth terminal of its associated terminal bank, conductor 341, to battery through the winding of relay 606. Relay 321, in operating, connects ground over conductors 326, 327 and 328 to the lowest make contact of each set of contacts in switch P1. Relay 322, in operating, connects battery to the windings of horizontal magnets 323, 324 and 325. Relays 606, in operating, associates the trunks outgoing to the succeeding stage from the lowest level (which corresponds to the dialed digit 0) of each secondary switch with the link circuit selector LCS.

Assume that, at this time, trunks T13 and T16 of switches S1 and S2, respectively, are both busy. Upon the operation of relay 606 therefore, relays 501 and 502 operate since the trunks associated with these relays are busy. The circuit for relay 501 may be traced from battery through the winding of the relay, fourth inner front contact and armature of relay 606, over conductor 607, to ground from the succeeding stage over sleeve conductor 705 of trunk T13. Relay 502 operates in the circuit from battery through its winding, over the seventh inner front contact and armature of relay 606, conductor 608, to ground from the succeeding stage over sleeve conductor 820 of trunk T16.

Trunk T19 of the last secondary switch of the group is assumed idle at this time but, since the link consisting of conductors 333, 334 and 818, which interconnects primary switch P1 with secondary switch S3 is being used on the call extending from incoming trunk T1 to outgoing trunk T18 as hereinbefore set forth, trunk T19 is therefore unavailable even though idle. Relay 503 operates in a circuit from battery through its

winding, over conductor 510, next-to-outer front contact and armature of relay 606, conductor 338, cross-point 337, conductor 326, to ground over the outer front contact of relay 321. Relay 819 also operates in a circuit from battery through its winding to the ground on conductor 338, the circuit for which has just been traced. Relays 501, 502 and 503, in operating, open the circuits to horizontal magnets 706, 821 and 824 of secondary switches S1, S2 and S3 respectively, to prevent the operation of these magnets upon the operation of the slow-to-operate relay 506 the circuit for which was closed by the operation of relay 606.

With trunks T13 and T16 busy, and trunk T19 unavailable since its associated link to switch P1 is in use, a chain circuit is closed from ground on conductor 707, over the two lowest cross-points of whichever set of contacts in the lowest horizontal row in switch S1 is operated, over conductor 708, the two lowest cross-points of whichever set of contacts in the lowest horizontal row in switch S2 is operated, over conductor 822, outer make contact and armature of relay 819, conductor 823, tenth contact terminal and brush 316 of level selector LS1, through the right winding of relay 305, to battery over the right inner front contact of relay 318. Relay 305 operates in this aforementioned circuit and locks through its left winding from battery over the right outer front contact of relay 313, its left winding and left front contact, to ground over the lower middle front contact of relay 340. Relay 305, in operating, removes the direct ground over its left outer back contact from the lower winding of relay 339 and connects ground through the left winding of transformer 342, over its left outer armature and front contact to that point instead. The right winding of transformer 342 connects to a source of a characteristic busy tone over conductors 343 and 344. This busy tone is induced in the left winding of transformer 342 and thence to the calling subscriber since relay 339 is operated over the calling subscribers' loop. Relay 305, in operating also opens the operating circuit for relay 319. Relay 319, in releasing, releases relay 320, connects ground over its normally closed right contacts to the sequence chain circuit extending through the other primary switches of the group, and, in addition, opens the operating circuit for relay 606 which releases. Relay 320, in releasing, releases relays 321 and 322. Relay 321, in releasing, removes ground from conductors 326, 327 and 328 thereby releasing relay 819 which was being held operated by the ground on conductor 326 over cross-point 337 and conductor 338. Relay 322, in releasing, opens the circuits from battery to horizontal magnets 323, 324 and 325. Relay 606, in releasing, opens the circuits through the windings of relays 501, 502, 503 and 506, all of which release, thereby restoring the link-trunk selector LTS3 and the link selector LCS to normal. The release of relay 819 opens the chain circuit between conductors 822 and 823. Relays 305, 313, 318, 339 and 340 remain operated pending disconnection.

When the calling subscriber replaces the receiver on the switchhook upon receipt of the tone signal indicating that all paths are busy, relay 339 releases due to the opening of the subscriber's loop by the switchhook contacts. With relay 339 released, release magnet 317 of the level selector LS1 is energized from battery through its winding, over the upper contacts of springs 306, left inner front contact of relay 313, lower outer front contact of slow-to-release relay 340, to ground over the back contact of relay 339. The energizing of magnet 317 causes brushes 315 and 316 to return to normal at which time springs 306 restore to their unoperated position, thereby opening the circuits through the windings of relay 319 and release magnet 317. Relay 339, in releasing, also opens the circuit through the winding of relay 340. Relay 340, in releasing, opens the locking circuits through the winding of relay 313 and the left winding of relay 305 causing relays 305 and 313 to release. The release of relay 340 also removes the ground over its upper front contacts from the sleeve conductors 311 and 312 of trunks T2 and T3 respectively, and these trunks may now be selected in the preceding stage by another call.

Relays 709 and 825, associated with secondary switches S1 and S2 respectively, perform the same function as hereinbefore described for relay 819 of switch S3. On a call being extended over any primary switch, relay 709 operates if the link between that primary switch and secondary switch S1 is in use. Similarly relay 825 operates if the link between that primary switch and secondary switch S2 is in use. The contacts of relays 709 and 825 parallel the two lower multiple cross-points in each horizontal row of contact sets in secondary switches S1 and S2 respectively. The operation of either relay 709 or 825 causes the all-trunks-busy chain circuit to be extended over secondary switch S1 or S2 since the outgoing trunk in the desired level, although not busy, is unavailable due to its associated link being in use. Whenever all trunks outgoing from any level of the secondary switches are busy, or unavailable due to busy links, the all-trunks-busy chain circuit is completed over the entire secondary switch group and provides for the operation of relay 305 of switch P1 or the corresponding relay of any other primary switch being used, and a busy tone is returned to the calling subscriber in the manner hereinbefore described.

What is claimed is:

1. In a telephone system, a plurality of group-selecting stages, means for sending successive series of impulses directly to the successive stages, primary and secondary switches at each of said stages, each of said switches comprising rows of separately operable contacts and coacting bars for operating the same, and means responsive to the impulses incoming to a stage for selectively operating the bars of the primary and secondary switches thereat.

2. In a telephone system, a plurality of selecting stages each comprising a number of primary and a number of secondary cross-bar switches, links interconnecting each primary and each secondary switch, means for sending successive series of designation impulses directly to the successive stages, and means responsive to the impulses incoming to a stage for selectively operating the primary and secondary switches thereat.

3. In a telephone system, a plurality of selecting stages each comprising a number of primary and a number of secondary cross-bar switches, links interconnecting each primary and each secondary switch, a plurality of groups of trunks outgoing from the secondary switches, each group having trunks appearing in a plurality of said secondary switches, means for sending successive series of designation impulses directly to the successive stages, and means responsive to the impulses incoming to a stage for selectively operating the primary and secondary switches thereat.

4. In a telephone system, a series of group-selecting stages each comprising a plurality of primary and a plurality of secondary cross-bar switches, impulse receiving mechanism associated with each of said stages, means for sending the successive series of impulses of a wanted designation directly to the impulse receiving mechanisms at the corresponding stages, and means responsive to the receiving mechanism at each stage for selectively operating the primary and secondary switches thereat.

5. In combination, serially related group-selecting stages each comprising a plurality of primary and a plurality of secondary cross-bar switches, a plurality of trunks incoming to each of said primary switches, impulse receiving mechanisms, each serving to receive the impulses incoming over any one of the trunks appearing in a primary switch, means for sending the successive series of impulses of a wanted number directly to the mechanisms at the corresponding stages, and means controlled by said mechanisms for operating the primary and secondary switches at the respective stages.,

6. In combination, serially related group-selecting stages each comprising a plurality of primary and a plurality of secondary cross-bar switches, a plurality of trunks incoming to each of said primary switches, impulse receiving mechanisms, each serving to receive the impulses incoming over any one of the trunks appearing in a primary switch, means for sending the successive series of impulses of a wanted number directly to the mechanisms at the corresponding stages, means effective when impulses are being received over one of said trunks for rendering busy all other trunks incoming to the same primary switch, and means controlled by said mechanisms for operating the primary and secondary switches at the respective stages.

7. In combination, a group selecting stage comprising a plurality of primary and a plurality of secondary cross-bar switches, groups of incoming trunks, each group appearing in a separate one of said primary switches, trunks outgoing from said secondary switches, links interconnecting the primary and secondary switches, impulse receiving devices individual respectively to said primary switches and responsive to a call on one of the incoming trunks for selectively operating the corresponding primary switch and one of said secondary switches to extend the call to an outgoing trunk and means effective when a number of incoming calls appear simultaneously for causing said calls to be extended one at a time through said switches to the outgoing trunks.

8. In a telephone system, a group-selecting stage comprising a plurality of primary and a plurality of secondary switches, trunks incoming to said primary switches, trunks outgoing from said secondary switches, link circuits interconnecting each primary switch with each of the several secondary switches, and means for testing the outgoing trunks and the link circuits comprising a test circuit extending to each of said outgoing trunks and a test circuit for each of the link circuits extending through contacts of the corresponding primary switches.

9. In a telephone system, a group-selecting stage having primary switches and secondary switches thereat, trunks incoming to the primary switches, trunks outgoing from the secondary switches, link circuits, each primary switch having one of said link circuits extending to each of the secondary switches, test relays for testing the condition of said outgoing trunks and the condition of said link circuits, a test circuit for each outgoing trunk extending to the winding of a particular test relay corresponding thereto, a test circuit for each of the links having access to such outgoing trunk extending to the winding of said relay, and means for closing the test circuit of any one of said links through contacts of the corresponding primary switch.

10. In a telephone system, a group-selecting stage comprising a plurality of primary cross-bar switches and a plurality of secondary cross-bar switches, link circuits interconnecting said primary and secondary switches, operating magnets for said primary switches, each magnet individual to a particular one of said link circuits, operating magnets for said secondary switches, each magnet individual to a particular one of said link circuits, and means for applying a source of potential to a plurality of magnets at said secondary switches and to a plurality of magnets at said primary switches to cause the simultaneous operation in a series circuit of a desired magnet at the secondary switch and a desired magnet at the primary switch.

11. In a telephone system, a plurality of primary cross-bar selector switches, a plurality of secondary cross-bar selector switches, links interconnecting said switches, each primary switch having one of said link circuits extending to each of said secondary switches, operating magnets at said primary switches individual to the respecive link circuits, operating magnets for the secondary switches individual to the respective link circuits, a source of battery potential, means for applying one pole of said battery to the windings of the secondary magnets for all link circuits incoming to a particular secondary switch, and means for applying the opposite pole of battery to the windings of the magnets of the primary switches individual to the respective link circuits extending to said particular secondary switch.

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