April 14, 1936. H. H. ABBOTT ET AL 2,037,106

TELEPHONE SYSTEM

Filed Sept. 1, 1933 7 Sheets-Sheet 1

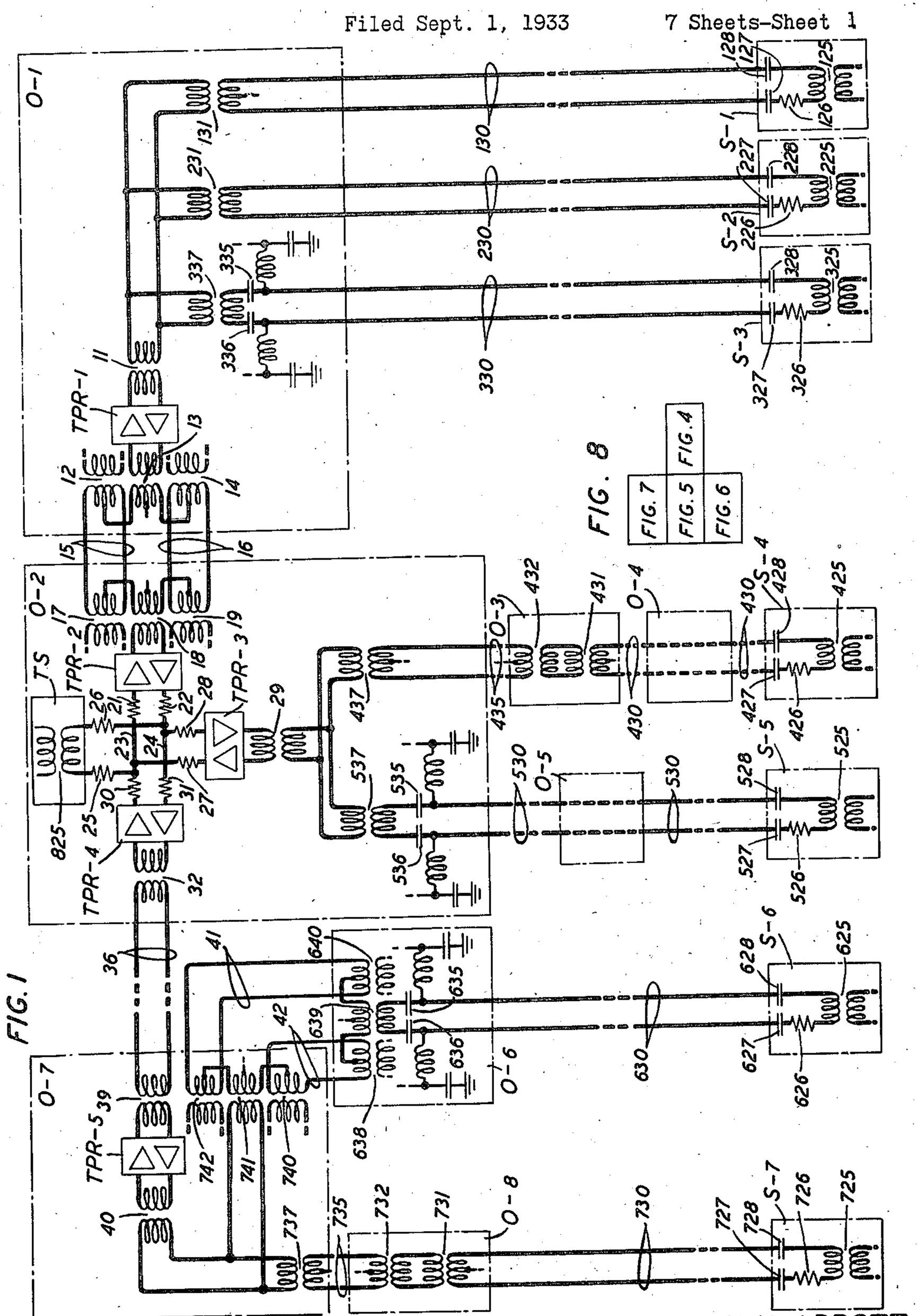

FIG. 1

FIG. 8

FIG. 7	FIG. 5	FIG. 6
		FIG. 4

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TELEPHONE SYSTEM

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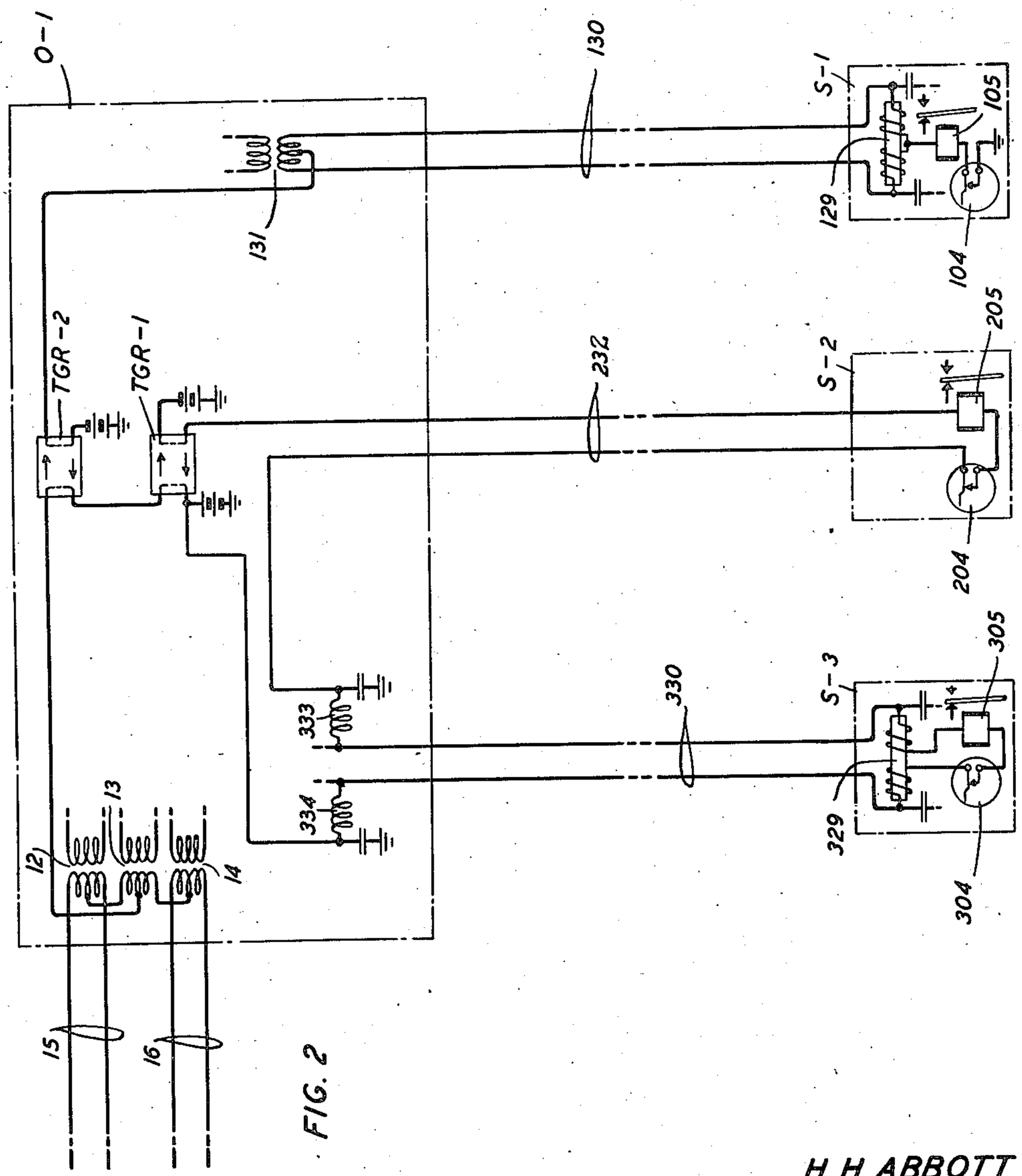

FIG. 2

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TELEPHONE SYSTEM

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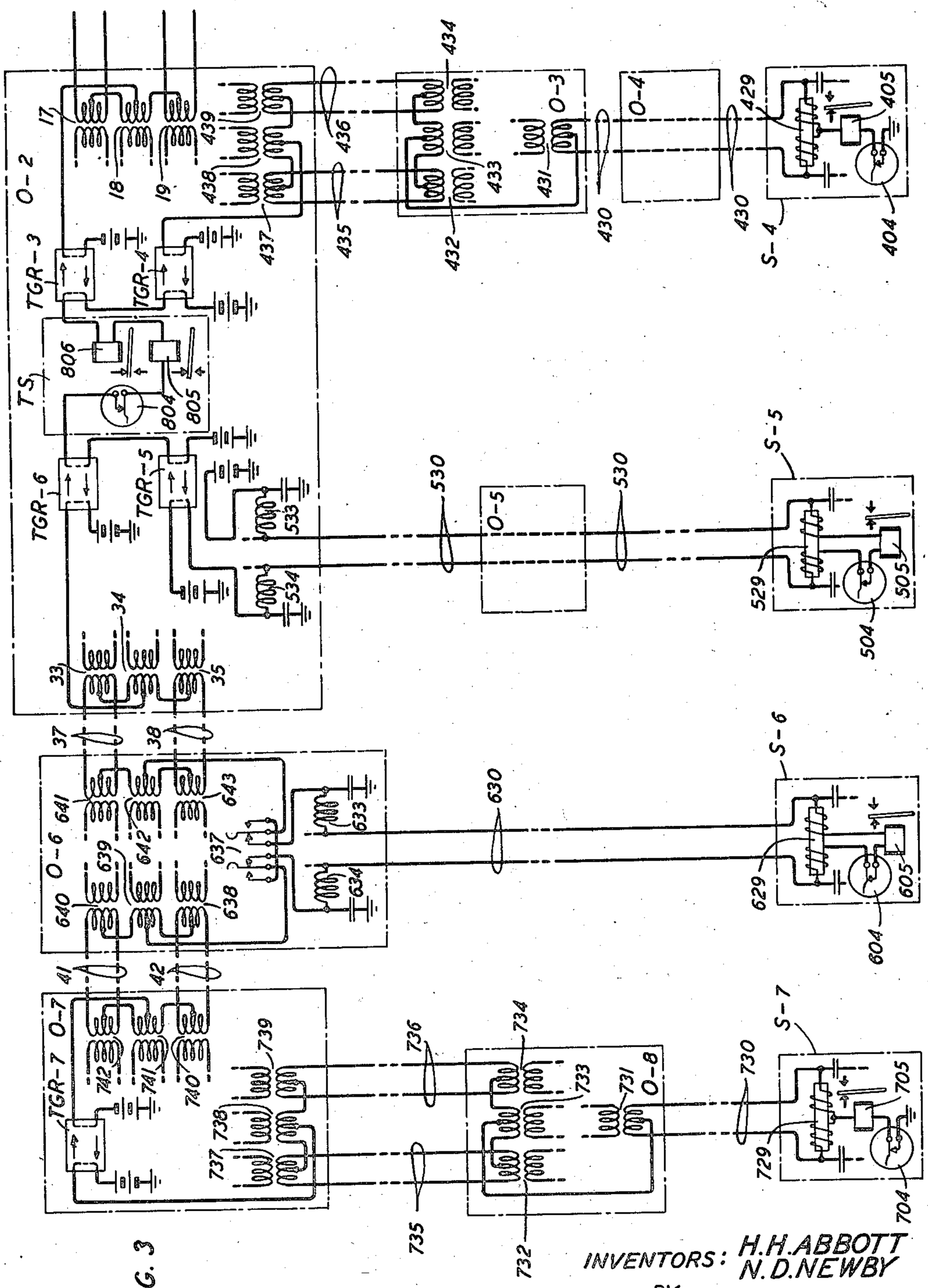

FIG. 3

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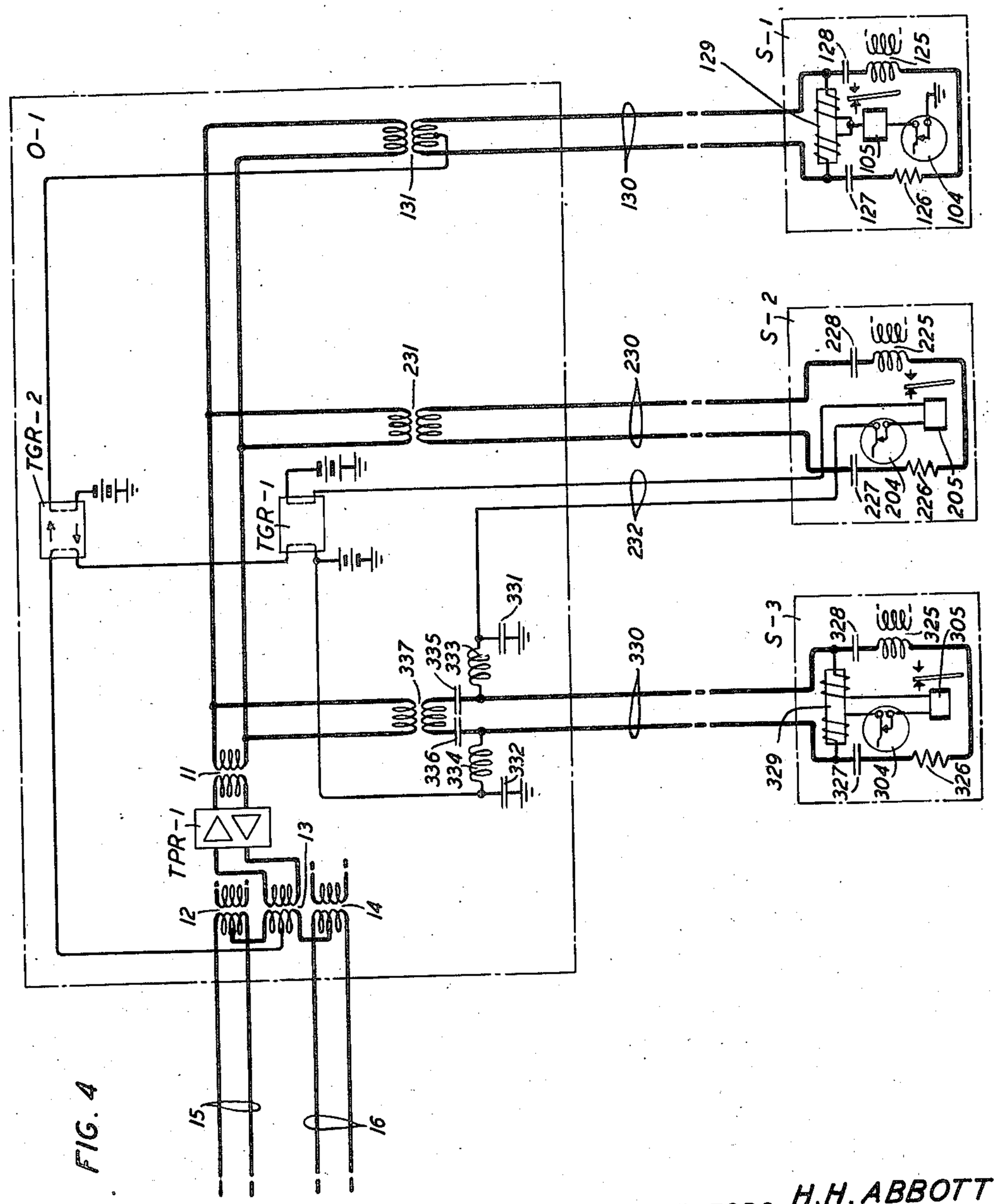

FIG. 4

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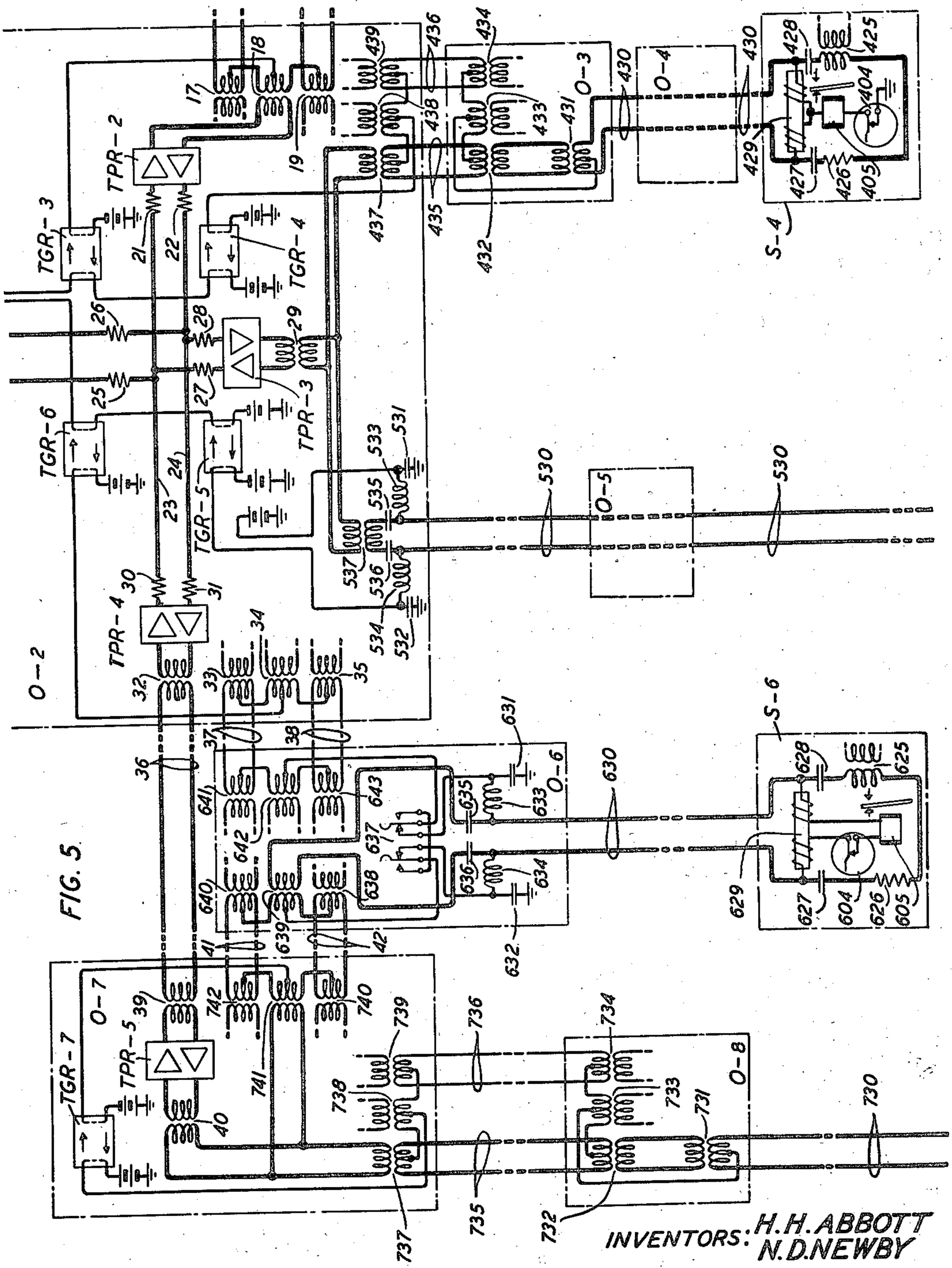

FIG. 5

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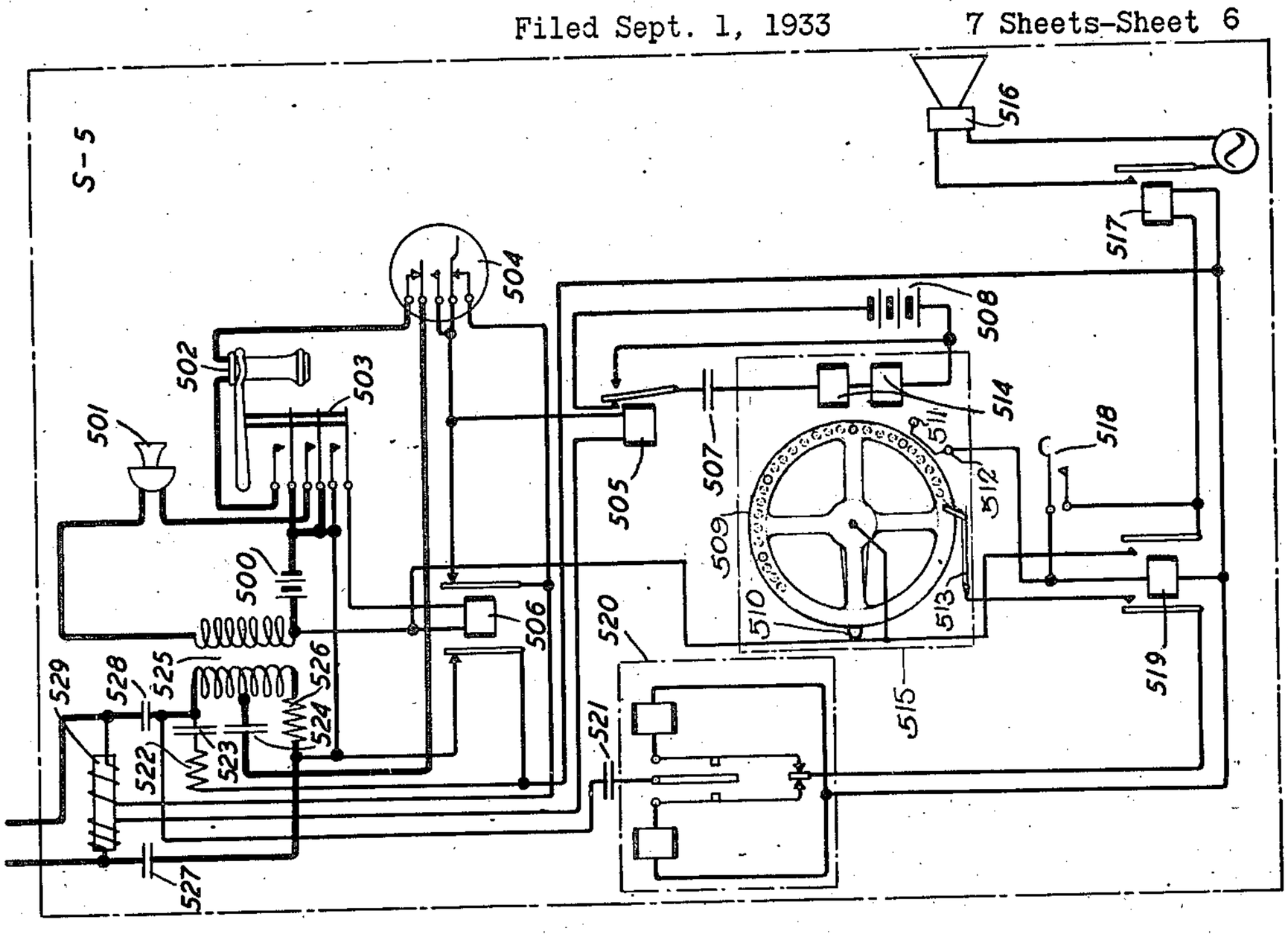
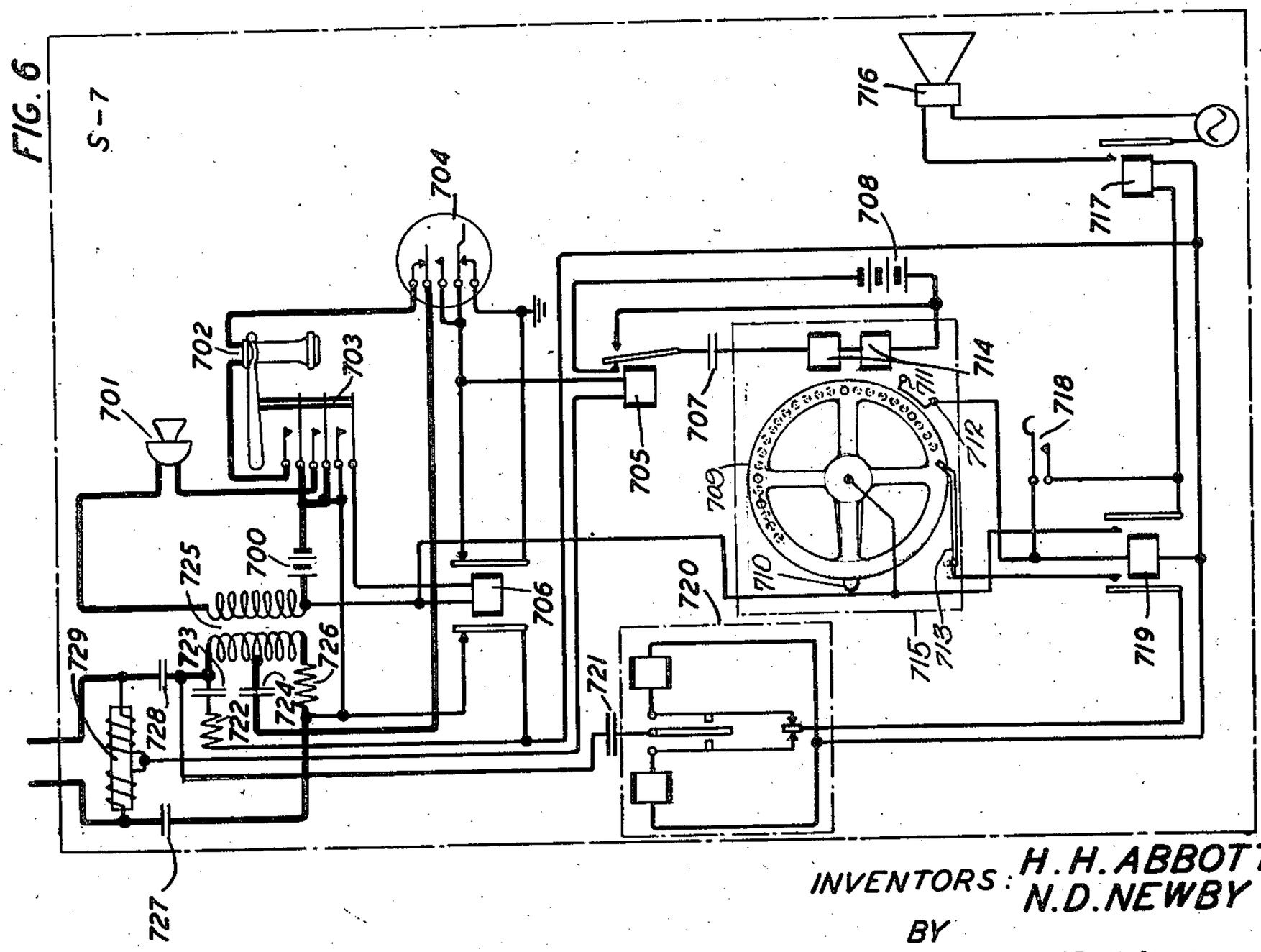


FIG. 6



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TELEPHONE SYSTEM

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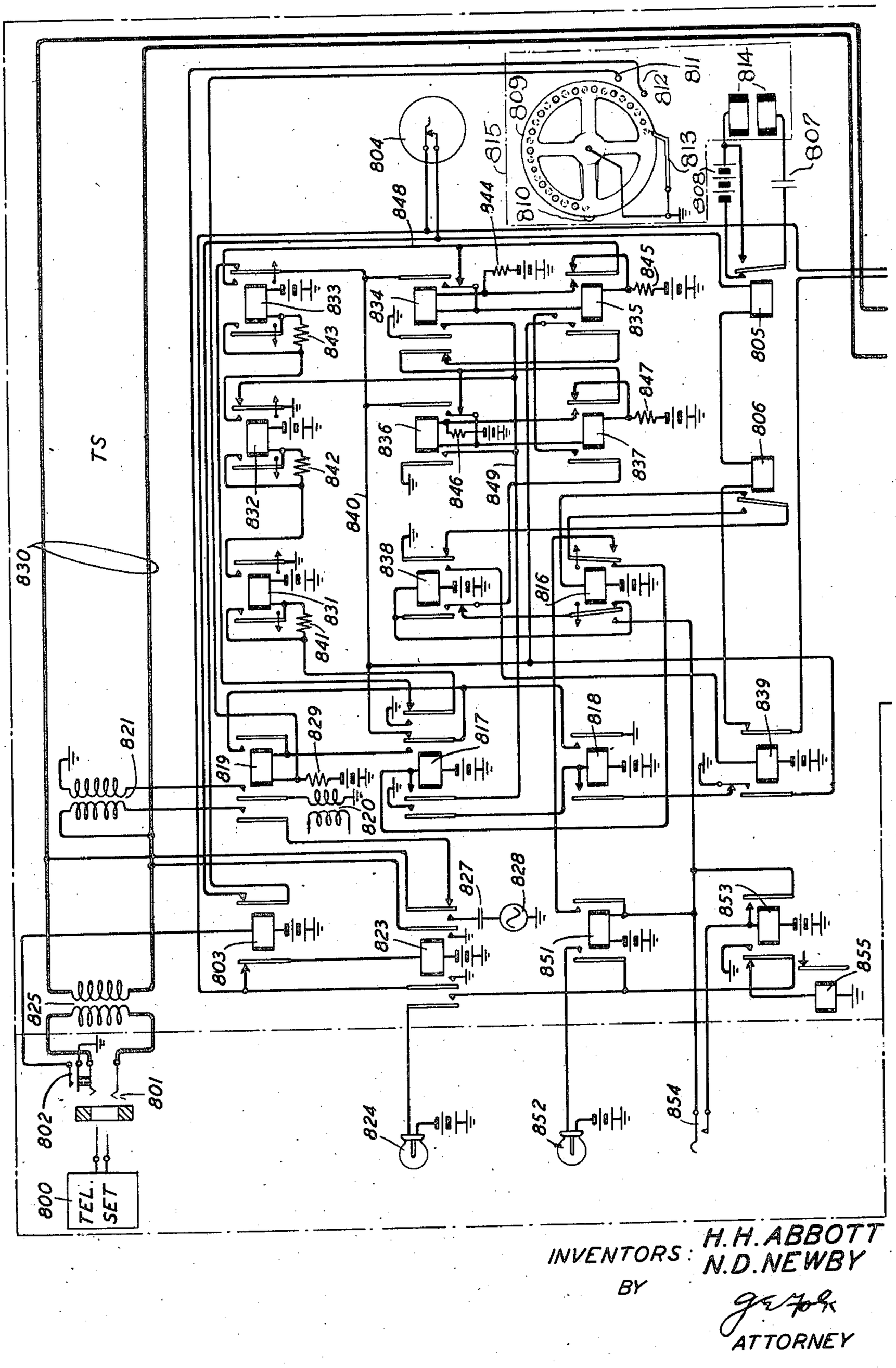
FIG. 7



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Patented Apr. 14, 1936 2,037,106

UNITED STATES PATENT OFFICE

2,037,106

TELEPHONE SYSTEM

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Application September 1, 1933, Serial No. 687,871

27 Claims. (Cl. 179—3)

This invention relates to telephone systems and more particularly to private automatic systems.

The object of the invention is to provide improved equipment and circuit arrangements for private telephone systems.

This invention is a private toll line system comprising a plurality of stations interconnected by toll lines, either physical or phantom. Each station is equipped with a dial for calling a desired station and with a selector responsive to impulses received from any other station for closing the ringing circuit when called. The dial impulses are transmitted over a telegraph circuit simplexed or composited on the same, or a different, toll-line channel as that which carries the talking circuit. Telephone and telegraph repeaters are employed at the junction points between two or more sections of the toll-line. Each station may be called from any of the other stations by dialing the number of the desired station; or any station may call all of the other stations simultaneously by dialing the proper number.

According to a feature of the invention a timing and alarm circuit is provided at a test station for connecting a busy tone to the talking circuit as soon as the first digit of a number has been dialed at one station to inform any one removing the receiver at any other station that the line is being used even though conversation is not heard. The tone is disconnected as soon as the dialing of a station number is completed or, if dialing is not completed, at the end of a fixed interval after dialing ceases. The timing and alarm circuit is also effective at the end of a certain interval of time after dialing is completed to automatically transmit a single impulse over the signaling circuit to effect the restoration of the selectors at all stations to normal. Upon restoration of the selector at the called station the ringing circuit is opened but an auxiliary bell may be provided for giving a continuous signal until the call is answered. According to a further feature a trouble alarm is sounded at the test station in case the signaling circuit goes open.

The drawings which form a part of this specification represent schematically the talking network of a system arranged in accordance with this invention, the signaling network of a system arranged in accordance with this invention, and a combined signaling and talking network of a system arranged in accordance with this invention.

Referring to the drawings:

Figure 1 shows the talking network of a private toll-line system comprising seven subscribers' stations and a test board station;

Figs. 2 and 3 show a signaling network for a system of seven subscribers' stations and a test board station;

Figs. 4 and 5 show a combination of the talking and signaling networks shown in Figs. 1, 2, and 3;

Fig. 6 shows the station equipment and circuit connections at two of the stations of the system;

Fig. 7 shows the test board station and the timing and alarm apparatus common to all of the stations of the system;

Fig. 8 shows how Figs. 4 to 7 inclusive are to be placed with respect to each other to form an operative system.

The system shown in Fig. 1 comprises the seven subscribers' stations S—1, S—2, S—3, S—4, S—5, S—6, and S—7 and the test board station TS interconnected for talking each with the other by toll lines terminating in eight toll offices. All apparatus other than that necessary for a complete talking network has been omitted. The station apparatus of stations S—5 and S—7 being shown in full in Fig. 6, only the talking condensers and induction coils are shown within each of the enclosures representing the stations in Fig. 1. Stations S—1, S—2, and S—3 are connected by lines 130, 230, and 330 with the toll office O—1; station S—4 is connected by line 430 to and through toll office O—4 to toll office O—3; station S—5 is connected by line 530 to and through toll office O—5 to toll office O—2; station S—6 is connected by line 630 with toll office O—6; and station S—7 is connected by line 730 with toll office O—8. The lines leading to the various stations may be local office lines or may be toll lines; in the latter case the line may pass through one or more intermediate toll offices such as O—4 and O—5. The phantom circuit over the two physical toll lines 15 and 16 constitutes the talking channel of the system between toll office O—1 and toll office O—2; the toll line 435 constitutes the talking channel of the system between toll offices O—2 and O—3; the toll line 36 constitutes the talking channel of the system between toll offices O—2 and O—7; the phantom circuit over the two physical toll lines 41 and 42 constitutes the talking channel of the system between toll offices O—6 and O—7; and the toll line 735 constitutes the talking channel of the system between toll offices O—7 and O—8. These various talking channels are connected through repeating coils and telephone repeaters in the various toll offices to form the talking network between the eight stations.

In toll office O—1 the toll lines 15 and 16 terminate in repeating coils 12 and 14, and the talking network of the system extends through repeating coil 13, telephone repeater TPR—1, to repeating coil 11 and thence in parallel through repeating coils 337, 231, and 131 to lines 330, 230, and 130; the coil 337 is part of a composite set, condensers 335 and 336 completing the talking connection with line 330. In toll office O—2 the toll lines 15 and 16 terminate in repeating coils 17 and 19; and the talking network of the system extends through repeating coil 18, telephone repeater TPR—2 and resistances 21 and 22 to the talking-bus conductors 23 and 24. From bus conductors 23 and 24, one talking path extends through resistances 25 and 26 to the test board station TS in office O—2; another talking path extends through resistances 27 and 28 and telephone repeater TPR—3 to repeating coil 29; and another talking path extends through resistances 30 and 31 and telephone repeater TPR—4 to repeating coil 32. From repeating coil 29, one talking path extends through repeating coil 437, over toll line 435 to office O—3, and through repeating coils 432 and 431 in office O—3 to line 430; and a second talking path extends through repeating coil 537, and through condensers 535 and 536 of a composite set, to line 530. From repeating coil 32, the talking network extends over toll line 36, through repeating coil 39 and telephone repeater TPR—5 in office O—7 to repeating coil 40. From repeating coil 40, one talking path extends through the phantom repeating coil 741, through repeating coils 740 and 742 terminating the toll lines 41 and 42 in office O—7 and repeating coils 638 and 640 terminating the toll lines 41 and 42 in office O—6, through the phantom repeating coil 639 and condensers 635 and 636 of a composite set in office O—6 to line 630; another talking path extends through repeating coil 737, over toll line 735 to office O—8, through repeating coils 732 and 731, to line 730. The repeating coils 131, 13, 18, 431, 432, 437, 639, 731, 732, 737, and 741 are each shown as having a middle tap, on the outside winding, for connection to a telegraph or other direct-current signaling circuit such for instance as the signaling network of the private toll line system for which Fig. 1 shows the talking network. Any other arrangement and combination of toll lines and talking channels by which efficient and balanced transmission is obtained might constitute the talking network for a private toll line system similar to that shown in Fig. 1.

The sysem shown in Figs. 2 and 3 comprises the same seven subscribers' stations S—1, S—2, S—3, S—4, S—5, S—6, and S—7, and test board station TS as are shown in Fig. 1, interconnected for signaling each other over toll lines which terminate in the same toll offices as are shown in Fig. 1. All apparatus other than that which is necessary for a complete signaling network has been omitted. The station apparatus for stations S—5 and S—7 being shown in full in Fig. 6 and the test board station apparatus being shown in full in Fig. 7, only the signal receiving relay and signal transmitting means (dial) are shown in each of the enclosures representing the stations in Figs. 2 and 3. Single line telegraph repeaters TGR—1, TGR—2, TGR—3, TGR—4, TGR—5, TGR—6 and TGR—7 are provided in offices O—1, O—2, and O—7 for repeating signaling impulses from one or more of the branches of the network to all other branches. These repeaters may be similar to that shown in Fig. 91 and described on pages 192, 193, and 194 of "Toll Telephone Practice" by Thiess and Joy, published in 1912. The dial impulses are variously transmitted in a simplex circuit over a line or toll line, in a phantom simplex circuit over two lines, or in a loop circuit; all signaling branches are normally closed and the impulse receiving relays are, therefore, normally operated. The signaling branch for station S—1 is a simplex circuit from signaling battery at the telegraph repeater TGR—2 in office O—1, through the lower winding of coil 131 and both sides of line 130 in parallel, through both windings of the impedance coil 129, winding of impulse receiving relay 105, and through the impulse contacts of dial 104 to ground. The signaling branch for stations S—2 and S—3 is a loop circuit from negative signaling battery through the right side of telegraph repeater TGR—1 over one conductor of line 232 to station S—2, through the winding of impulse receiving relay 205 and the impulse contacts of dial 204, back over the other conductor of line 232 to office O—1, through retard coil 333 of a composite set, out over one conductor of line 330 to station S—3, through the right winding of impedance coil 329, winding of impulse receiving relay 305, impulse contacts of dial 304, left winding of impedance coil 329, back over the other conductor of line 330 to office O—1, through retard coil 334 of the aforementioned composite set, to positive signaling battery at repeater TGR—1. Line 232 is used only for signaling but line 330 may, due to its termination at a composite set in office O—1, be used for both talking and signaling. The signaling circuit from office O—1 to office O—2 is traced from positive signaling battery through the left side of telegraph repeater TGR—1, the left side of telegraph repeater TGR—2, through the outside windings of repeating coils 13, 12, and 14, out over the four conductors of toll lines 15 and 16 in parallel to office O—2, through the outside windings of repeating coils 17, 19 and 18, and through the right side of telegraph repeater TGR—3 to negative signaling battery. The signaling circuit for station S—4 is from negative signaling battery through the right side of telegraph repeater TGR—4 in office O—2, through the outside windings of repeating coils 438, 437, and 439, out over the four conductors of toll lines 435 and 436 in parallel to office O—3, through the outside windings of repeating coils 432, 434, and 433, through the outside winding of repeating coil 431, out over both conductors of line 430 in parallel, through office O—4 to station S—4, through both windings of impedance coil 429, winding of impulse receiving relay 405, and through the impulse contacts of dial 404 to ground. The signaling circuit for the test board station TS in office O—2 is from positive battery through the left side of telegraph repeater TGR—4, left side of telegraph repeater TGR—3, through the windings of the impulse receiving relays 806 and 805 and impulse contacts of the dial 804, through the right side of telegraph repeater TGR—6 and through the right side of telegraph repeater TGR—5 to negative signaling battery. The signaling circuit for station S—5 is from negative signaling battery through the left side of telegraph repeater TGR—5, through retard coil 534 of a composite set, out over one conductor of line 530, through office O—5, to station S—5, through the left winding of impedance 529, impulse contacts of dial 504, winding of impulse

receiving relay 505, right winding of impedance 529, back over the other conductor of line 530, through office O—5 to office O—2, and through retard coil 533 of the composite set to positive signaling battery. The signaling circuit for station S—6 is from positive signaling battery through the left side of telegraph repeater TGR—6, outside windings of repeating coils 34, 33, and 35, over the four conductors of toll lines 37 and 38 in parallel to office O—6, through the outside windings of repeating coils 642, 641, and 643, through the right normally closed contacts of key 637, through retard coil 633 of a composite set, over one conductor of line 630 to station S—6, through the right winding of impedance 629, winding of impulse receiving relay 605, impulse contacts of dial 604, left winding of impedance 629, back over the other conductor of line 630 to office O—6, through retard coil 634 of the composite set, left normally closed contact of key 637, outside windings of repeating coils 639, 638, and 640, over the four conductors of toll lines 41 and 42 in parallel to office O—7, through the outside windings of repeating coils 741, 740, and 742, and through the right side of telegraph repeater TGR—7 to negative signaling battery. The signaling circuit for station S—7 is from positive signaling battery through the left side of telegraph repeater TGR—7, the outside windings of repeating coils 738, 737, and 739, over the four conductors of toll lines 735 and 736 in parallel to office O—8, through the outside windings of repeating coils 733, 732, and 734, through the outside winding of repeating coil 731, over the conductors of line 730 in parallel to station S—7, through both windings of impedance 729 in parallel, winding of impulse receiving relay 705, and through the impulse contacts of dial 704 to ground. It is aparent that all of the signaling branches are normally closed so that the impulse receiving relays of all stations are normally operated. The operation of the signaling apparatus is unaffected by the removal of the receiver at any other station, but dialing is ineffective unless the receiver has been removed at the calling station.

In addition to the impulse receiving relay and dial, the signaling apparatus at each station includes a selector of the type commonly employed in train dispatching telephone systems, a ringer, a signal horn, and controlling relays for the ringer and horn. (See Fig. 6.) For a description of the construction and operation of such a selector, reference may be had to the patent to J. C. Field, No. 1,343,256, granted June 15, 1920. Since this type of selector is arranged to operate in response to reversals of current through its windings, the impulse receiving relay in its operated position charges a condenser in series with the selector magnets and in its non-operated position discharges the condenser through the selector magnets, causing the advance of the selector two steps for each signal impulse received. The station dials are, therefore, arranged to send only half as many impulses as there are units in the digit dialed, and all station numbers are composed of even digits. Twenty-four steps being required for the closing of the local signaling circuit at any station, the station codes are made up of three or more digits, the sum of which equals 24 (0 being counted as 10). The code wheel of each selector is, therefore, provided with pins in positions corresponding to the number of the station at which the selector is located; these pins are effective to hold the code wheel in advanced position after the dialing of the particular digit or combination of digits which have caused the advance. For instance, if the station number is 4802 the pins would be located in the fourth, twelfth, twenty-second and twenty-fourth code-wheel pin holes. Although the selectors at all stations will step as each number is dialed, only the one with the code pins set in positions corresponding to the particular digits dialed will be advanced to the twenty-fourth position; all other selectors will revolve back to normal after some one or more of the digits since there will be no code pin at some one or more of the corresponding positions to retain the code wheel. In order that all stations may be simultaneously signaled, the code wheels of all selectors are provided with pins in the fourth and fourteenth positions in addition to the positions which correspond to the stations' individual numbers, so that the dialing of 400 is effective to close the local signaling circuit at all stations. The test-board station TS includes, for signaling purposes, (as shown in Fig. 7) two impulse receiving relays 805 and 806, a selector 815, an incoming call lamp 824, a dial 804 and a number of control relays. The selector 815 is similar to that at each of the subscribers' stations except that there is a retaining pin in every even numbered position up to and including the twenty-sixth. This arrangement results in the selector being retained in advanced position in response to the dialing of each digit of all station numbers and results in the lighting of the incoming line lamp 824 whenever the test board number (any number whose digits total 26, such as 006), is dialed at any of the subscribers' stations. The test-board station TS also includes timing and alarm apparatus common to all of the stations of the system, arranged to connect a busy-tone to the talking network upon the first digit of a number being dialed at any station, to disconnect the busy-tone when the dialing of a number is completed, to connect a ringing tone to the talking network when the line lamp is lighted on incoming calls, and arranged to open the test-board station branch of the signaling network to cause the return of all selectors in the system to normal. The operation of the signaling apparatus at the test board station will be further described below in connection with the detailed description of the system shown in Figs. 4, 5, 6, and 7. Any other arrangement and combination of toll lines and signaling channels by which all stations are permanently connected for receiving direct-current signaling impulses from any other station and for transmitting such impulses from each station to all other stations simultaneously might constitute the signaling network for a private toll line system similar to that shown in Figs. 2 and 3.

The system shown in Figs. 4, 5, 6, and 7, also comprises the same eight stations S—1, S—2, S—3, S—4, S—5, S—6, S—7, and TS as are shown in Fig. 7 and in Figs. 2 and 3, the combined talking and signaling networks being but one of any number of possible combinations of talking and signaling channels for interconnecting these stations. The station apparatus and circuit connections are completely shown for stations S—5 and S—7; but only the signal receiving relay, the dial and the talking circuit induction coil are shown within the enclosures representing stations S—1, S—2, S—3, S—4, and S—6, all other apparatus being omitted. The lines connecting stations S—1, S—3, S—4, S—5, S—6, and S—7 with the toll offices are used for both talking and

signaling; but station S—2 is connected to toll office O—1 by two lines, line 230 for talking and line 232 for signaling. The test board station TS and the associated timing and alarm apparatus which is common to all stations is shown in detail in Fig. 7.

To originate a call from any one of the stations, the calling party removes the receiver from the hook and listens, the movement of the receiver-hook being effective to close the receiver and transmitter circuits. If no tone or conversation is heard, the calling party challenges to determine whether there is another party on the line. The challenge going unanswered and no busy tone or ringing tone being audible, the calling party dials the number of the station with which conversation is desired. After the first digit is dialed, a busy tone is connected to the talking network at the test board station. When the last digit of the number has been dialed, the ringer at the called station is energized and an audible ringing tone is connected to the talking network, and the busy tone connection is opened at the test board station. The operation of the ringer at the called station continues for about three seconds before the timing apparatus of the test board station causes the transmission of a release impulse to effect the return of the selectors, at all stations, to normal. The signal horn at the called station is also energized, in addition to the ringer, if the associated key is in its closed position in which case the ringer and horn sounds continuously until the receiver is removed from the hook. Removal of the receiver opens the ringing circuits and closes the transmitter energizing circuit. If the calling party makes an error in dialing, it is necessary to wait approximately three seconds before the busy tone is disconnected and dialing can be started over again. Any station can be called while the receiver is off the hook at any one or more of the other stations, the dial impulses being heard as subdued clicks.

The operation of the system shown in Figs. 4, 5, 6, and 7 will be further described in connection with a call from station S—5 to station S—7. The receiver 502 having been removed at station S—5 and there being neither busy nor ringing tone on the line, and having heard no response to his challenge, the calling party dials the number assigned to station S—7 which we will assume to be 4802. The lower (impulse) contacts of dial 504 alternately open and close the signaling circuit through impulse receiving relay 505 and over line 530 to telegraph repeater TGR—5 in office O—2. These impulses, and the impulses corresponding to the other digits of the called number, are repeated by repeater TGR—5 to the test board station TS, by repeaters TGR—5, TGR—3, and TGR—2 to station S—1, by repeaters TGR—5, TGR—3, and TGR—1 to stations S—2 and S—3, by repeaters TGR—5 and TGR—4 to station S—4, by repeaters TGR—5 and TGR—6 to station S—6, and by repeaters TGR—5, TGR—6 and TGR—7 to station S—7. The impulse receiving relays at all stations are thereby alternately released and reoperated half as many times for each digit dialed as there are units in these digits. At the called station S—7 the alternate release and reoperation of relay 705 is effective to alternately discharge and charge condenser 707 through the polarized windings of stepping magnets 714; at station TS impulse receiving relays 805 and 806 both respond to the impulses, the alternate release and reoperation of relay 805 being effective to alternately discharge and charge condenser 807 through the polarized windings of stepping magnets 814. The resulting energization of magnets 714 and 814 successively in reverse direction by the discharge and charge of condensers 707 and 807 advances the code wheels 709 and 809 step-by-step. A similar action takes place at all other stations. The number 4802 being dialed, the code wheels 709 and 809 at stations S—7 and TS are successively advanced in a clockwise direction to and retained in positions 4, 12, 22, and 24; the code wheels at the other stations are also advanced in response to the impulses for each digit but none of them reach position 24 since in each of them there is no retaining pin in one or more of these positions.

When the code wheel of the selector at station S—7 reaches position 24, a circuit is closed from the negative pole of battery 700, through the left back contact of relay 706, winding of relay 719, contact 711 and contact spring 710 of selector 715, to the positive pole of battery 700. Relay 719 operates, closing a circuit from the negative pole of battery 700 through one of the windings and closed contacts of ringer 720, left front contact of relay 719, holding spring 713 and code wheel 709 of selector 715 to the positive pole of battery 700. The ringer 720 operates to signal the subscriber at that station. If the switch key 718 is operated, the winding of relay 717 is in parallel with the winding of relay 719 and the operation of relay 717 closes the alternating current circuit through the winding of signal horn 716; in this case relay 719 is locked through its right front contact independently of the selector contacts and under the control of the receiver-hook switch so that the ringing signals (ringer and horn) will continue to operate until the receiver is removed. An audible ringing signal is transmitted from ringer 720 through condenser 721 to the talking network as long as ringer 720 is being operated. Removal of the receiver 702 actuates the hook switch 703, connecting battery 700 and the right winding of induction coil 725 in series with transmitter 701, and connecting receiver 702 through resistance 726 and condenser 724 across the lower half of the left winding of induction coil 725. Actuation of the hook-switch also closes a circuit for operating relay 706 to cause the release of relays 719 and 717, and thus interrupt the operation of the ringer and horn. When conversation is completed, the receivers are replaced upon the receiver hook to open the local battery transmitter circuits.

If the number 400 is dialed at any station, the selectors at all stations are advanced to and retained in position 24, thereby causing the operation of the ringer at all stations other than the calling station.

The aforementioned response of relay 806 of the test board station TS to the first impulse transmitted over the signaling network causes the operation of relay 817; the circuit for operating relay 817 is traced from battery through its winding, right front contact of relay 816, back contact of relay 806, to ground at the back contact of relay 838. Relay 816, normally operated, is slow in releasing and does not release when dial impulses are being received. Relay 817 locks over conductor 849 to ground at the back contact of relay 832 and closes circuits for operating relays 818 and 831. Relay 818 locks under control of relay 839, and closes a circuit for operating relay 819. Relay 819 bridges the left winding of transformer 821 across the talking conductors 830 and closes a path from ground through the

right winding of transformer **821**, inner left front contact of relay **819** and through the right winding of the busy-tone transformer **820** to ground, thereby causing the transmission of a busy-tone over the talking network to all of the stations of the system to warn against dialing at any station other than the one at which the call originated. If the calling party completes the dialing of a station number, and selector **815** is advanced to the twenty-fourth position, a circuit is closed from battery through resistance **829**, through contact **811**, contact spring **810** and code wheel **809** to ground. The winding of relay **819** is thereby short-circuited to cause its release and the consequent disconnection of the busy-tone from the talking network.

The aforementioned operation of relay **831** closes a circuit for operating relay **832**; and relay **832** closes a circuit for operating relay **833**. With relay **832** operated, relays **834** and **836** normal, and with the operating circuit of relay **817** open due to the reoperation of relay **806** or release of relay **816**, relay **817** releases to start the measuring of a time interval of approximately four seconds, the measuring being effected by the cooperative operation of relays **831** to **837** inclusive. If the dialing of the called number proceeds without delay, the operation of these relays to measure the four second interval, is interrupted each time relay **817** reoperates. When relay **817** releases, and does not reoperate, the measuring of a four second interval proceeds without further interruption. Relays **831**, **832** and **833** are somewhat slow in operating due to the inclusion of resistances **841**, **842**, and **843** in their operating circuits; and these relays are also slow in releasing due to the short-circuiting of these resistances when the relays are operated. The time interval occupied by the successive release and the following successive operation of relays **831**, **832**, and **833** is about one second. The release of relay **817** causes the successive release of relays **831**, **832**, and **833**. With relay **817** released and before relay **833** releases, a circuit is closed from ground through the right front contact of relay **818**, the right inner back contact of relay **817**, over conductor **840**, through the right front contact of relay **833**, conductor **848**, right back contact and winding of relay **834** and through resistance **844** to battery. With relay **834** operated, a connection is closed from conductor **840** through the right front contact of relay **834** to the windings of relays **834** and **835** in parallel. Relay **834** is held operated but relay **835** does not immediately operate since its winding is short-circuited by its right back contact in series with the right front contact of relay **833**. When relay **833** releases, the winding of relay **835** is energized and relay **835** operates. With relay **833** released, (and relay **817** not having reoperated) a circuit is closed, through the outer right back contact of relay **817** and right back contact of relay **833** to conductor **840** for reoperating relay **831**. Relays **832** and **833** are then reoperated, thus establishing the connection from ground over conductor **840** to conductor **848** and thereby causing the short-circuiting of the winding and consequent release of relay **834**. Relay **835** now holds through the right back contact of relay **834** over conductor **848** and the right front contact of relay **833** to ground on conductor **840**. The aforementioned reoperation of relay **833** opens the circuit through the winding of relay **831** so that relays **831**, **832** and **833** are again successively released, the successive operation and release of these relays being repeated until both of relays **835** and **837** have been operated as hereinafter described. The second release of relay **833** opens the holding circuit for relay **835** so that relays **834** and **835** are operated and released once while relay **833** is operated and released twice. Approximately two seconds elapse from the time relay **834** operates until relay **835** releases.

When relay **834** releases, due to the reoperation of relay **833** as above described, a circuit connection is closed from conductor **840**, through the outer left front contact of relay **835**, left back contact of relay **834**, right back contact and winding of relay **836**, and through resistance **846** to battery. Relay **836** operates and a connection is closed from conductor **840** through the right front contact of relay **836** to the windings of relays **836** and **837** in parallel. Relay **836** is held operated but relay **837** does not operate since its winding is short-circuited by its right back contact in series with the left back contact of relay **834** and left outer front contact of relay **835**. When relay **835** releases due to the second release of relay **833**, relay **837** operates. When relay **834** releases the second time, a connection is closed from conductor **840** through the outer right front contact of relay **835** and the left back contact of relay **834**, and through the right front contact of relay **837** to short-circuit the winding and cause the release of relay **836**. Relay **837** holds through the right back contact of relay **836** until relay **835** releases the second time. Relays **836** and **837** are, therefore, operated and released once while relays **834** and **835** are operated and released twice and approximately four seconds elapse from the first operation of relay **834** until the second release of relays **835** and the first release of relay **837**. With relays **835** and **837** both operated, approximately three seconds after the release of relay **826**, a circuit is closed from battery through the winding of relay **838**, left front contact of relay **816**, left back contact of relay **838**, left front contact of **837**, inner left front contact of relay **835**, over conductor **840**, through the inner right back contact of relay **817** to ground at the right front contact of relay **818**. Relay **838** locks through its left front contact and the front contacts of relays **837** and **835** over conductor **840**. Relay **838** closes a circuit for operating relay **839**. The operation of relay **839** causes the release of relay **818** and connects ground to conductor **840** thereby holding relay **819** operated if it has not already been released on account of the advance of selector **815** as above described. The operation of relay **839** also opens the signaling circuit through the windings of relays **805** and **806**, causing the release of relays **805** and **806** and the impulse receiving relays at all other stations of the system. The release of the impulse receiving relay at each station causes the selector thereat to advance one step only, and there being no retaining pin in odd numbered positions all of the selectors are thereupon restored to normal. Relays **838** and **839** are held operated, until relay **835** releases, due to the second release of relay **833**, about one second after the operation of relay **838**. The opening of the signaling circuit for an interval of one second is sufficient to cause the release of the normally operated slow-to-release relay **816**. The release of relay **839** causes the release of relay **819**, if not already released, and closes the signaling circuit. The closing of the signaling circuit reoperates the impulse receiving relays at all sta-

tions; the selectors are, therefore, again advanced one step and immediately restored to normal. The reoperation of impulse receiving relay 806 causes the reoperation of relay 816.

To signal the test board station, a number whose digits total 26 (for instance 006) is dialed, selector 815 being advanced to and retained in position 26. In this position a circuit is closed from ground through code wheel 809, contact spring 810 and contact 812 to operate relay 823. The operation of relay 823 lights the line lamp 824 and closes a connection from the source of ringing current 828 through condenser 827, the right outer front contact of relay 823, the right winding of induction coil 825 to ground at the inner right front contact of relay 823; an audible ringing tone is thus transmitted over the talking network. When the plug of the test board operator's telephone set 800 is inserted in jack 801, a talking connection is established through induction coil 825 and a circuit is closed from ground at contacts 802 to operate relay 803. The operation of relay 803 releases relay 823 thereby extinguishing lamp 824.

If the signaling network is opened in any one or more of its branches for an interval of more than four seconds, the timing relays function as hereinbefore described as a result of the release of relay 806. Relay 816 releases due to the prolonged release of relay 806 and when relay 837 operates after a measured interval of about three seconds, a circuit is closed from ground through the right front contact of relay 818, inner right back contact of relay 817, conductor 840, inner left front contact of relay 835, left front contact of relay 837, left back contact of relay 838, left back contact of relay 816, and through the winding of relay 851 to battery. Relay 851 locks through its right front contact, the right back contact of relay 816 and the back contact of relay 806 to ground at the right back contact of relay 838. Relay 851 lights the trouble indicating lamp 852 and operates the associated audible signal 855. To silence the audible signal, key 854 is momentarily operated thereby closing a circuit for operating relay 853. Relay 853 locks in parallel with relay 851, lamp 852 remaining energized. When the signaling channel is again closed, relay 806 reoperates, relay 816 reoperates, relay 853 releases, and relay 851 releases extinguishing the lamp 852.

Outgoing calls from the test board station are made by inserting the plug of the telephone set 800 in jack 801. The operation of relay 803 renders the impulse contacts of the dial effective to transmit impulses.

What is claimed is:

1. In a telephone system, a plurality of stations, an individual line for each of said stations, each of said lines being used for both signaling and for talking, toll lines common to said individual lines, a network interconnecting the lines of all of said stations for signaling, said signaling network comprising a first one of said toll lines and excluding a second one of said toll lines, a network interconnecting the lines of all of said stations for talking, said talking network comprising said second one of said toll lines and excluding said first one of said toll lines, a dial at each of said stations for transmitting impulses over said signaling network to all of the other stations, signaling means at each of said stations, and switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number.

2. In a telephone system, a plurality of stations, an individual line for each of said stations, each of said lines being used for both signaling and for talking, toll lines common to said individual lines, a network interconnecting the lines of all of said stations for signaling, said signaling network comprising a first one of said toll lines and excluding a second one of said toll lines, a network interconnecting the lines of all of said stations for talking, said talking network comprising said second one of said toll lines and excluding said first one of said toll lines, a dial at each of said stations for transmitting impulses over said signaling network to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, and means at one of said stations for transmitting a busy tone over said talking network immediately after the dialing of the first digit at any of said stations.

3. In a telephone system, a plurality of stations, lines one for each of said stations, each of said lines for use in signaling and in talking, a talking circuit extending to the lines of all of said stations, a signaling circuit extending to the lines of all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, means at one of said stations for transmitting a busy tone over said talking circuit immediately after the dialing of the first digit at any of said stations, and means for ending the transmission of said busy tone as soon as the dialing of a station number is completed.

4. In a telephone system, a plurality of stations, lines one for each of said stations, each of said lines for use in signaling and in talking, a talking circuit extending to the lines of all of said stations, a signaling circuit extending to the lines of all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, means at one of said stations for transmitting a busy tone over said talking circuit immediately after the dialing of the first digit at any of said stations, and means for ending the transmission of said busy tone at the end of a desired interval after the beginning of dialing.

5. In a telephone system, a plurality of stations, a talking circuit extending to all of said stations, a signaling circuit extending to all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any

other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, and means at one of said stations effective after the dialing of a station number is completed for transmitting an impulse of greater duration than an impulse created by the operation of a dial, the switching means at each station being arranged to restore to normal in response to said prolonged impulse.

6. In a telephone system, a plurality of stations, a talking circuit extending to all of said stations, a signaling circuit extending to all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, and trouble indicating means at one of said stations operative in response to the opening of said signaling circuit for an interval exceeding a predetermined interval of time.

7. In a telephone system, a plurality of stations, a talking circuit extending to all of said stations, a signaling circuit extending to all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, and switching means at each of said stations for responding to impulses from any other station, each of said signaling means being simultaneously rendered effective by the associated switching means in response to impulses corresponding to a common station number.

8. In a telephone system, a plurality of stations, an individual line for each of said stations, each of said lines being used for both signaling and for talking, toll lines common to said individual lines, a network interconnecting the lines of all of said stations for signaling, said signaling network comprising a first one of said toll lines and excluding a second one of said toll lines, a network interconnecting the lines of all of said stations for talking, said talking network comprising said second one of said toll lines and excluding said first one of said toll lines, and talking and signaling means at each of said stations, said signaling means comprising a dial for sending signal impulses over said signaling network and impulse receiving means for receiving signal impulses over said network.

9. In a telephone system, a plurality of stations, an individual line for each of said stations, each of said lines being used for both signaling and for talking, toll lines common to said individual lines, a network interconnecting the lines of all of said stations for signaling, said signaling network comprising a first one of said toll lines and excluding a second one of said toll lines, a network interconnecting the lines of all of said stations for talking, said talking network comprising said second one of said toll lines and excluding said first one of said toll lines, and talking and signaling means at each of said stations, said signaling means comprising a dial for sending signal impulses over said signaling network, impulse receiving means for receiving signal impulses over said network and means at one of said stations for transmitting a busy tone over said talking network in response to the operation of the dial at any one of said stations.

10. In a telephone system, a plurality of stations, an individual line for each of said stations, each of said lines being used for both signaling and for talking, toll lines common to said individual lines, a network interconnecting the lines of all of said stations for signaling, said signaling network comprising a first one of said toll lines and excluding a second one of said toll lines, and a network interconnecting the lines of all of said stations for talking, said talking network comprising said second one of said toll lines and excluding said first one of said toll lines, the apparatus at each station comprising a dial for transmitting impulses over said signaling network, a receiver and transmitter connected to said talking network, a ringer and selective switching means operatively responsive to impulses received over said signaling network for causing the operation of the associated ringer.

11. In a telephone system, a plurality of stations, a signaling network interconnecting said stations, a talking network interconnecting said stations, the apparatus at each station comprising a dial for transmitting impulses over said signaling network, a receiver and transmitter connected to said talking network, a ringer, and selective switching means operatively responsive to impulses received over said signaling network for causing the operation of the associated ringer, and means at each station for transmitting a ringing tone over said talking network while the ringer at the associated station is being operated.

12. In a telephone system, a plurality of stations, a signaling network interconnecting said stations and comprising a plurality of toll-line signaling channels, a talking network interconnecting said stations and comprising a plurality of toll-line talking channels, telegraph repeaters for repeating signaling impulses from one or more branches of the signaling network to all other branches, signal transmitting and signal receiving means at each station, and selective switching means at each station responsive to signals transmitted from any other station.

13. In a telephone system, a plurality of stations, a signaling network interconnecting said stations and comprising a plurality of toll-line signaling channels, a talking network interconnecting said stations and comprising a plurality of toll-line talking channels, means including telephone repeaters for repeating the voice currents from one or more of the branches of the talking network to all other branches, signal transmitting and signal receiving means at each station, and selective switching means at each station responsive to signals transmitted from any other station.

14. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of stations, a signaling network comprising signal transmitting and signal receiving means at each station, lines connecting said stations to said toll offices, toll-line signaling channels between said offices and telegraph repeaters for connecting the various branches of the network, one or more of said signaling channels being arranged for simplex signaling over the toll line, a talking network comprising a plurality of toll-line talking channels, and selective switching means at each station responsive to signals transmitted from any other station.

15. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of

stations, a signaling network comprising signal transmitting and signal receiving means at each station, lines connecting said stations to said toll offices, toll-line signaling channels between said offices and telegraph repeaters for connecting the various branches of the network, one or more of said signaling channels being arranged for simplex signaling over the phantom circuit of two toll lines, a talking network comprising a plurality of toll-line talking channels, and selective switching means at each station responsive to signals transmitted from any other station.

16. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of stations, a signaling network comprising signal transmitting and signal receiving means at each station, lines connecting said stations to said toll offices, toll-line signaling channels between said offices and telegraph repeaters for connecting the various branches of the network, the toll line of one or more of said signaling branches having associated therewith a composite set whereby the toll line is adapted for use in a talking connection in addition to its use in said signaling network, a talking network comprising a plurality of toll-line talking channels, and selective switching means at each station responsive to signals transmitted from any other station.

17. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of stations, a signaling network comprising signal transmitting and signal receiving means at each station, lines connecting said stations to said toll offices, toll-line signaling channels between said offices and telegraph repeaters for connecting the various branches of the network, the toll line of one or more of said signaling branches having associated therewith a composite set whereby the toll line is also adapted for use in a talking connection and whereby the signals are transmitted over both conductors of said line in series, a talking network comprising a plurality of toll-line talking channels, and selective switching means at each station responsive to signals transmitted from any other station.

18. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of stations, a signaling network interconnecting said stations, said signaling network comprising signal receiving and signal transmitting means at each station and signaling channels over some of said toll lines, a talking network interconnecting said stations, one or more of the branches of said talking network comprising a toll line provided with a composite set whereby the toll line is adapted for use in signaling in addition to its use in said talking network, and selective switching means at each station responsive to signals transmitted from any other station.

19. In a telephone system, a plurality of toll offices, toll lines between said offices, a plurality of stations, a signaling network interconnecting said stations, said signaling network comprising signal receiving and signal transmitting means at each station and signaling channels over some of said toll lines, a talking network interconnecting said stations, one or more of the branches of said talking network comprising a phantom circuit over two toll lines, and selective switching means at each station responsive to signals transmitted from any other station.

20. In a telephone system, a plurality of toll offices, toll lines connecting said offices, signaling channels over said toll lines, talking channels over said toll lines, a plurality of stations, signal transmitting and receiving means at each station, a signaling network including an individual line from a toll office to each of said stations and including said signaling channels for transmitting call signals between each station and all other stations, a talking network including said individual lines from the toll offices to each station and including said talking channels for transmitting voice currents between all of said stations, and selective switching means at each station responsive to call signals received over said signaling network from any other station.

21. In a telephone system according to claim 1, means at one of said stations effective a predetermined interval of time after the receipt of a dial impulse providing no additional dial impulse is received during said interval for transmitting an impulse of greater duration than a dial impulse, the switching means at each station being arranged to restore to normal in response to said prolonged impulse.

22. In a telephone system, a plurality of stations, a talking circuit extending to all of said stations, a signaling circuit extending to all of said stations, a dial at each of said stations for transmitting impulses over said signaling circuit to all of the other stations, signaling means at each of said stations, switching means at each of said stations for responding to impulses from any other station, each of said signaling means being rendered effective by the associated switching means in response to impulses corresponding to an individual station number, and means at only one of said stations for transmitting over said signaling circuit an impulse of greater duration than an impulse created by the operation of the dial at any of said stations.

23. In a telephone system, a plurality of stations, a signaling network interconnecting said stations and comprising a plurality of toll-line signaling channels, a talking network interconnecting said stations and comprising a plurality of toll-line talking channels, single line telegraph repeaters for repeating signaling impulses from one or more branches of the signaling network to all other branches, signal transmitting and signal receiving means at each station, and selective switching means at each station responsive to signals transmitted from any other station.

24. In a telephone system, a plurality of toll offices, toll lines, signaling channels and talking channels over said toll-lines, a plurality of stations, individual lines for connecting each of said stations to one of said toll offices, a signaling network comprising signal transmitting and signal receiving means at each station, said individual lines and certain of said signaling channels, and a talking network comprising a receiver and microphone at each station, said individual lines and certain of said talking channels.

25. In a telephone system, a plurality of toll offices, toll lines interconnecting said offices, signaling channels and talking channels over said toll lines, a plurality of stations, individual lines for connecting each of said stations to one of said offices, a signaling network interconnecting the lines of said stations and comprising some of said signaling channels, and a talking network interconnecting the lines of said stations and comprising some of said talking channels, one or more of said toll lines being included only in the talking network.

26. In a telephone system, a plurality of toll offices, toll lines interconnecting said offices, signaling channels and talking channels over said toll

lines, a plurality of stations, individual lines for connecting each of said stations to one of said offices, a signaling network interconnecting the lines of said stations, and comprising some of said signaling channels, and a talking network interconnecting the lines of said stations and comprising some of said talking channels, one or more of said toll lines being included only in the signaling network.

27. In a telephone system, a plurality of toll offices, toll lines, signaling channels and talking channels over said toll-lines, a plurality of stations, individual lines for connecting each of said stations to one of said toll offices, a signaling network comprising signal transmitting and signal receiving means at each station, said individual lines and certain of said signaling channels, and a talking network comprising a receiver and microphone at each station, said individual lines and certain of said talking channels, the removal of the receiver at one or more of the stations being ineffective to interfere with the transmission of selective impulses over said signaling network or with the selective operation of the signal receiving means at any of said stations.

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