Feb. 9, 1932. E. H. CLARK 1,844,147

AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

Filed July 3, 1930 10 Sheets-Sheet 1

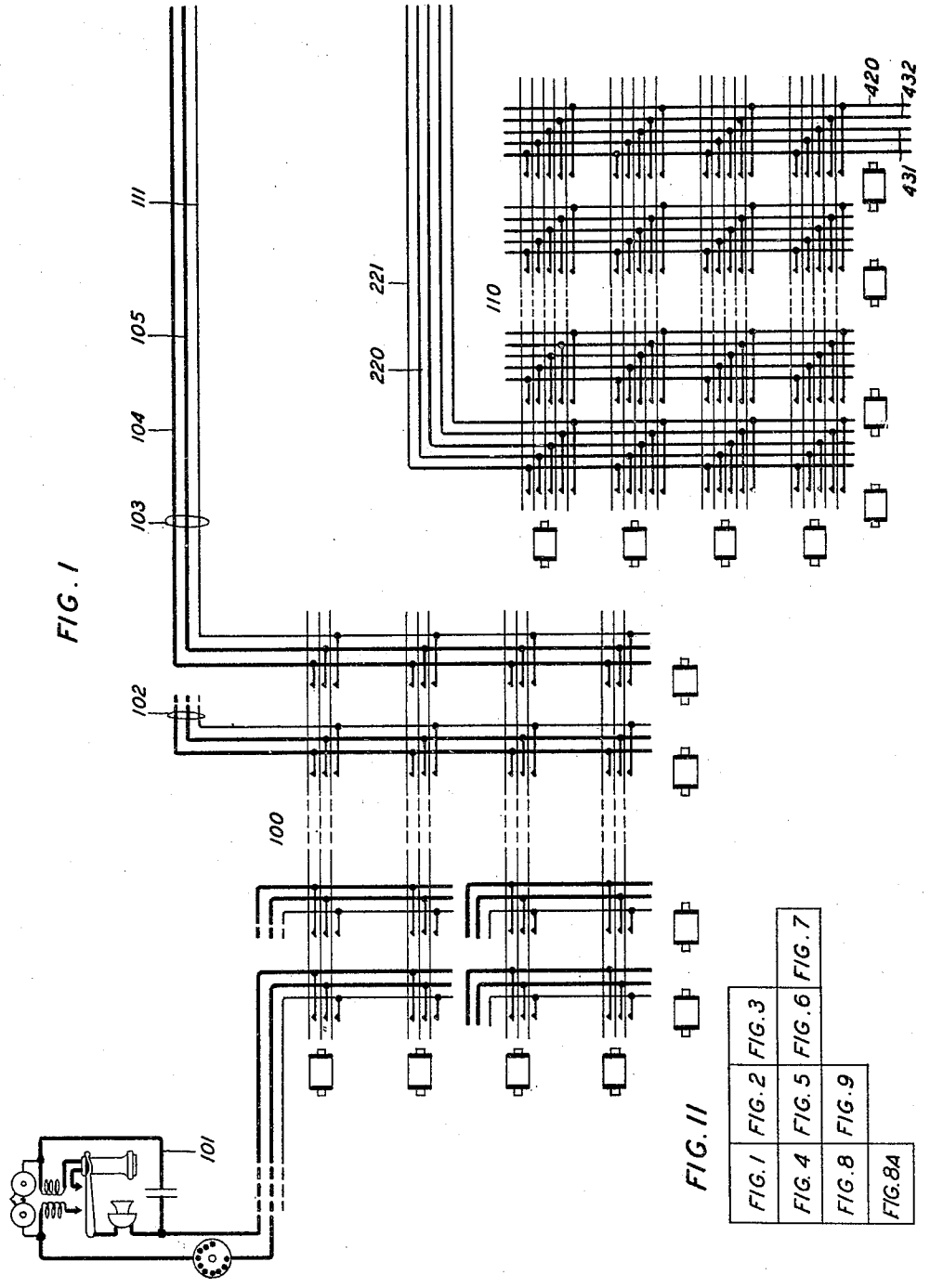

FIG. 1

FIG. 11

FIG. 1	FIG. 2	FIG. 3	FIG. 7
FIG. 4	FIG. 5	FIG. 6	
FIG. 8	FIG. 9		
FIG. 8A			

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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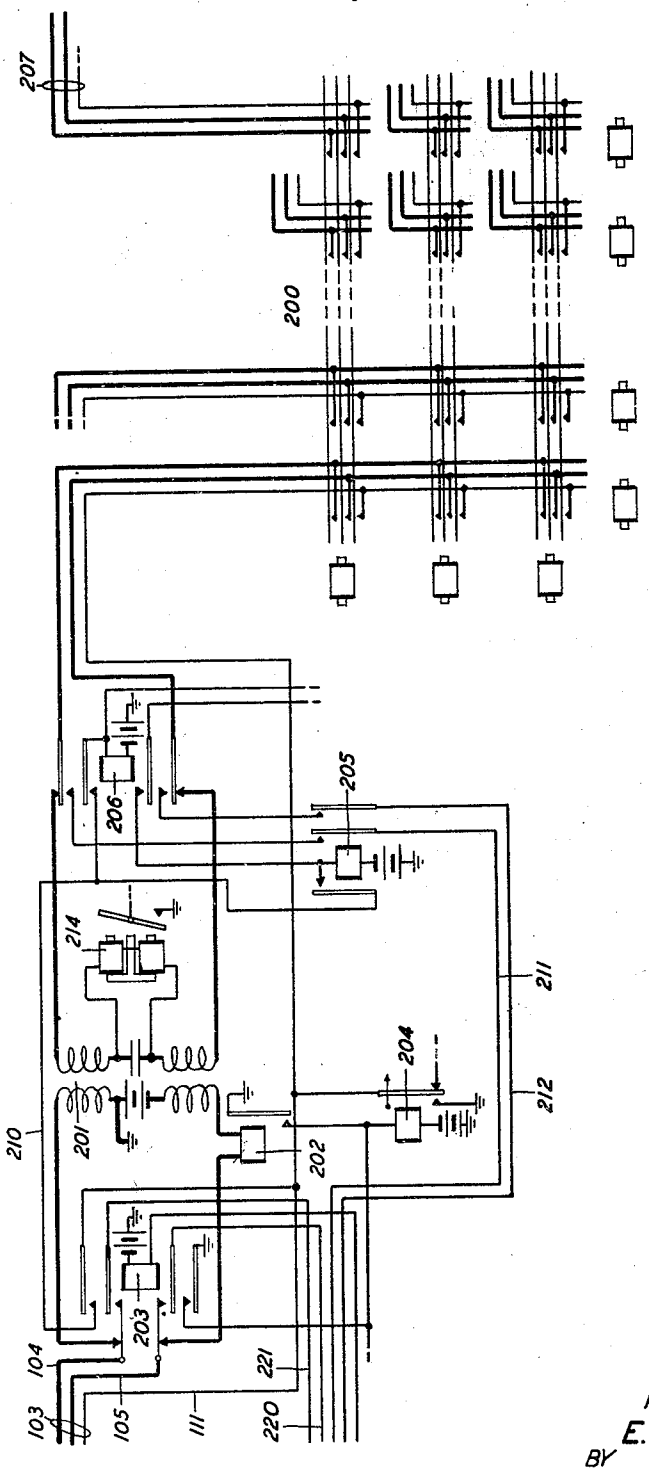

FIG. 2

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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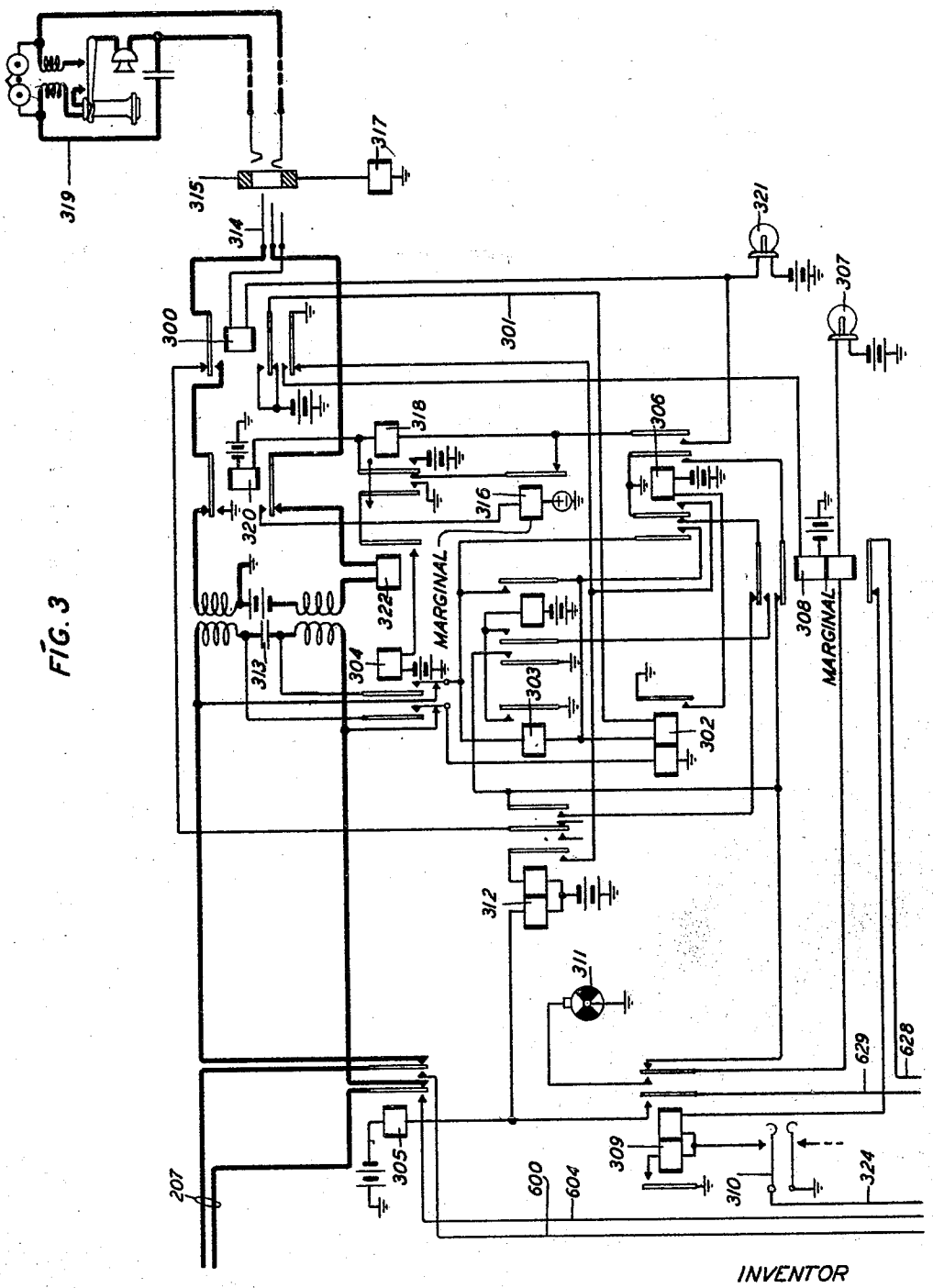

FIG. 3

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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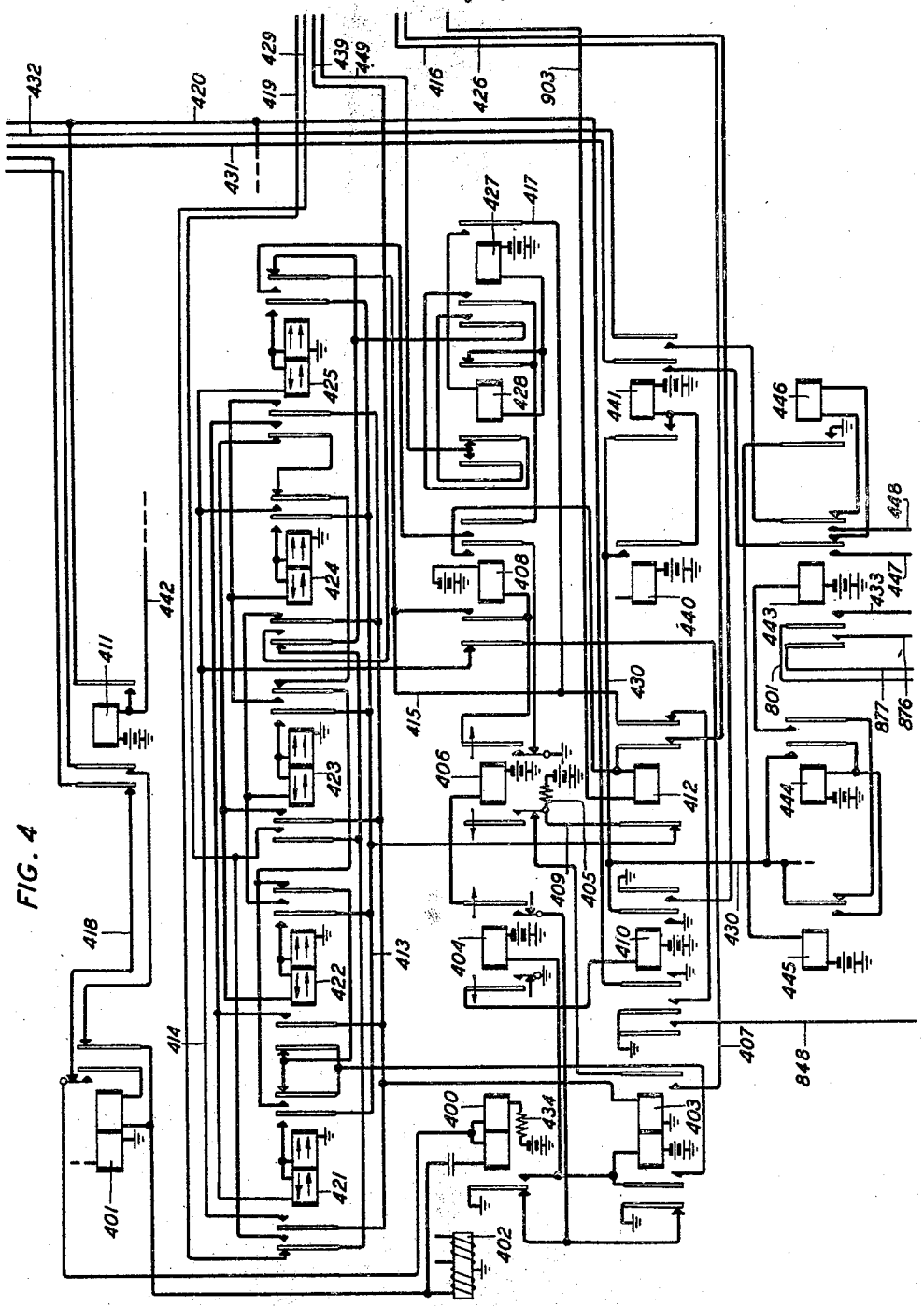

FIG. 4

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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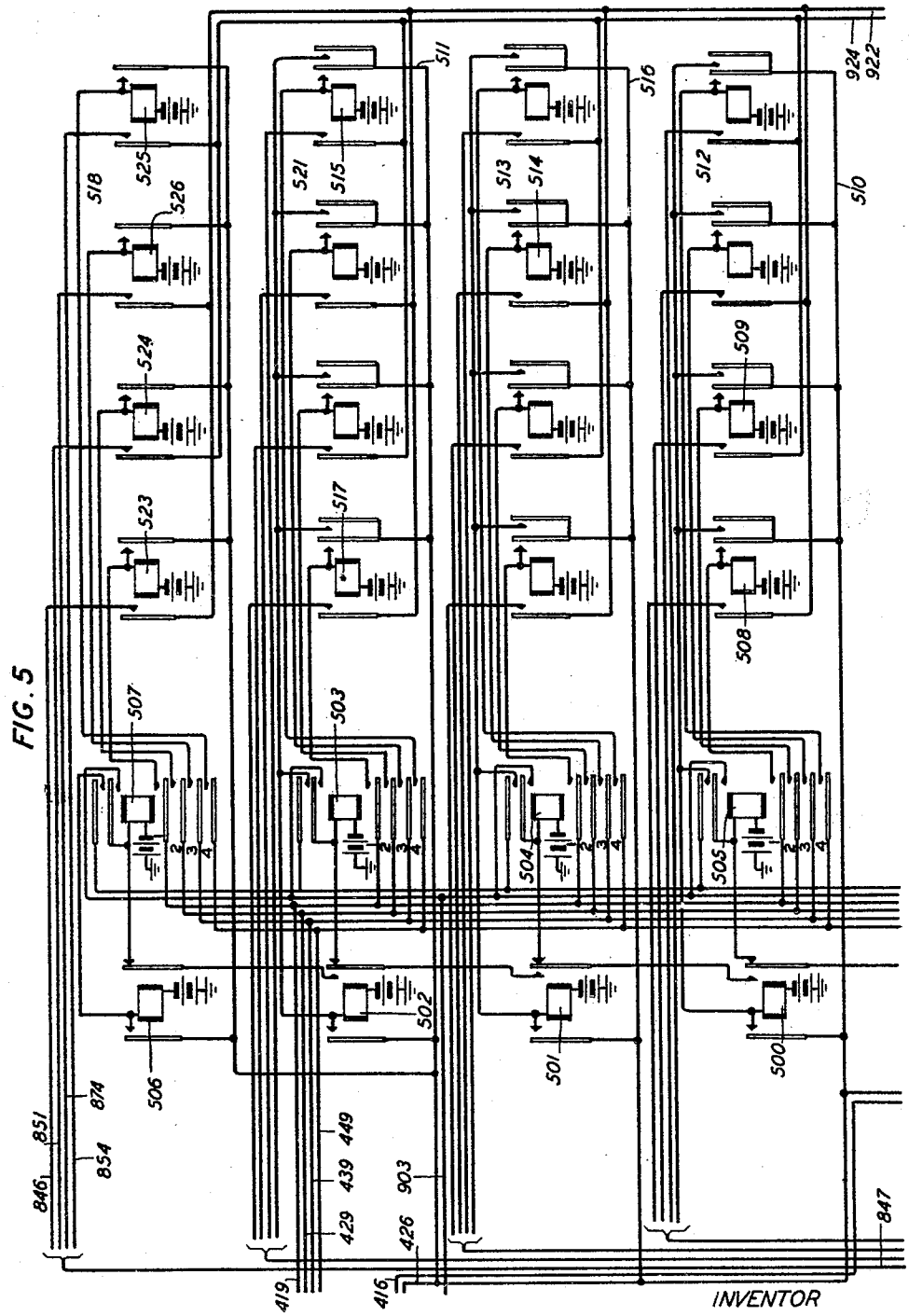

FIG. 5

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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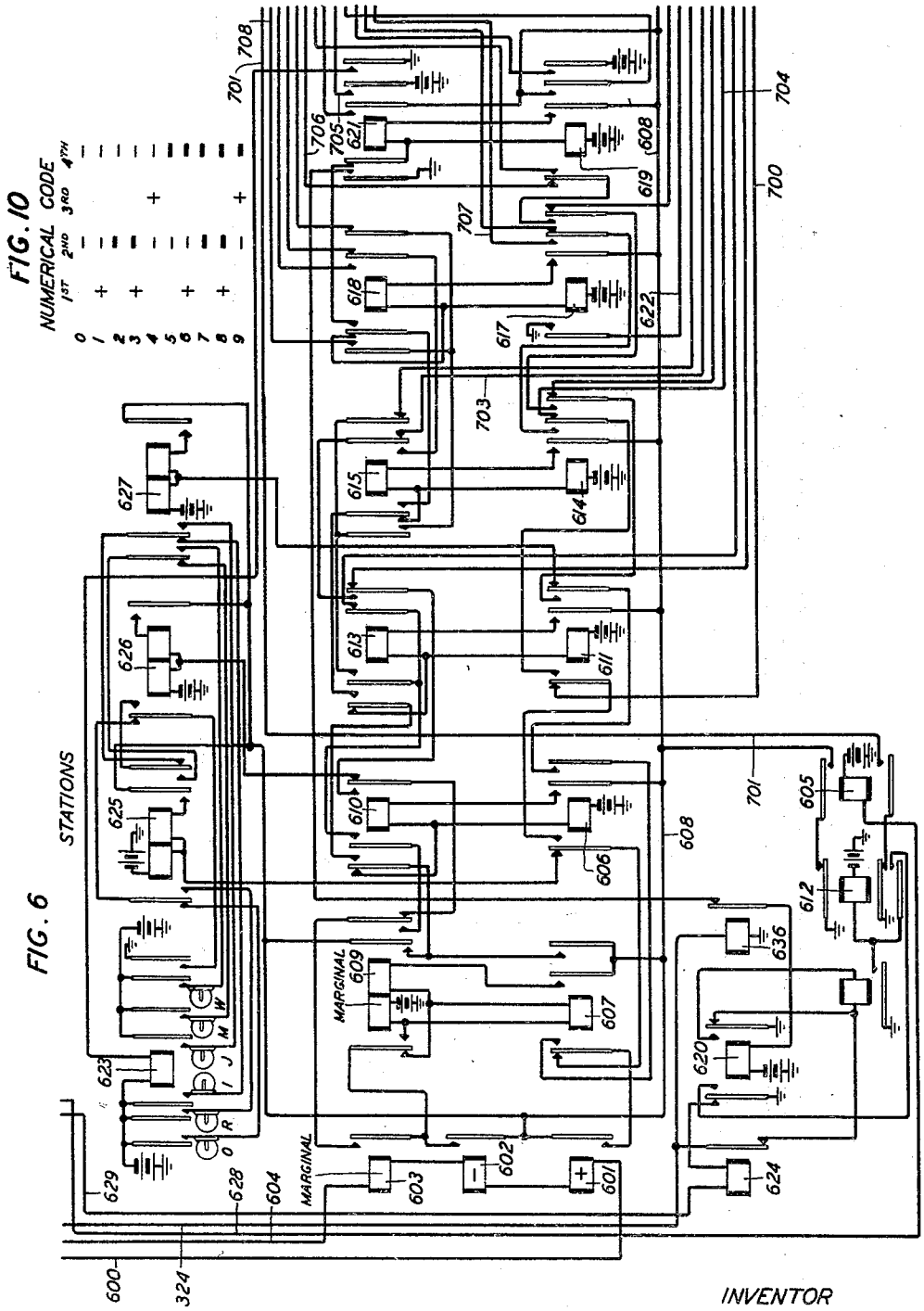

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AUTOMATIC AND SEMI-AUTOMATIC TELEPHONE SYSTEM

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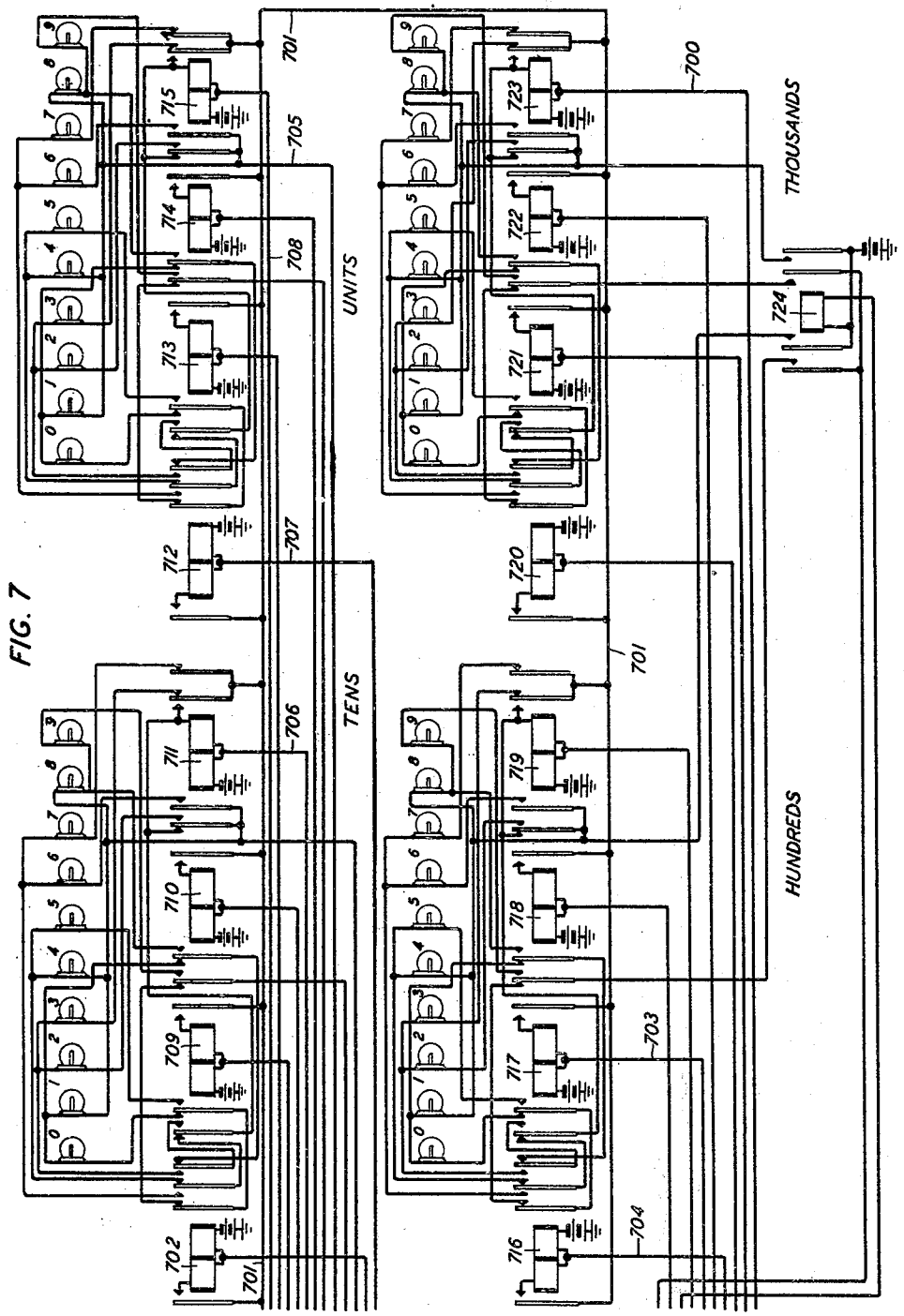

FIG. 7

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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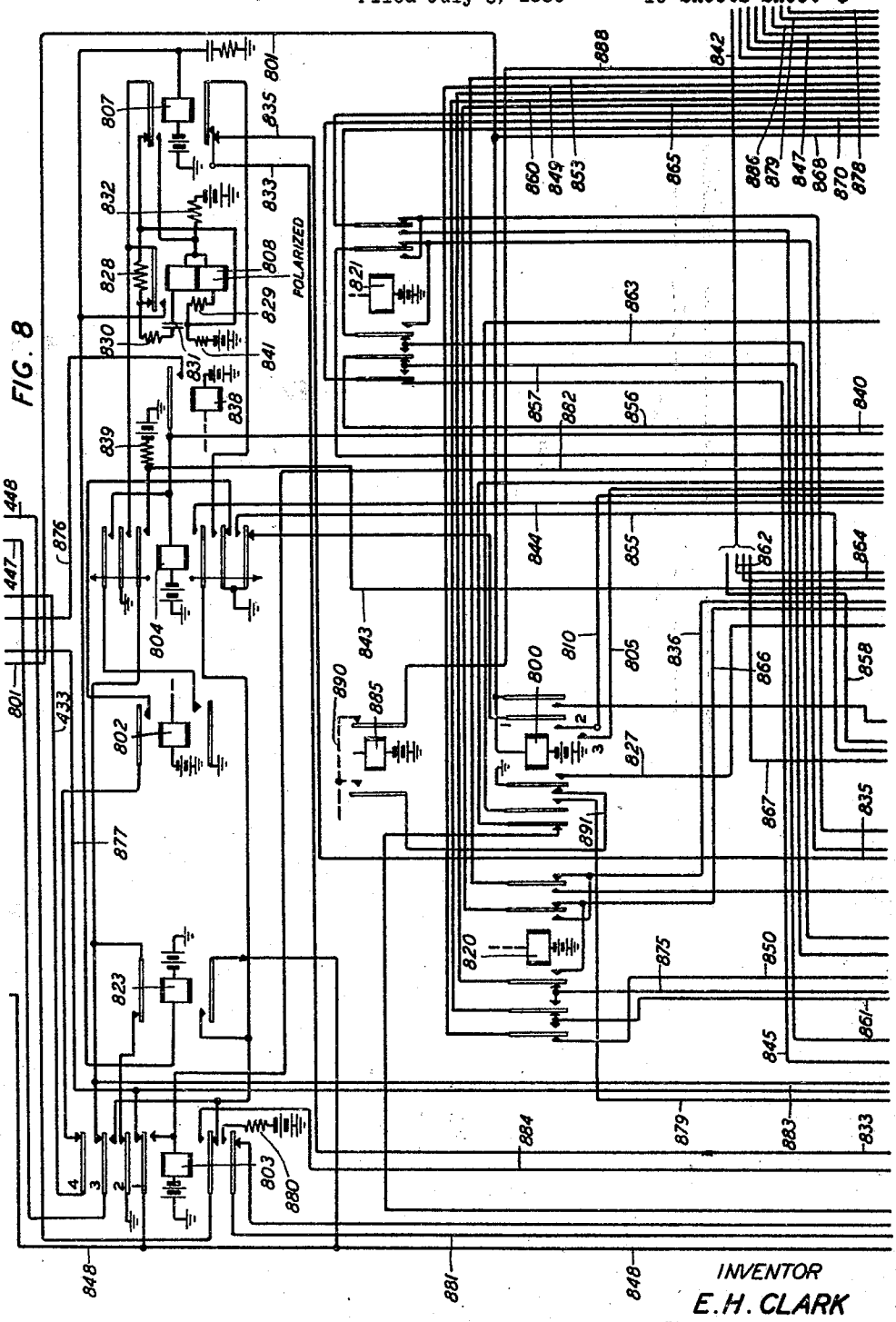

FIG. 8

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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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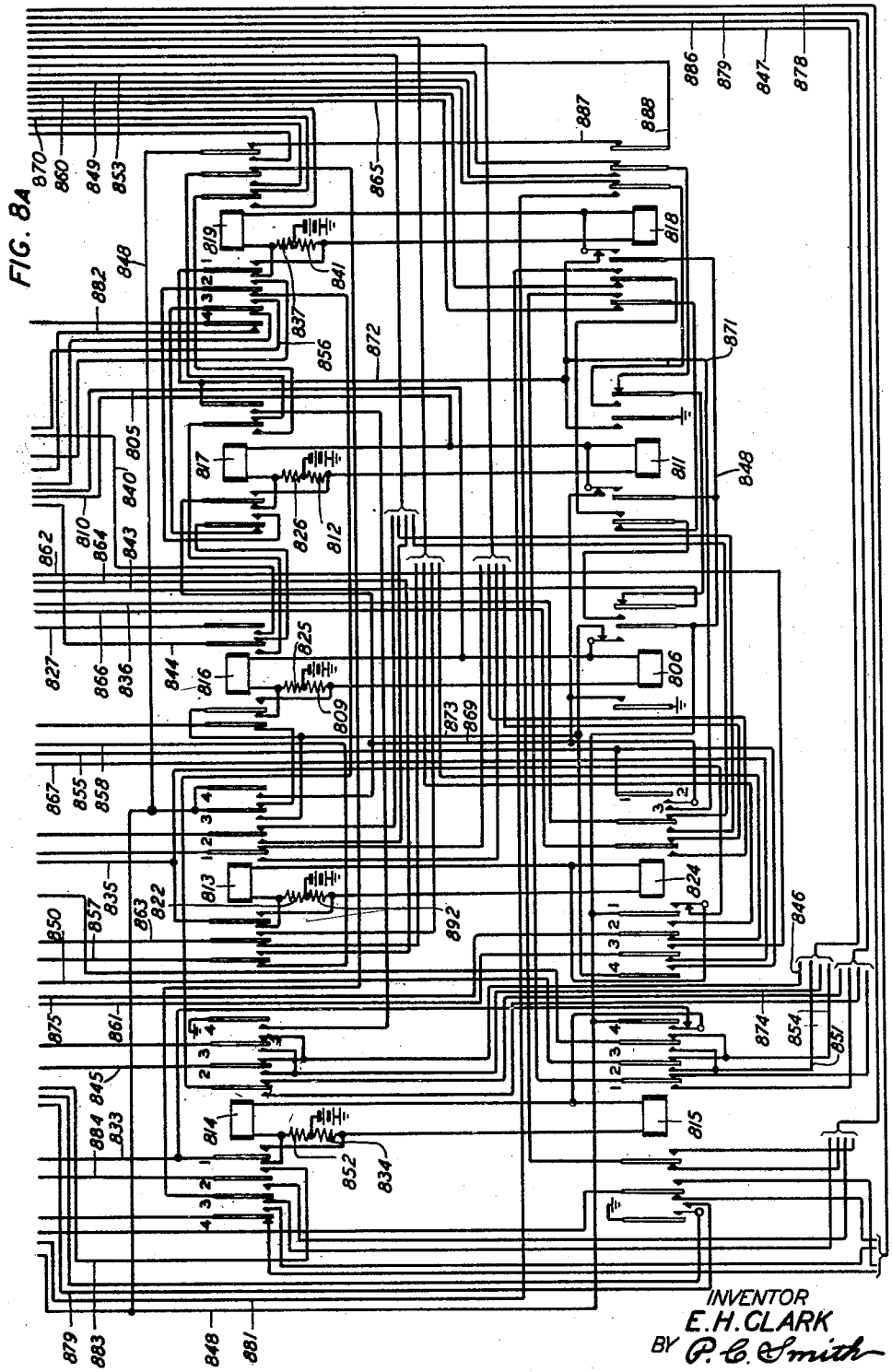
FIG. 8A



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AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

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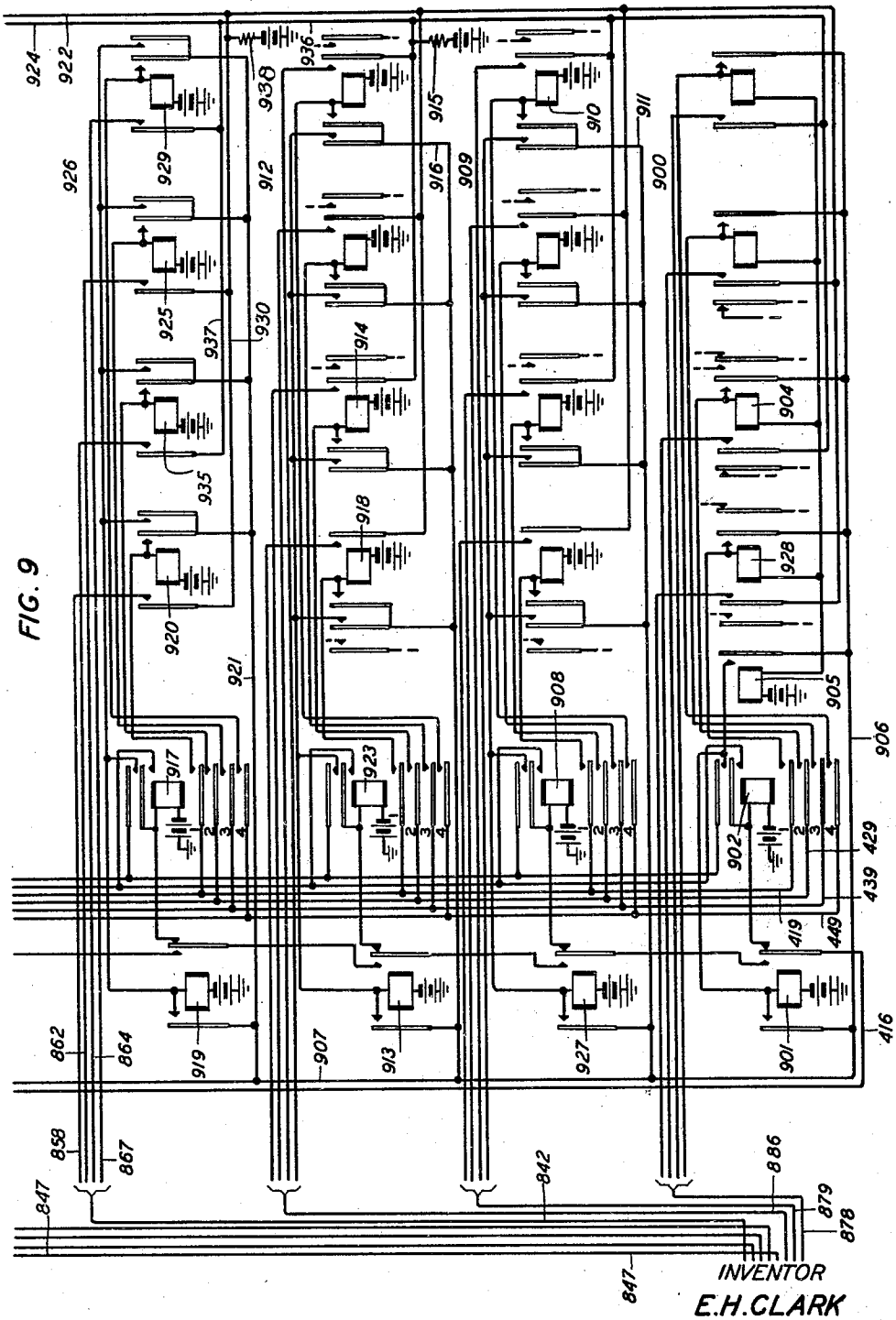

FIG. 9

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Patented Feb. 9, 1932 1,844,147

UNITED STATES PATENT OFFICE

EDGAR H. CLARK, OF FOREST HILLS, NEW YORK, ASSIGNOR TO BELL TELEPHONE LABORATORIES, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK

AUTOMATIC AND SEMIAUTOMATIC TELEPHONE SYSTEM

Application filed July 3, 1930. Serial No. 465,484.

This invention relates to telephone exchange systems and more particularly to an impulse transmitting circuit which may be incorporated in any sender adapted to transmit to a terminating office a number of impulses determined by a group of operated registers. The object of the invention is to provide an improved arrangement of relays in a sender in which the registration of the wanted number is recorded, whereby the designations of such number may be transmitted more efficiently and economically by means of code impulses to the receiving circuit in the terminating office.

Heretofore, the impulse transmitting system which forms part of some senders consists, in the most general case, of a rotating device which, in combination with registers containing the record of the wanted number, generates a series of electrical impulses, the battery polarity and current density of each of which is controlled by the registers. There are other senders in which relays have replaced the rotating device, but it is believed that the present invention offers a distinct improvement over the latter as well as former class of senders, particularly as it combines a known method of precision impulsing in combination with less relays than formerly used and without the use of any mechanical apparatus, thereby resulting in a more efficient and economical impulse transmitting system.

In accordance with the invention, therefore, one specific embodiment of which is disclosed herein by way of illustration, this is accomplished in the following improved manner through the use of novel circuit improvements which are covered by the patent applications of O. R. Miller Ser. No. 359,365 and of O. Cesareo Ser. No. 187,971 and to which reference is made for a complete description of their respective manner of operation.

There are five distinct types of impulses which are transmitted by the impulse system in the proposed invention, namely, a blank impulse, a light positive impulse, a heavy positive impulse, a light negative impulse and a heavy negative impulse. A blank impulse is one in which no current is transmitted to the receiving circuit, but the pair of conductors, which are hereinafter designated as the impulsing conductors and termed tip lead and ring lead respectively, are open circuited. A light positive impulse is characterized as one having the grounded positive side of the battery on the ring conductor and the ungrounded negative side of the battery on the tip conductor and having a current strength of definite value as determined by a high resistance in series with the tip conductor, the resistance of the call indicator receiving circuit of a type shown in Patent No. 1,438,743 to E. H. Clark granted Dec. 12, 1922 and the resistance of the trunk line connecting the impulse transmitting circuit with the receiving circuit. A heavy positive impulse is identical in character with the light positive impulse except that the current strength is greater as determined by the value of a resistance in series with the tip conductor and also the resistance of the receiving circuit and trunk line. A light negative impulse is characterized as one having the grounded side of the battery on the tip conductor, the ungrounded negative side of the battery on the ring conductor and having a current strength of definite value as determined by the value of a resistance in series with the ring conductor, the resistance of the receiving circuit and that of the trunk line. A heavy negative impulse is identical in character with a light negative impulse except that the current strength is greater as determined by the value of a resistance in parallel with the resistance used in the case of a light negative impulse.

The impulses to be transmitted are arranged in groups of four for each digit and providing for the transmission of a maximum of eight digits with a final heavy positive impulse for signaling purposes as described hereinafter. The impulses are transmitted in a certain order with the odd impulses as either blank or light positive and the even impulses as light or heavy negative.

Five pairs of counting relays are used, each pair being arranged in the manner disclosed in application Serial No. 187,971 mentioned above. The front and back con-

tacts, respectively, of the relays of two of the five pairs are connected directly to the contacts of the separate registers, the operated condition of each of which determines the character of the impulse to be transmitted as more particularly described hereinafter. The impulsing conductors over which the impulses are thus modified for transmission to the trunk line and to the receiving circuit in the terminating office are connected to the switching contacts of the two pairs of counting relays through the medium of the contacts of the remaining three pairs of counting relays, which function to steer the said impulse modifying conductors from one group of wires connecting with the registers to the next group of wires in the order of succession in which the impulses are to be sent.

The impulsing circuit itself which generates the impulses is disclosed in application Serial No. 359,365 mentioned above and consists of a polarized impulsing relay having two normally opposing windings, one of which is in series with a non-inductive resistance and condenser of suitable capacity. This impulsing relay is operated and released on the principle of opposing magnetizing forces in both windings wherein the opposing force in the winding containing the condenser and resistance delays the operation of the relay until the condenser is fully charged to the potential of the battery. While the relay is thus in its non-operated condition a blank impulse is effective over the trunk loop unless the character of the impulse is, at this time, changed into a positive impulse by an electrical closure of the loop by the registers containing the recorded number as more particularly described hereinafter. The duration of this impulse is governed by the time taken for the condenser in the opposing winding to become fully charged. The length of time during which the impulse lasts is, therefore, a function of the capacity of the condenser and the ohmic resistance in series with it, which governs the rate at which the condenser thus becomes charged and hence the rate at which the opposing force is built against the magnetizing influence of the active or operating winding. When the condenser becomes fully charged and no further current can thus flow in the opposing winding the current in the active winding builds up to its full value, the relay operates, and the impulse is terminated. With the operation of the impulsing relay two other relays in parallel are operated from its contacts, one of which relays controls the closure of the trunk loop with the proper battery polarity for a light negative impulse, while the other controls the successive operation and release of the two pairs of counting relays whose contacts are connected directly to the registers. These two pairs of counting relays, in turn, control the operation of the three other pairs of counting relays, so that, with each impulse, the character of the operated counting relay combination of the five pairs of relays is changed. With the operation of the above mentioned two relays in parallel, the impulsing conductors are reversed and the counting relays are operated. During the interval that the impulsing relay is in its operating position a negative impulse is transmitted, the current strength of which can be modified by operated registers as is described hereinafter.

With the operation of the impulsing relay the polarity of the condenser charging current is reversed, as is likewise the direction of current flow in the active winding. The impulsing relay is thus made ready to release since, the relay being polarized, the current in the active winding will flow in the wrong direction. In this case however the discharge condenser current in the opposing winding delays the immediate rise of the current in the active winding and consequently delays the release of the relay until the magnetizing force of the active winding is greater than the force in the opposing winding. In this case also the length of the negative impulse is measured by the time taken for the impulsing relay to release which, as mentioned above in connection with the positive impulse, is a function of the electrical time constant of the condenser and resistance combination in series with the opposing winding. When the impulsing relay releases, the two relays in parallel mentioned above are also released, the trunk loop is opened and grounded on one side, the counting relays are operated once more and a positive impulse is thereafter transmitted if the register to which the other trunk conductor is now connected closes the proper polarity battery thereon; otherwise it will be a blank impulse. The operation and release of the impulsing relay is repeated in this manner, the impulses being sent out in alternate succession of blank or positive and negative impulses, while the three pairs of steering counting relays progressively transfer the impulse modifying conductors from one group of contacts connected with the registers to the next in the numerical order in which the impulses are to be sent out. When the last group of impulses is transmitted a special heavy positive impulse is transmitted for the purpose of closing through the circuits of automatic selector switches in the distant offices through which the trunk line may have been routed in order to reach the terminating office where the impulses are received, if the connection has been so routed.

It is seen that the impulses generated by the impulsing circuit thus described consist of either blank or light negative impulses.

These impulses are modified either to light positive or heavy negative by the operated or non-operated condition of the registers containing the recorded number when, during the transmission of each impulse, the impulsing modifying conductors are switched progressively from one group of registers to the next. The modification of the blank and light negative impulses generated by the impulsing circuit consists either in transforming a blank impulse into a light positive impulse by the register connecting battery on the tip conductor during the transmission of a positive impulse or transforming a light negative impulse into a heavy negative impulse by the register placing battery through a low resistance in parallel with the battery through the high resistance to the ring conductor during the transmission of a negative impulse. The modified impulses serve to operate marginal and polarized relays in the receiving equipment which control the operation of numerical registers and associated lamps to display the number represented by the positive and heavy negative impulse codes thus transmitted. The light negative impulses control the switching relays of the receiving circuit for transferring the record of the impulses received to the appropriate group of numerical registers.

When the exchange code and number of the wanted subscriber is recorded on the registers of a sender, and a trunk line to the desired terminating office has been selected by the automatic switches, an assignment lamp, individual to the selected trunk, is lighted at the operator's position where the trunk terminates. The sender is, at this time, connected to the trunk in question and is ready to respond to a signal from the operator at the distant office, which signal is given when an assignment key is depressed in response to the lighting of the assignment lamp. The depression of the key causes the trunk conductors to be connected to the impulse receiving circuit at the operator's position and, at the same time, causes the release of a relay in the sender. The release of this relay is the signal awaited by the sender for connecting the impulsing circuit to the line and extending the impulse modifying conductors to the registers by way of the counting relays. The impulses corresponding in code form to the number recorded in the registers are then transmitted in the manner already described; the sender extending the impulse modifying conductors through the steering counting relays, in proper combination, to the conductors of the registers containing the recorded number and which are to transmit their impulses in the order in which the said impulse modifying conductors are connected to the separate relays of the registers. When all the impulses have been sent the relay which first connected the trunk conductors to the impulse circuit is released and other circuits are then closed to release the sender and restore it to normal.

A clearer conception of the scope and purpose of the invention will be obtained from a consideration of the following description taken in connection with the attached drawings in which Figures 1 to 9, when arranged in the order illustrated in the diagram of Figure 11, discloses as much of the telephone exchange system incorporating the features of the invention as is necessary for a thorough understanding thereof.

Figure 1 illustrates, in a schematic manner, a calling subscriber's line and a line switch of the coordinate type for extending the lines to outgoing trunks. This figure also shows diagrammatically a sender selector switch of the coordinate type.

Figure 2 shows a portion of the detailed circuits of one of the trunks outgoing from the line switch of Figure 1 and also a diagram of a coordinate group selector switch in which said trunk terminates.

Figures 4, 5, 8, 8A and 9, taken together, show one of a number of register sender controlling mechanisms incorporating the invention herein described and which is associable with the trunks by means of the sender selector switch illustrated in Figure 1.

Figure 4 illustrates the dial impulsing relays and other control relays of the sender.

Figure 8 shows the controlling relays for sending code impulses representing the recorded designations.

Figure 8A shows the counting relays which are associated with the control relays of Figure 8 and the relay registers of Figures 5 and 9.

Figures 5 and 9, taken together, show relay registers on which designations are recorded under the control of the calling subscriber's line.

Figure 3 illustrates the incoming end of an interoffice trunk circuit. This trunk terminates in a plug-ended cord circuit at a manual operator's position in the called office. This figure also shows a called subscriber's line terminating at a manual office.

Figures 6 and 7 show a register circuit serving the purpose of a call indicator.

Figure 10 shows a chart indicating the character of the impulses transmitted for the digits zero to nine, inclusive.

The line switch 100, the group selector switch 200 and the sender selector switch 110 are of the coordinate type such as shown and described in detail in the Patent No. 1,507,140 granted September 2, 1924 to J. N. Reynolds.

The calling subscriber 101, on initiating a call, has his line automatically extended by way of the line switch 100 to an idle trunk, such as the trunk 103, terminating in the group or district selector switch 200. At the same time the trunk 103 is associated with an

idle register sender by means of the sender selector switch 110. Following this, the subscriber dials a number of digits which are recorded on the several registers of the associated sender. Thereafter, in any suitable manner, the register sender determines the selective operation of the district selector switch 200 from the number of the recorded digits which indicate the route, and an idle trunk is selected leading to the distant manual office at which it appears. Inasmuch as the present invention is not concerned with the detailed description of the selector switches, nor with the manner in which the register sender exercises its control over the switches, several elements have been illustrated in schematic fashion. For a more detailed explanation of the way in which the operating circuits of the various switches function and the manner in which the register sender controls the selection of trunks, reference is made to Patent 1,517,331 granted December 2, 1924 to S. B. Williams.

After a trunk has been selected by switch 200 in the mechanical office leading to the distant manual office illustrated in Figures 3, 6 and 7, it is necessary to transfer the record established in the register sender over the trunk to the distant office to bring about the operation of the call indicator in order that the operator may be advised of the called line number. This is accomplished by means of the equipment shown in Figure 5, 8, 8A and 9 particularly illustrating the present invention, wherein the relay devices 807 and 808 control operations which result in the creation of impulses which form codes according to the record established on the registers and transmits these impulses over the line to the distant manual office. The record is established on the distant manual office in the call indicator registers and causes the illumination of the proper lamps before the operator. In case the distant called office is one involving machine switching apparatus for building a connection, code impulses will be transferred to a register sender thereat which, in turn, will control the operation of switches in the distant called office.

A detailed description will now be given of the establishment of a connection between a calling line in a mechanical office, such as line 101, and a called subscriber's line, such as line 319 in a distant manual office, involving the transfer of the called line record from the first office to the second office over a direct trunk. Assuming that the entire designation of the called number is 253—1345 wherein the first three digits indicate the designation of the called office and the remaining four digits the numerical designation of the called line in that office, all these digits are recorded on seven of the eight registers shown in Figures 5 and 9, namely, registers 900, 909, 912, 926, 512, 513 and 521 in the order named. If the called subscriber is on a party line, an additional digit will be dialed indicating the station and this digit will be recorded on register 518.

When the calling subscriber initiates a call, his line 101 is extended automatically through the line switch 100 to the first idle one of a number of outgoing trunks 102, 103, etc. If the trunk 103 is the first one to be idle, it is selected and the called line is extended thereover to the district selector switch 200. At the same time that the calling line is extended to the district selector, the sender selector switch 110 is operated automatically and the trunk 103 is connected to the idle register sender shown partially in the drawings of Figures 4, 8, 8A, 5 and 9.

During the operation of the sender selector switch 100, a circuit may be closed in any suitable manner for relay 204. Relay 204 operates and applies ground potential to the holding or sleeve conductor 111. As soon as the sender selector switch 110 is operated, it may complete a circuit in any suitable manner for relay 203. Relay 203 operates and, at its bottom outer contacts, closes a substitute circuit for the slow releasing relay 204. Relay 203 also extends the tip and ring conductors 104 and 105 of the trunk through the sender selector 110 to the selected sender by way of conductors 221 and 220, respectively. An impulse circuit is now traceable from battery through resistance 434, right winding of relay 400 in the sender, normal inner contacts of relay 401, conductor 418, left outer contacts of relay 411, through selector 110, conductor 220, bottom inner make contacts of relay 203, conductor 105, through the line switch 100, over the loop of the calling line and returning through the line switch 100 to the conductor 104, top inner make contacts of relay 203, conductor 221 through the selector 110, left inner contacts of relay 411, outer contacts of relay 401, left winding of coil 402 to ground. Relay 400 closes a circuit for slow release relay 404 which, in turn, closes on its left contacts a circuit for relay 410. Relay 410 operates and, on its left inner contacts, applies holding ground to conductor 420 which provides holding circuits for the sender selector switch 110 and for relay 203 in the trunk circuit. Relay 400 also closes a parallel circuit through the left winding of relay 403 which relay operates and closes a circuit for relay 425 extending from battery, resistance 405, left contacts of relay 406, right contacts of relay 403, conductor 407, left back contacts of relay 408 through both windings of relay 425 in series to ground. Relay 425 operates and locks in a circuit extending from battery through resistance 405, conductor 409, left contacts of relay 412, conductor 413, right inner contacts of relay 425, right winding of relay 425 to ground. Relay 425 also closes a circuit

for relay 421 extending from battery and left winding of relay 403, left inner contacts of relay 403, left outer back contacts of relay 422, right outer back contacts of relays 422, 423 and 424, left outer front contacts of relay 425 through both windings of relay 421 in series to ground. This circuit, however, is ineffective at this time due to the direct connection from the left front contact of relay 403 to ground through the front contacts of relay 400, thus keeping relay 421 short-circuited at this time. The apparatus is now in condition for receiving the first series of impulses.

The operation of the counting relays shown in Fig. 4 in response to dial pulses forms the subject matter of Patent No. 1,563,738, granted on December 21, 1925 to O. C. From. Remembering that the number assumed to be dialed is 253—1346 the calling subscriber now manipulates the dial or other impulse transmitter to send a series of two impulses or interruptions of the impulse circuit. In response to the first interruption of the circuit, relay 400 releases and permits the above traced circuit for relay 421 to become effective, whereupon relay 421 operates and locks in a circuit from ground through its right winding and right inner contacts, conductor 413, left contact of relay 412, conductor 409, resistance 405 to battery. Relay 421 also closes a circuit from battery through resistance 405 on conductor 413, right inner contacts of relay 425 through the left winding of relay 425, left inner contacts of relay 421 to ground through the right winding of relay 403, the current in which circuit opposes that in the locking circuit for relay 425 and releases relay 425 differentially. The locking circuit for relay 421 is in shunt of its energizing circuit through the left winding of relay 403 and tends to release relay 403. The circuit through the right winding of relay 403 which releases relay 425 is differential to the circuit of the left winding of relay 403, so that with relay 400 released, relay 403 releases quickly upon the operation of relay 421.

At the time relay 400 falls back in response to the first impulse, a circuit is closed from ground on the back contacts of relay 400, right contacts of relay 404, winding of relay 406 to ground. Relay 406 operates and opens the initial energizing circuit for relay 425. Relay 406 also closes an obvious circuit for relay 408. Relay 408 operates and locks in a circuit from battery through its winding and left inner contacts right middle back contacts of relay 412, left outer contacts of relay 410 to ground. Relay 408 closes circuits the purpose of which will be made clear hereinafter.

At the end of the first impulse interruption, relay 400 again attracts its armature, relay 403 is operated and a circuit is completed for relay 422 by way of battery through the left winding and left inner contacts of relay 403, right outer front contacts of relay 421, right outer back contacts of relays 423 and 424, left outer back contacts of relay 425 through both windings of relay 422 in series to ground. Relay 422 does not operate at this time as it is shunted by the ground on the front contacts of relay 400. Relay 406, being slow to release, does not retract its armatures during the time that a train of impulses is being transmitted.

At the next interruption of the circuit, relay 400 falls back permitting relay 422 to operate in series with the left winding of relay 403. Relay 422 operates and locks to battery through resistance 405 over conductor 413 and closes a differential releasing circuit for relay 421 extending from ground through the right winding of relay 403, left inner contacts of relay 422, left winding of relay 421, right inner contacts of relay 421 to conductor 413. Relays 421 and 403 release.

At the closure of the line after the second impulse, the first train of impulses is terminated and relay 400 remains energized long enough to permit relay 406 to de-energize and retract its armatures. Since relay 408 was operated and locked, a circuit is closed from ground on the right normal contacts of relay 406, right inner contacts of relay 408, right inner contacts of relay 412, conductor 416, right back contacts of relay 901, winding of relay 902 to battery. Relay 902 attracts its armatures and locks in a circuit including its top inner contacts, conductor 903, winding of relay 412 and thence over the above traced circuit to ground at the right normal contact of relay 406. Relay 412, being shunted by the operating ground for relay 902, does not energize at this time. Relay 902 extends conductors 419, 429, 439 and 449 to the relays of the first code digit register 900. Since relay 422 is the only counting relay operated as a result of a train of two dialed impulses, a circuit may be traced from ground at the left middle contacts of relay 410, right outer contacts of relay 412, conductor 415, right outer back contacts of relay 425, left outer back contacts of relays 424 and 421, conductor 429, No. 2 contacts of relay 902, winding of relay 904, winding of relay 905 to battery. Relays 904 and 905 operate and lock in a circuit from battery, windings of the two relays, right inner contacts of relay 904, conductor 906, conductor 907, conductor 426, right outer contacts of relay 410 to ground. Relay 905 closes a circuit for relay 901 from ground on conductor 906 operating this relay and locking it to ground on conductor 906. As its right back contacts, relay 901 opens the shunt around the winding of relay 412, permitting that relay to energize in series with the locking circuit of relay 902.

Relay 412, at its left contacts, opens the locking circuit of the counting relays and, at its right outer contact, the locking circuit of relay 408. The counting relays are restored to normal. Relay 408 releases and opens the circuit of relays 412 and 902 disconnecting the register 900 from the counting relays. As soon as relay 412 falls back, the original circuit for relay 425 is closed again and that relay energizes and prepares a circuit for relay 421 as before.

The subscriber next dials the second digit of the called number, that is "5". In response to the first interruption of the dialing circuit relay 406 is energized, in turn energizing relay 408. Relay 421 is operated and relay 425 released. In response to the next interruption of the circuit, relay 422 operates and relay 421 releases. In response to the third interruption of the circuit, relay 423 is energized in a circuit from battery through the left winding of relay 403, left inner contacts of relay 403, right outer back contacts of relay 421, right outer front contacts of relay 422 through both windings of relay 423 in series to ground. Relay 423 attracts its armatures and releases relays 422 and 403 in a manner similar to that for the other counting relays previously described. In response to the fourth circuit interruption, the circuit prepared for relay 424, extending from battery through the left winding and left inner contacts of relay 403, right outer back contacts of relays 421 and 422, right outer front contacts of relay 423 through both windings of relay 424 in series to ground, becomes effective and relay 424 attracts its armatures, releasing relays 423 and 403 and locking to conductor 413. The fifth interruption of the dialing circuit causes the operation of relay 425 in a circuit from battery through the left winding and left inner contacts of relay 403, right outer back contacts of relays 421, 422 and 423, right outer front contacts of relay 424, the two windings of relay 425 in series to ground. Relay 425 locks to conductor 413 through its right winding and releases relays 424 and 403. Relay 425 also completes a circuit from battery through the winding of relay 427, right contacts of relay 428, right outer contacts of relay 408, right outer front contacts of relay 425, conductor 415, right outer contacts of relay 412, left middle contacts of relay 410 to ground. Relay 427 operates and locks in a circuit through the winding of relay 428 right contacts of relay 427 conductor 417 right outer contacts of relay 412 to ground on the left middle contacts of relay 410. Relay 428 cannot operate being shunted by the energizing circuit of relay 427. When, at the close of this series of impulses, relay 400 remains energized for a considerable period of time, relay 406 releases and completes a circuit from ground on the right normal contacts of relay 406, right inner contacts of relay 408, right inner contacts of relay 412, conductor 416, right front contacts of relay 901, right back contacts of relay 927, winding of relay 908 to battery. Relay 908 operates and locks in a circuit including its top inner contacts, conductor 903, winding of relay 412, right inner contacts of relay 408, to ground on the right normal contacts of relay 406. Relay 908 extends conductors 419, 429, 439, 449 to register 909. Since relays 425 and 427 are operated, a circuit is closed from ground at the left middle contacts of relay 410, right outer contacts of relay 412, conductor 415, right outer front contacts of relay 425, right outer contacts of relay 408, left inner contacts of relay 427, left inner contacts of relay 428, conductor 449, No. 4 contacts of relay 908, winding of relay 910 to battery. Relay 910 operates and locks by way of its left inner contacts, conductor 911 to grounded conductor 907. Relay 910 also connects ground from conductor 911, left outer contacts of relay 910, winding of relay 927 to battery. Relay 927 operates and locks to conductor 911. The operation of relay 927 opens the energizing circuit for relay 908 which was in shunt of the winding of relay 412 and relay 412 operates. Relay 412 opens the locking circuit for the counting relays and that of relay 408. Relay 408 in releasing, opens the circuits of relays 412 and 908, whereupon these relays also release and the circuits of Fig. 4 are ready to receive the next series of impulses. Relay 400, being energized at the time, as soon as relay 408 closes its left outer contacts, the previously traced circuit for relay 425 is closed and that relay prepares a circuit for relay 421 as before.

The calling subscriber now manipulates his dial to send a series of three impulses, which represents the last digit of the office code. Relays 406 and 408 are operated at the first interruption of the dialing circuit and, at the end of the third interruption of the circuit, relay 423 is operated and the other counting relays de-energized. Relay 400, remaining energized thereafter for a considerable period, permits relay 406 to release. A circuit is then closed from ground on the right normal contacts of relay 406, right inner contacts of relay 408, right inner contacts of relay 412, conductor 416, right front contacts of relays 901 and 927, right back contacts of relay 913, winding of relay 923 to battery. Relay 923 operates and locks in a circuit through its top inner contacts, conductor 903, winding of relay 412, right inner contacts of relay 408 to ground on the right normal contacts of relay 406. Relay 923 extends conductors 419, 429, 439, 449 to the relays of register 912. Since relay 423 alone is energized, a circuit is closed from ground at the left middle contacts of relay 410, right outer contacts of relay 412, conductor 415,

right outer back contacts of relay 425, left outer back contacts of relay 424, left outer contacts of relay 423, conductor 419, No. 1 contacts of relay 923, winding of relay 918 to battery. A circuit is also closed from ground on conductor 415, right outer back contacts of relay 425, left outer back contacts of relay 424, left outer back contacts of relay 421, conductor 429, No. 2 contacts of relay 923, winding of relay 914 to battery. Relays 918 and 914 operate and lock by way of conductor 916 to grounded conductor 907. The operation of these relays also extends ground from conductor 916 to relay 913, which relay operates and locks to conductor 916. The operation of relay 913 opens the energizing circuit of relay 923, permitting relay 412 to energize and bring about the release of the counting relays as before.

The calling subscriber next operates his dial to send a single impulse which represents the first digit of the called subscriber's number. In response to this impulse, relay 421 is operated and relay 425 released. At the completion of the impulse, relay 406 releases and a circuit is completed from ground though the right normal contacts of relay 406, right inner contacts of relay 408, right inner contacts of relay 412, conductor 416, right front contacts of relays 901, 927 and 913, right back contacts of relay 919, winding of relay 917 to battery. Relay 917 operates and locks by way of its top inner contacts, conductor 903, winding of relay 412 and thence over the previously traced circuit to ground. Due to the energization of relay 421, a circuit is closed from ground on conductor 415, right outer back contacts of relay 425, left outer back contacts of relay 424, left outer front contact of relay 421, conductor 419, No. 1 contacts of relay 917, winding of relay 920 to battery. Relay 920 operates and locks by way of conductor 921 to grounded conductor 907. In addition, relay 920 closes an obvious circuit for relay 919 from ground on conductor 921. Relay 919 operates and locks to conductor 921. Relay 919, on operating opens the circuit in shunt of relay 412 and this relay energizes and brings about the restoration of the counting relays and the disconnection of register 926 from the energizing conductors.

The subscriber next dials the series of impulses representing the digit 3 and, by the dialing circuit operations identical with those previously described for the digit 3 of the office code, relay 505 is operated, whereupon relays 508 and 509 of register 512 are operated and locked. The operation of these relays closes obvious circuits for relay 500 which, on operating and locking to ground through conductors 510 and 426, transfers the register cut-in circuit to relay 504 of register 513.

The subscriber next dials the series of impulses representing the digit 4. Through the means of circuits previously described, relay 424 is operated by this series of impulses and, when relay 400 has been operated for a considerable period and relay 406 has released, a circuit is closed from ground on the right normal contacts of relay 406, right inner contacts of relay 408, right inner contacts of relay 412, conductor 416, right front contacts of relays 901, 927, 913, 919 and 500, right back contacts of relay 501 winding of relay 504 to battery. Relay 504 operates and locks to grounded conductor 903. A circuit is closed from ground on the left middle contacts of relay 410, right outer contacts of relay 412, right outer back contacts of relay 425, left outer front contacts of relay 424, conductor 439, No. 3 contacts of relay 504, winding of relay 514 to battery. Relay 514 locks to ground on conductor 516 and closes an obvious circuit for relay 501 which also operates and locks to ground on conductor 516 and thereafter opens the energizing circuit of relay 504. This operation removes the shunt around relay 412 which operates and restores the dialing circuit in preparation for the next digit.

The subscriber next dials the series of impulses representing the digit 6 which is the last digit of the called number. The dialing of five of the six impulses proceeds in the same manner as previously described for the impulses of the digit 5 of the office code. It will be recalled that, at the termination of the fifth impulse, relay 425 was operated and likewise relay 427. Relay 428, however, remained shunted due to the presence of the operating ground for relay 427 on the left side of the winding of relay 425. When, however, the sixth impulse is received and relay 421 is operated, relay 425 is released by the shunting ground through the right winding of relay 403 and the left inner front contacts of relay 421 so that the short circuit around relay 428 is removed, causing this relay to operate and lock in series with relay 427 to ground on the left middle contacts of relay 410. When the sixth impulse is thus received and terminated, a circuit is closed from ground on the right normal contacts of relay 406, left inner front contacts of relay 408, right inner contacts of relay 412, conductor 416, right front contacts of relays 901, 927, 913, 919, 500 and 501, right back contacts of relay 502, winding of relay 503 to battery. Relay 503 operates and locks through its top inner contacts to ground on conductor 903. Circuits are also closed from ground on the left middle contacts of relay 410, right outer contacts of relay 412, right outer back contacts of relay 425, left outer contacts of relays 427 and 428 to conductor 449, while another branch of this circuit is extended from the right outer back contacts of relay 425 to the left outer back contacts of relay 424, left outer front contacts of relay

421 to conductor 419. Conductor 449, over the path previously traced, is extended to the No. 4 contacts of relay 503 and from thence through the winding of relay 515 to battery. Likewise, conductor 419 is extended over No. 1 contacts of relay 503 and from thence through the winding of relay 517 to battery. Relays 515 and 517 operate, lock to grounded conductor 511 and close obvious circuits for relay 502 which also operates and locks to grounded conductor 511. The operation of relay 502 opens the energizing circuit of relay 503 and removes the shunt around relay 412 causing it to operate and restore the dialing circuit for the reception of further digits.

The subscriber has now dialed the entire number. Should it be, however, that the called subscriber is on a party line and a corresponding letter designation is necessary, the impulse designation of the party letter will be recorded on register 518 in the same manner as described for the dialing of any of the previous digits.

After the subscriber has set up the office code record on registers 900, 909 and 912 the district selector switch 200 is operated under the control of these registers and cooperating circuits in the sender for the purpose of selecting an idle trunk 207 extending to the distant called office. These circuits are not shown as they form no part of the present invention and can be arranged in any suitable manner with the cooperating circuit elements of the sender for the performance of this function. During the operation of switch 200, relay 206 is operated and locked through its top inner contacts, conductor 210, top outer contacts of relay 203 to the grounded conductor 111. Upon the operation of relay 206, relay 205 is operated by the switch 200 in a suitable manner and locks through its left armature to conductor 210.

After the connection has been extended to the distant office, the apparatus is placed in condition to transmit code impulses over the trunk in accordance with the settings of the numerical registers in Figs. 5 and 9, that is, registers 926, 512, 513, 521 and, if a party letter has been dialed, register 518 also. When, after a suitable time delay has been allowed to permit the subscriber to dial a party letter, and the circuits in the sender are ready to transmit the impulses designating the wanted number, a circuit is completed, in any suitable manner, for relay 440. A circuit is also closed in any suitable manner, for relay 802 if, from the translation of the office code registration contained in registers 900, 909 and 912, circuits are closed in the sender which indicate that the call is to be completed over a direct route to a manual office having call indicator apparatus therein. The manner in which the above mentioned operations take place is shown and described in detail in Patent No. 1,517,331, granted December 2, 1924 to S. B. Williams. Relay 440 closes a circuit from battery through the winding of relay 441, contacts of relay 440 to ground on the right inner contacts of relay 410. Relay 441 operates in this circuit, locks through its left contacts to the operating ground and connects relay 446 through its right contacts to the tip and ring conductors of the trunk line resulting in a circuit as follows: Battery through the bottom inner back inner contacts of relay 300, conductor 301, right winding of relay 302, winding of relay 303, inner normal contacts of relay 304, outer back contacts of relay 305, thence over the tip side of the trunk 207 through switch 200, top outer front contacts of relay 206, right inner contacts of relay 205, conductor 211, through the selector switch 110, conductor 431, right inner contacts of relay 441, right inner back contacts of relay 443, winding of relay 446, right outer back contacts of relay 443, right outer contacts of relay 441, conductor 432 through the switch 110, conductor 212, right outer contacts of relay 205, bottom outer front contacts of relay 206 through the switch 200, thence over the ring side of the trunk line 207, inner back contacts of relay 305, outer normal contacts of relay 304, left winding of relay 302 to ground. Relays 302 and 303 operate and relay 302 closes a circuit for relay 306. Relay 306 operates and, at its left outer contacts, closes a circuit around relay 303, releasing this relay and preventing it from reoperating in series with the right winding of relay 302. Relay 306 also closes a circuit from battery through the assignment lamp 307, lower winding of relay 308, right outer back contacts of relay 309, top inner contacts of relay 308, right inner contacts of relay 306 to ground. Lamp 307 lights to advise the operator that a call is awaiting attention on the incoming trunk 207. Due to the character of relay 308, however, it is not energized sufficiently to attract its armature.

The code impulses are sent to the receiving office over a full metallic circuit comprising both tip and ring conductors of the line in series. These impulses may be of either positive or negative polarity dependent upon the side of the line circuit to which the positive pole of the battery is connected. They may also be weak or strong, dependent upon whether the battery is fed to the line through a high or low resistance. The impulses are received by the relays 601, 602 and 603. Relay 601 is polarized in such a manner as to respond only to the current produced when the positive pole of the battery is connected to the tip side of the line. Relay 602 is polarized in such a manner as to respond to current of the opposite polarity. Both relays 601 and 602 respond either to strong or weak impulses provided the polarity is in

the proper direction. Relay 603 responds to strong impulses of either polarity but does not respond to weak impulses.

At the time the above traced circuit is closed, relay 446 in the sender at the mechanical office also operates in series with relays 302 and 303 and closes an obvious circuit for relay 445. Relay 445 operates and closes a circuit from ground on the right inner contacts of relay 410 to the winding of relay 444 which operates and locks to the same ground.

Returning to the called office, the operator, observing the illumination of lamp 307, presses the individual assignment key 310 to associate the call indicator with trunk 207. Key 310 closes a circuit from battery through the winding of relay 605, conductor 628, bottom contacts of relay 308, right winding of relay 309, top contacts of key 310, conductor 324, contacts of relay 624 to ground at the right back contacts of relay 620. Relay 309 operates and locks in a circuit from battery through winding of relay 605, conductor 628 bottom contacts of relay 308, windings of relay 309 to ground on its left contacts. Relay 309 opens the original circuit of lamp 307 and connects this lamp in series with interrupter 311. The lamp flashes during the period that impulses are received, as described hereinafter, and until the operator inserts the trunk cord plug into the jack of the called line. Relay 309 also closes a circuit from battery through the winding of relay 305 and in parallel with battery through the left winding of relay 312, right inner contacts of relay 309, conductor 629 winding of relay 624 to ground at the left back contacts of relay 620. Relay 305 operates and extends the tip and ring conductors of the incoming trunk to conductors 600 and 604 respectively. When relay 305 operates it opens the circuit including relays 302 and 446. Relay 302 releases and opens the circuit of relay 306 which also deenergizes. The release of relay 446 permits the release of 445, which relay now completes a circuit from battery through the winding of relay 443, outer contacts of relay 444, back contacts of relay 445 conductor 430 to ground on the right inner contacts of relay 410. Relay 443 disconnects relay 446 from the trunk conductors, connects them to the impulsing circuit shown in Fig. 8 by way of conductors 447 and 448 and closes a circuit for relay 800 from battery through the winding of relay 800, conductor 801, left inner contacts of relay 443, conductor 433, No. 4 contacts of relay 803, top contacts of relay 802 bottom middle back contacts of relay 804 to ground. From this moment on, the impulse circuit begins to transmit impulses in codes, controlled by the operated relays in the various registers of Figs. 5 and 9.

Relay 800, when it operates, closes a number of circuits as follows: ground on the bottom outer back contacts of relay 804, right Nos. 1, 2 and 3 contacts of relay 800, conductor 805, winding of relay 806, resistance 809 to battery. Also another circuit from the same aforetraced ground Nos. 1 and 2 contacts of relay 800, conductor 810, winding of relay 811, resistance 812 to battery. Relay 806 operates in the former circuit, locking to ground through its right inner front contacts, conductor 848 to the left outer contacts of relay 410, and relay 811 operates over the latter circuit and locks through its left inner front contacts, conductor 848 to ground. During the period that relay 806 is still normal, but in preparation for operating by the closure of the aforetraced energizing circuit, relay 816 remains short circuited by the connection of operating ground on conductor 805 to the right side of its winding and also the same ground on its other side by way of the left inner back contacts of relay 816 conductor 873 to the right normally made contacts of relay 806. When, however, relay 806 has operated and opened these normally made contacts, relay 816 operates over a circuit from battery, through resistance 825, winding of relay 816, right inner front contacts of relay 806 to ground on conductor 848. Likewise, relay 817 will remain short circuited until relay 811 opens its left inner normally made contacts and, when this occurs, relay 817 will operate in a circuit from battery through resistance 826, winding of relay 817, left inner front contacts of relay 811 to ground on conductor 848. The operation of relay 811 closes a circuit from ground on its right inner contacts, left inner normally made contacts of relay 818, winding of relay 818, resistance 841 to battery. Relay 818 operates and locks over its left innermost front contacts to ground on conductor 848. Relay 819, which is paired with relay 818, remains short circuited due to the presence of the locking ground for relay 818 on the right side of its winding and ground from the right inner front contacts of relay 811 on the left side of its winding by way of conductor 872 and the No. 1 back contacts of relay 819.

When relay 816 operates, a circuit is closed from ground on the left inner front contacts of relay 800, conductor 827, right outer contacts of relay 816, conductor 840, winding of relay 804 to battery. Relay 804 operates and locks over its top outer contacts to ground at relay 802 and opens the circuit of relay 800 which releases. Relay 804 closes ground through its top middle front contacts, top back contacts of relay 807, resistance 841 to battery and also a parallel circuit extending from resistance 841, through resistance 829, bottom winding of impulse relay 808, resistance 832 to battery. At the same time that this circuit is established, yet another circuit is closed in parallel with the

foregoing circuit through resistance 828, resistance 830, condenser 831, upper winding of impulse relay 808, resistance 832 to battery. Relay 808 tends to operate because of the energizing circuit through its lower winding. However, the charging circuit through the condenser 831 and upper winding overcomes the energizing circuit during the time required to charge the condenser, so that during the charging period, relay 808 remains normal. In the meanwhile a circuit is established from ground on the bottom middle front contacts of relay 804 to the back contacts of relay 807 and from these contacts two parallel circuits are established, one by way of conductor 835, normally made contacts of the No. 1 contact set of relay 824, winding of relay 824, resistance 892 to battery, and the other by way of conductor 833, normally made contacts of the No. 4 contact set of relay 815, winding of relay 815, resistance 834 to battery. Both of these relays energize and lock to ground; relay 815 through its No. 4 front contacts to grounded conductor 848 and relay 824 through its left No. 1 front contacts to grounded conductor 848. Relay 814, however, which is paired with relay 815, remains short circuited since the operating ground on conductor 833 is connected on the left side of the winding by way of the No. 1 back contacts of relay 814. Likewise, relay 813, which is paired with relay 824, remains short circuited due to the ground on conductor 835 being likewise effective on the left side of the winding of relay 813 by way of its left innerback contacts.

As soon as relays 815 and 824 are operated, ground from the bottom outer front contacts of relay 804, conductor 855, No. 4 contacts of relay 824, left inner front contacts of relay 816 and winding of relay 806 shunts relay 806, thereby causing it to release, and the same ground on conductor 855 is also closed through the right Nos. 1 and 2 contacts of relay 824 to conductor 869, left inner front contacts of relay 817 and winding of relay 811, shunting relay 811 and causing it to release also. Relays 816 and 817, however, do not release because, with the release of relays 806 and 811, holding circuits for each of these relays are closed respectively, from battery through resistance 825, winding of relay 816, right inner normally made contacts of relay 806, No. 4 contacts of relay 824, conductor 855 to ground on the bottom outer front contacts of relay 804, and battery, resistance 826, winding of relay 817, left inner normally made contacts of relay 811, right Nos. 2 and 1 contacts of relay 824 to the aforetraced ground on conductor 855.

With the above described operated and normal condition of the relays shown in Figs. 8 and 8A and during the period when relays 806 and 811 are releasing, the first impulse is transmitted. The order of the transmission of impulses designating the wanted number in the case of a call extending directly to a call indicating office is as follows: stations, thousands, hundreds, tens and units. In the case under consideration it has been assumed that no stations letter has been dialed. This, however, simply means that neither positive impulses nor heavy negative impulses will be transmitted but only two light negative impulses in order to operate the register steering relays in the call indicator circuit at the distant office and to light the lamp thereat to designate zero stations.

The transmission of impulses to the call indicator office will now be described and the effect of these impulses at that office will be considered hereinafter when describing the operation of the call indicator circuits.

Since no stations letter has been dialed, none of the relays in register 518 are operated and the first impulse of the four impulses representing the stations letter will, therefore, be a blank impulse, that is, the impulse time interval during which no current flow over the trunk loop to the call indicator office. This is apparent from an inspection of Figs. 8 and 8A and the operated or normal conditions of relays 815, 814, 824 and 813, 806 and 816, 811 and 817, 818 and 819 as previously described. The impulse time interval is measured from the time that ground is applied to the winding of relay 808 to the time that the said relay is operated, as described hereinafter. With the above-mentioned relays that are operated in conjunction with those not operated, the trunk line conductor 447 is connected to ground by way of the No. 3 back contact of relay 803, top contacts of relay 823 to ground on the No. 2 contacts of relay 803. Trunk conductor 448, however, is open at this time because it is connected through the combination of relays above operated to relay 523 of register 518 as follows: conductor 448, bottom inner back contacts of relay 803, bottom inner contacts of relay 804, conductor 844, right inner front contacts of relay 816, right inner front contacts of relay 817, right inner back contacts of relay 819, conductor 870, left outer back contacts of relay 821 which is normal, conductor 845, right back No. 2 contacts of relay 814, conductor 846 included in the bracket line 847, conductor 846, bracket line 847, conductor 846, Fig. 5, to the left contact of relay 523. Since no stations letter was dialed, relay 523 is normal so that conductor 846 remains open at this relay, thereby resulting in a blank or open impulse on the trunk conductors connecting with the call indicator circuit at the terminating office.

During the time it takes to charge condenser 831 and relay 808 is normal, the first impulse is transmitted as just described. When the condenser has become fully charged, the flow of current through the up-

per winding of relay 808 ceases and the operating circuit through the lower winding is then effective to operate relay 808. The relationship between the constants of the opposing circuit through the upper winding of relay 808 and the time of operation of the said relay is completely described in the patent application of O. R. Miller above referred to. When relay 808 operates, it closes a circuit from ground on the top middle contacts of relay 804, front contacts of relay 808 to the winding of relay 807 and also to the winding of relay 823. Relay 807 operates and opens its bottom contacts thereby removing ground from conductors 833 and 835, causing the shunt around relays 814 and 813 to be removed, which now operate and lock in series with relays 815 and 824 respectively. The operation of relay 813 closes ground from conductor 848 on its No. 4 contacts to the left inner front contact of relay 817 directly to the winding of relay 811 and maintaining the short circuit around this relay. Relay 813 also closes the same ground on its right No. 3 contacts to the left inner front contacts of relay 816 to the winding of relay 806 likewise maintaining the short circuit around this relay. Finally, the operation of relay 814 closes ground on its right No. 4 contacts, right outer contacts of relay 817, No. 1 back contacts of relay 819, winding of relay 819, thereby providing another short circuit path for this relay in addition to the one now effective to conductor 871. Relays 816 and 817 remain operated, over their previously described circuits, but the following additional holding circuits to relays 816 and 817 are closed for a purpose described hereinafter: battery through resistance 825, winding of relay 816, right inner normally made contacts of relay 806, conductor 873, No. 3 contacts of relay 813 to ground on conductor 848 and the latter by a circuit from battery through resistance 826, winding of relay 817, left inner normally made contacts of relay 811, conductor 869, No. 4 contacts of relay 813 to ground on conductor 848. Relay 823, in operating, reverses the polarity of the trunk conductors 447 and 448 by connecting ground on conductor 848 through its own bottom contacts and bottom inner back contacts of relay 803 to conductor 448 and battery through high resistance 839, top inner contacts of relay 804, No. 3 back contacts of relay 803 to conductor 447. In this condition of the circuit, namely, while relays 808, 807 and 823 are operated and the resulting changes as above described are taking place in the operated combination of the counting relays in Fig. 8A the impulsing circuit transmits the second of the series of the four impulses representing the stations letter.

It will be noted that the only change which took place in the counting relay circuits as a preparation for the second impulse was the operation of relays 814 and 813 while all the other counting relays remained as they were for the first impulse. It will also be noted that theimpulse begins as soon as relay 823 either makes its bottom contacts or breaks its top contacts and which operation is controlled by the impulsing operation of relay 808. The corresponding changes in the operating or released combination of the counting relays in Fig. 8A takes place, of necessity, during the impulse interval. It will be found on inspection, however, that those counting relays which control the character of the impulse then being transmitted are not disturbed during these operations, they having been prepared in advance during the transmission of the preceding impulse.

The second impulse is always negative, it being closed over the trunk loop independent of the registers and controlled by resistance 839 as above described. Its character as a light negative impulse, however, may be altered by imposing a parallel circuit condition on conductor 843 in which case the light negative impulse is changed into a heavy negative one. Conductor 843, is at this time, connected to the left contact of relay 524. As no stations letter has been dialed and the relays of register 518 are all normal, conductor 843 is open, thereby effecting no change in the light negative pulse. The path of conductor 843 is as follows: resistance 839, conductor 843, outer back contacts of relay 806, right outer back contacts of relay 811, right middle front contacts of relay 818, conductor 849, left outer back contacts of relay 820 which is normal, conductor 850, No. 2 front contacts of relay 815, conductor 851, bracket line 847, conductor 851 in Fig. 5, left contact of relay 524. Relay 524 is normal so that no circuit is available to effect the character of the impulse circuit over the trunk loop including resistance 839 and battery on conductor 447, ground on conductor 448 and relays 601, 602 and 603 in series in the loop itself at its other end at the call indicator office.

When relay 807 operated, the ground which previously caused the operation of relay 808 is connected to resistance 832 which results in a reversal of potential in the operating circuit of the lower winding of relay 808 and also in that of the condenser opposing circuit through the upper winding. Relay 808 is polarized and the effect of this change in direction of current flow tends to release relay 808. However, the battery potential on the condenser being removed, the

condenser will now discharge and the discharge circuit is of such intensity and direction as to oppose the effect of the releasing circuit through the lower winding of relay 808 so that this relay does not begin to release until condenser 831 is completely discharged. When this occurs, the circuit through the lower winding becomes effective and releases relay 808, which, in turn, releases relays 807 and 823. The release of relay 823 reverses the trunk conductors while the release of relay 807 recloses ground on conductors 833 and 835. The ground on conductor 833 short-circuits relay 815 due to the fact that this ground is now connected to left No. 1 front contacts of relay 814 and winding of relay 815. Relay 815 releases but relay 814 is held operated over a circuit from battery, resistance 852, winding of relay 814, normally made contacts of the No. 4 contact set of relay 815 to ground on conductor 833. A similar operation takes place with respect to relay 824 due to the presence of ground on conductor 835 likewise resulting in a release of relay 824 and holding relay 813 locked through the left inner normally made contacts of relay 824 to conductor 835. The electrical conditions of relays 816, 806, 817, 811, 818 and 819 are at this time, under the control of the operated relay 813 as already explained and since, by the release of relay 807 and associated circuits, relay 813 was undisturbed, the above mentioned relays remain undisturbed also. During these operations the impulse circuit transmits the third impulse of the stations digit, which, like the first, is a blank pulse due to the fact that no relay of register 518 is operated and the extension of trunk conductor 448 to the stations register by way of conductor 844 is opened at the left contacts of relay 526. This path is as follows: trunk conductor 448, bottom inner back contacts of relay 803, bottom inner contacts of relay 804, conductor 844, right inner front contacts of relay 816, right inner front contacts of relay 817, right inner back contacts of relay 819, conductor 870, left outer back contacts of relay 821, conductor 845, right No. 2 front contacts of relay 814, conductor 874, bracket line 847, conductor 874, Fig. 5, left contact of relay 526. Relay 526 is normal and the trunk loop is consequently open during the third impulse interval.

The release of relay 807 reconnects ground to the operating circuit of relay 808 causing, ultimately, the next operation of relay 808 in the manner already described and the subsequent operation of relays 807 and 823. The reoperation of relay 807 disconnects ground from conductors 833 and 835 and thereby causes the release of relays 813 and 814 respectively. The release of relay 813 opens the ground on the Nos. 3 and 4 front contacts, which ground holds operated relays 816 and 817 causing them to release. The removal of ground on the right No. 4 contacts of relay 814 opens the short circuit around relay 819 causing it to operate and lock in series with relay 818. The impulse circuit transmits the fourth or last of the series of impulses designating the stations letter during these operations which impulse is like the second, a light negative impulse, since relay 525 of register 518, controlling the modification of this impulse, is not operated. The impulse circuit loop is from battery through resistance 839, top inner contacts of relay 804, No. 3 back contacts of relay 803, conductor 447, the trunk loop including relays 601, 602 and 603, conductor 448, inner bottom back contacts of relay 803, bottom contacts of relay 823 to ground on conductor 848. The negative impulse modifying conductor 843 is extended to the left contact of relay 525 over the following path: conductor 843 at resistance 839, right outer back contacts of relay 806, right outer back contacts of relay 811, right middle front contacts of relay 818, conductor 849, left outer back contacts of relay 820, conductor 850, No. 2 back contacts of relay 815, conductor 854, bracket line 847, conductor 854, Fig. 5, to the left contact of relay 525.

The four impulses characterizing the thousands digit are next transmitted. Since this digit is 1, an inspection of the impulse chart Fig. 10 shows that, for this digit, the impulse combination consists of a light positive impulse, a light negative impulse, a blank impulse and a light negative impulse.

It will be recalled that the last impulse of the stations letter was transmitted while relays 808, 807, 818 and 819 were operated, and the remaining counting relays, that is, relays 814, 815, 813, 824, 816, 806, 817 and 811 were released. When relays 808 and 807 release in the manner described relays 815 and 824 are again operated while relays 814 and 813 remain short circuited in the manner described. When, therefore, relays 815 and 824 operate a circuit is closed for relay 806 as follows: ground on the bottom outer front contacts of relay 804, conductor 855, No. 4 contacts of relay 824, right inner normally made contacts of relay 806, winding of relay 806, resistance 809 to battery. A circuit is also closed for relay 811 from the aforetraced ground from conductor 855, right Nos. 1 and 2 right outer contacts of relay 824, left inner normally made contacts of relay 811, winding of relay 811, resistance 812 to battery. A parallel circuit for this relay is also closed from ground on the left contacts of relay 806.

Relay 816, however, remains short circuited due to the fact that the operating ground for relay 806 is effective at the left inner back contacts of relay 816 and the winding thereof by way of the No. 4 contacts of relay 824. Relay 817 likewise remains short circuited due to the fact that the operating ground for relay 811 is effective at the left inner back contacts of relay 817 and winding thereof by way of the right Nos. 1 and 2 contacts of relay 824. The circuit conditions for relays 818 and 819 have been changed by the fact that the operation of relay 811 connected ground on its right inner contacts and conductor 872 to the No. 1 front contacts of relay 819 which short circuits and releases relay 818. Relay 819, however, is held operated over a circuit from battery through resistance 837, winding of relay 819, left inner normally made contacts of relay 818 to ground on the right inner contacts of relay 811.

While the above changes are taking place in the operated and released condition of the counting relays the first impulse of the thousands digit is transmitted, which impulse, it will be recalled, is positive and necessitates the application of battery through a high resistance on conductor 448 and ground on conductor 447. It will be recalled, also, that the registration of the thousands digit on register 926 was effected by the operation and locking of relay 920 so that the light positive impulse circuit is traced as follows: ground on the No. 2 contacts of relay 803, top contacts of relay 823, No. 3 contacts of relay 803, conductor 447 over the aforetraced trunk loop including relays 601, 602 and 603, conductor 448, bottom inner back contacts of relay 803, bottom inner front contacts of relay 804, conductor 844, right inner back contacts of relay 816, left outer back contacts of relay 817, No. 3 front contacts of relay 819, conductor 856, left middle back contacts of relay 821, conductor 857, left outer back contacts of relay 813, conductor 858, bracket line 842, conductor 858, Fig. 9, left contacts of relay 920, conductor 930, resistance 903 to battery. Resistance 938 is of such a value as to cause only relay 601 in the indicator circuit to respond as more fully described hereinafter.

The next impulse is the second one of the four designating the thousands digit 1 and will, according to the chart of Fig. 10, be a light negative impulse. This impulse begins when relay 808 operates; the short circuits around relays 814 and 813 being removed causing these relays to operate and lock in series with relays 815 and 824, respectively. The circuit conditions surrounding relays 816, 806, 817, 811, 819 and 818 remain unchanged. The negative impulse circuit is closed from battery through high resistance 839 over the aforetraced circuit to conductor 447, the aforetraced loop, bottom contacts of relay 823 to ground on conductor 848. The dialing of the thousands digit 1 did not result in the operation of any relay other than relay 920 of register 926 so that, while conductor 843 is extended to the left contact of relay 935, the character of the impulse will not be affected since relay 935 is normal. The extension of conductor 843 to the left contact of relay 935 is traced as follows: conductor 843, at resistance 839, right outer front contacts of relay 806, left outer front contacts of relay 811, left middle back contacts of relay 818, conductor 860, left middle back contacts of relay 820, conductor 861, left No. 3 front contacts of relay 824, conductor 862, bracket line 842, conductor 862, Fig. 9 to left contact of relay 935. Relay 935 is normal and the light negative impulse, therefore is unaltered. If the impulse under consideration belonged to a code of a digit requiring a heavy negative impulse for its second impulse, such as for example digit 3, then relay 935 would be operated and battery through low resistance 915 would be connected by way of conductors 936 and 937 to the left contacts of relays 935. This circuit would then be connected in parallel by way of conductor 843 of the aforetraced path with that including resistance 839 to conductor 447 of the trunk loop and result in an impulse of a heavier current intensity than the impulse being transmitted in which the parallel battery circuit through resistance 915 is not used.

The third impulse is a blank impulse and is transmitted, in a manner of speaking, with relays 808, 807 and 823 released so that ground is again connected to conductors 833 and 835 causing the release of relays 815 and 824 in the manner described, while the remaining counting relays remain in the same condition as for the previous impulse due to the fact that relay 813 remains operated. Under such circumstances ground is present on trunk conductor 447 while trunk conductor 448 and the extension thereof to conductor 844, is connected to the left contact of relay 925 of register 926 and is opened thereat since relay 925 is normal. This path is traced as follows: conductor 448, bottom inner back contacts of relay 803, bottom inner contacts of relay 804, conductor 844, right inner back contacts of relay 816, left outer back contacts of relay 817, No. 3 front contacts of relay 819, conductor 856, left middle back contacts of relay 821, conductor 857, left outer front contacts of relay 813, conductor 864, bracket line 842, conductor 864 Fig. 9, to left contact of relay 925 which is normal.

When relay 808 reoperates the last impulse of the thousands digit is transmitted. The resulting operation of relay 807 removes ground from conductors 833 and 835, thereby causing the release of relays 814 and 813.

The short circuit around relay 816 is now removed causing this relay to operate and lock in series with relay 806 and the fact that relay 806 remains operated preserves the short circuit around relay 817 while relay 811 remains locked to ground on conductor 848. Relay 811 also preserves relays 819 and 818 in their respective operated and released conditions. The negative impulse loop is now closed from battery through high resistance 839 over the aforetraced loop on conductor 447 to ground on conductor 448 over the bottom contacts of relay 823. The extension of conductor 843 to the left contacts of relay 929 of register 926 is opened at the contacts of relay 929 since this relay was not operated when digit 1 was dialed. This path is as follows: conductor 843 at resistance 839, right outer front contacts of relay 806, left outer front contacts of relay 811, left middle back contacts of relay 818, conductor 860, left middle back contacts of relay 820, conductor 861, left No. 3 back contacts of relay 824, conductor 867, bracket line 842, conductor 867, Fig. 9, left contact of relay 929. Relay 929 is normal and the light negative impulse is, therefore, transmitted unaltered.

It is thought that the operations described above sufficiently show how each impulse is transmitted, in what manner the negative impulses may be altered by the operated registers, how the loop is closed by the operated registers for the transmission of light positive impulses and how, during each impulse, the combination of the groups of counting relays is changed so as to advance either of the two conductors 843 and 844 over which the impulse may either be altered to the impulse circuit closed, to the next succeeding relay of the register containing the record of the dialed number, as to make further description unnecessary. The chart below has been compiled for convenience instead and shows the operated or released condition of each of the counting relays described above for each impulse transmitted over the loop conductors. In this chart the relay designations are tabulated horizontally, numbers are assigned to the various impulses in a vertical row under the caption "Impulse No." and the symbol "N" or "O" under each of the relay designations indicates the normal or operated condition respectively of the relay for the impulse number shown under "Impulse No." in the corresponding horizontal row. Under the column headed "Digit" is indicated to which digit the impulse in the horizontal row belongs. For reasons noted below the first impulse considered in the above description, that is, the first blank impulse of the stations letter designation is impulse No. 13 in the chart and all the other impulses specifically described belong to the stations letter and the thousands digit following thereafter.

Impulse Chart

Impulse No.	808	815	814	824	813	806	816	811	817	818	819	Digit
1	N	O	N	O	N	O	N	O	N	O	N	1st code digit
2	N	O	N	O	N	O	N	O	N	O	N	1st code digit
3	N	O	N	O	N	O	N	O	N	O	N	1st code digit
4	N	O	N	O	N	O	N	O	N	O	N	1st code digit
5	N	O	N	O	N	O	N	O	N	O	N	2nd code digit
6	N	O	N	O	N	O	N	O	N	O	N	2nd code digit
7	N	O	N	O	N	O	N	O	N	O	N	2nd code digit
8	N	O	N	O	N	O	N	O	O	O	N	2nd code digit
9	N	O	N	O	N	O	N	O	O	O	N	3rd code digit
10	N	O	N	O	N	O	N	O	O	O	N	3rd code digit
11	N	O	N	O	N	O	N	O	O	O	N	3rd code digit
12	N	O	N	O	N	O	N	O	O	O	N	3rd code digit
13	N	O	N	O	N	O	N	O	O	O	N	Station
14	N	O	N	O	N	O	N	O	O	O	N	Station
15	N	O	N	O	N	O	N	O	O	O	N	Station
16	N	O	N	O	N	O	N	O	O	O	O	Station
17	N	O	N	O	N	O	N	O	N	O	O	Thousands
18	N	O	N	O	N	O	N	O	N	O	O	Thousands
19	N	O	N	O	N	O	N	O	N	O	O	Thousands
20	N	O	N	O	N	O	N	O	N	O	O	Thousands
21	N	O	N	O	N	O	N	O	N	O	O	Hundreds
22	N	O	N	O	N	O	N	O	N	O	O	Hundreds
23	N	O	N	O	N	O	N	O	N	O	O	Hundreds
24	N	O	N	O	N	O	N	O	N	O	O	Hundreds
25	N	O	N	O	N	O	N	O	O	O	O	Tens
26	N	O	N	O	N	O	N	O	O	O	O	Tens
27	N	O	N	O	N	O	N	O	O	O	O	Tens
28	N	O	N	O	N	O	N	O	O	O	O	Tens
29	N	O	N	O	N	O	N	O	O	O	O	Units
30	N	O	N	O	N	O	N	O	O	O	O	Units
31	N	O	N	O	N	O	N	O	O	O	O	Units
32	N	O	N	O	N	O	N	O	O	O	O	Units
33	N	O	N	O	N	O	N	O	N	O	N	
34	O	O	O	O	O	O	N	O	N	O	N	

The impulses are thus transmitted in the order shown in the impulse chart and it is evident that when impulse No. 32 is transmitted all of the impulses necessary for the designation of the wanted number are exhausted. During the transmission of impulse No. 31, at which time the counting relays are being prepared for impulse No. 32, relays 818 and 819 are released. The release of these relays has the effect of extending grounded conductor 848 over the right outer back contacts of relay 819, conductor 887, right outer back contacts of relay 818, conductor 888, right contacts of relay 885 to conductor 890. This conductor may be extended to the circuits of the sender in any suitable manner to prepare its release. When the sender releases relay 802 is released, in turn, releasing relay 804 and the ultimate release of relay 410 opens the ground or conductor 848 restoring all operated counting relays. The release of the remaining parts of the sender proceeds in the well known manner.

It will be observed from an examination of the above impulse chart that the operation and release of the various counting relays shown therein proceeds in a cyclic order. Thus relays 815 and 824 are operated for two impulses and released for two impulses; relays 813 and 814 are likewise operated for two impulses and released for two pulses but relay 806 is operated for four impulses and released for four impulses. In a like manner relay 816 is operated and released. Relays 811 and 817 are operated for eight impulses and released for eight impulses, while relays 818 and 817 are operated for eight impulses and released for eight im-

pulses, while relays 818 and 819 are operated for sixteen impulses and released for the remaining sixteen. Thus it is seen that relays 811 and 817 operate twice as fast as relays 818 and 819, relays 806 and 816 operate twice as fast as relays 811 and 817, while relays 824, 815, 814 and 813 operate twice as fast as relays 806 and 816.

If the call being considered were one to be routed via a tandem office equipped with call indicator apparatus and extending therefrom to a terminating office in any suitable manner, it becomes necessary, under such circumstances, to apprise the call indicator operator of the designation of the called office as well as of the number of the wanted subscriber therein. Additional impulses designating the digits of the office code will have to be transmitted by the sender and the call indicator receiving circuit at the tandem office is provided in a manner well known to the art with additional registers and lamps to record the impulses and display the corresponding numbers of the office code thereat. Assuming that the translation by the sender of the office code indicates a tandem routing then relay 838 is operated in the sender in any suitable manner. When relay 443 operates in response to the depression of the trunk assignment key at the tandem call indicator office a circuit is completed for relay 804 from battery through the winding of relay 804, contacts of relay 838, conductor 876, left outer contacts of relay 443, conductor 877, No. 1 back contacts of relay 803 to ground on conductor 848. Relay 804 operates and closes ground through its top middle contacts to the windings of the impulse relay 808 in the manner described and also closes ground through its bottom middle front contacts, bottom contacts of relay 807 to conductors 833 and 835. The impulsing circuit now begins to function and relays 815 and 824 operate in the described manner, the ground on conductor 833 and 835 keeping relays 814 and 813 short circuited respectively. Relay 806 operates over a circuit from battery through resistance 809, winding of relay 806, right inner normally made contacts of relay 806, No. 4 contacts of relay 824, conductor 855 to ground on the bottom outer front contacts of relay 804. Relay 816 is short circuited at this time due to the connection of the operating ground for relay 806 to its winding by way of the left inner back contacts of relay 816 and conductor 873. A circuit is also closed for relay 811 from battery through resistance 812, winding of relay 811, left inner normally made contacts of relay 811, right Nos. 2 and 1 contacts of relay 824, conductor 855, to ground on the bottom outer front contacts of relay 804. Another circuit is also closed for this relay from a ground on left contacts of relay 806. Relay 817 is held short circuited to the connection of operating ground for relay 811 to the winding of relay 817 by way of its left inner back contacts, conductor 869, right Nos. 2 and 1 contacts of relay 824, conductor 855 to ground. Relay 818 also operates over a circuit from battery through resistance 841, winding of relay 818, left inner normally made contacts of relay 818 to ground on the right inner contacts of relay 811. This ground is also effective in keeping the relay 819 short circuited as it is further extended by way of conductor 872, No. 1 back contacts of relay 819 to the left side of the winding thereof.

The above description compares with the normal or operated condition of the counting relays as shown in the above impulse chart for impulse No. 1. The impulses which are now transmitted are from 1 to 12 inclusive, divided into groups of four, each group in the numerical order of the impulses as numbered representing, in code form, the first, second and third digits of the office code record recorded on registers 900, 909 and 912. By an inspection of the condition of the counting relays as indicated in the above mentioned impulse chart together with a consideration of Figs. 8 and 8A the paths of the impulse correcting conductor 843 and impulse closing conductor 844 may be traced for the three groups of impulses above enumerated as follows:

First digit of office code—bracket line 878—register 900.

Second digit of office code—bracket line 879—register 909.

Third digit of office code—bracket line 886—register 912.

The transmission of the remaining impulses proceeds immediately after impulse No. 12 without any interruption and in the manner already described for impulses transmitted directly to a terminating call indicating office except for the fact that during the transmission of impulse No. 16 when relay 819 operates, a circuit is closed for relay 800 from battery through the winding of relay 800, conductor 868, right outer front contacts of relay 819 to ground on conductor 848.

Referring once again to the above impulse chart it is apparent that 32 pulses in all are required to transmit a complete set of impulses representing the digit designations including those for the office code. In the present state of the telephone art it is also possible to extend the call to the terminating office via what is known as a two-wire office selector located somewhere in the trunk route between originating and terminating office. Such a selector is shown in Patent No. 1,567,271, granted to L. H. Johnson on December 29, 1925, and reference is made thereto for a complete description of its operation. The present invention provides

for completing calls through such a selector and the principal apparatus of that circuit, so far as it concerns the present invention, is a marginal polarized relay included in the trunk conductors during the time that call indicator impulses are being transmitted. This relay controls the preparation of the talking circuit after all such impulses have been transmitted and responds to a discriminating impulse different from those so far described. The impulse to operate this relay is a positive impulse of a certain minimum current intensity but, as already mentioned, this relay does not respond to the light positive impulses which have thus far been described nor to any of the negative impulses. When the impulses designating the wanted subscriber's number have all been transmitted it is necessary to operate this relay. For this purpose provision is made in the present embodiment of the invention to send an additional positive impulse of the proper current value. If, therefore, the translation of the office code record in the sender indicates that the connection will be extended to a terminating office via a two-wire office selector, relay 885 will be operated in any suitable manner by circuits controlled through the contacts of the operated relays in registers 900, 909 and 912.

When impulse No. 32 has been sent relays 808 and 807 release. Relays 815, 824, 806, 811 and 818 operate while the others remain short circuited in the described manner. Impulse No. 33 is transmitted at this time, it being a blank impulse since conductor 844 is connected by relays 816, 817 and 819 to the left outer back contacts of relay 800. This blank impulse is provided in order to give the polarized relay in the two-wire office selector an opportunity to dissipate its residual magnetism should impulse No. 32 have been a heavy negative impulse.

When relays 807 and 808 operate at the termination of impulse No. 33 relays 814 and 815 operate in the regular manner and a circuit for relay 803 is now closed from battery through the winding of relay 803, conductor 882, No. 4 contacts of relay 819, left middle contacts of relay 800, conductor 879 to ground at the left outer contacts of relay 815. Relay 803 operates and locks over its No. 1 front contacts to ground on conductor 848. A heavy positive impulse circuit is now closed from battery through low resistance 880, bottom outer front contacts of relay 803, conductor 881, left middle front contacts of relay 818, left outer front contacts of relay 811, right outer front contacts of relay 806, conductor 843 to resistance 839. A parallel circuit is joined at this point with battery through resistance 839, top inner contacts of relay 804, conductor 883, left No. 2 front contacts of relay 814, conductor 884, bottom inner front contacts of relay 803, conductor 448, the trunk loop above traced including the positive polarized relay in the two-wire office selector, conductor 447, No. 3 front contacts of relay 803, bottom contacts of relay 823 to ground on conductor 848. The relay in the two-wire office selector operates in this circuit and serves to establish the proper talking condition on the trunk conductors of that selector as more particularly described in the above mentioned patent. Mention is here made of the fact that, when a call is routed to a terminating call indicating office via the two-wire office selector above mentioned, additional provision is made in the call indicator circuit to neutralize the effect of the heavy positive impulse on relays 601, 602 and 603 thereat. This modification is fully described in the above mentioned patent to L. H. Johnson and no further description is therefore necessary here.

When relay 803 operates the circuit of relay 800 is broken at the No. 4 contacts of relay 803 causing this relay to release and relay 800 now closes a ground on its left inner back contacts, conductor 891, left contacts of relay 885, conductor 890, which can be extended to the circuits of the sender to release it in the well known manner.

Another type of call to which the present invention is adapted is one terminating in a call indicator office but for which the subscriber's number therein exceeds 10,000. Under such circumstances the calling subscriber, after having dialed the office code, proceeds to dial the wanted subscriber's number and records on register 926 the 10,000 digit thereof. Register 512 will then record the thousands instead of the hundreds digit, register 513 the hundreds instead of the tens digit, register 521 the tens instead of the units digit and register 518 the units instead of the stations digit. The translation of the office code record will then indicate the fact that the called number is over 10,000 and thereafter causes the operation of relays 820 and 821 in any suitable manner. When the time comes for transmitting the code impulses the fact that relays 820 and 821 are operated has the effect of connecting the counting relays as they are operated for impulse No. 13 to the four conductors 859, 862, 864 and 867 leading to the contacts of the relays in register 926. All other conductors are also shifted ahead in groups of four so that when the time comes for transmitting impulses No. 29 to 32 inclusive, the counting relays, as they are operated in preparation for each of these impulses will, in turn, connect to conductors 846, 874 and 854 of the stations register 518. For the transmission of a code representing a wanted number whose designation is over 10,000 the order of the transmission of impulses is thus; ten thousands (on thousands register), thousands (on hundreds register), hundreds (on

tens register), tens (on units register), and units (on stations register).

Returning now to the call indicator apparatus in the distant office reached over a direct trunk from the calling office it will be recalled that the depression of key 310 result in connecting the trunk conductors to conductors 600 and 604, including the impulsing relays 601, 602 and 603. Relay 603 is marginal and responds only to heavy impulses, relay 602 is negatively polarized and responds only to negative impulses, while relay 601 is positively polarized and responds only to positive impulses. When the trunk conductors became thus connected to the call indicator impulsing relays, relay 446 in the sender at the distant office released which then caused the preparation of the impulsing circuit to transmit to the call indicator office the impulses above described. The stations letter impulses are first transmitted and, as no stations letter was dialed, the impulse code consists of but two light negative impulses. When the first light negative impulse is transmitted over the loop between the impulsing conductors in the distant sender and the impulsing relays 601, 602 and 603, the circuit thus established operates relay 602. Relay 602 closes a circuit from ground on the top contacts of relay 612, top contacts of relay 605, conductor 608, contacts of relay 602, left back contacts of relay 609, winding of relay 607, left winding of relay 609 to battery. Relay 607 operates in this circuit, but relay 609 is marginal and does not operate with its right hand winding short circuited.

The peculiar action and interactions of the relays 607 and 609 should be noted at this time. Relay 609 has two windings, the left one being marginal and used as a holding winding after the relay has been operated by the energization of the right winding. When ground is first placed on the left armature of relay 609, relay 607 is energized in series with the left winding of relay 609, but this left winding of relay 609 being marginal, as already noted, does not cause the operation of the relay. Relay 607 is operated and short-circuits the right-hand winding of relay 609.

Upon the removal of ground on the left back contacts of relay 609 the short circuit around the right winding of relay 609 is removed causing relay 609 to operate in series with relay 607. When ground is again placed on the left front contacts of relay 609, the winding of relay 607 and the right-hand winding of relay 609 are short-circuited and relay 607 becomes deenergized, but relay 609 remains energized through its left-hand holding winding. When, finally, the ground on the left contacts of relay 609 is removed, relay 609 becomes deenergized and releases.

Thus, through two successive applications and removals of ground on the left contacts of relay 609 there occurs first, an operation of relay 607, second, an operation of relay 609 in series with relay 607, third, a release of relay 607, with a local holding of relay 609, and fourth, a release of relay 609.

Going back to the time when relay 602 operated as a result of the first light negative impulse transmitted from the sender, as soon as the impulse terminates, relay 602 releases, removing thereby ground from the right winding of relay 609 and causing this relay to operate and hold in series with relay 607, the circuit being as follows: Battery, left winding of relay 609, winding of relay 607, right winding of relay 609, right inner contacts of relay 607 to ground on conductor 608. At the time that relay 607 operated a circuit was closed for relay 606 as follows: Battery through the winding of relay 606, left outer back contacts of relay 610, right outer contacts of relay 607 to ground on conductor 608. Relay 606, in operating, connects ground through its right inner contacts to the winding of relay 610, but this relay remains short-circuited due to the presence of ground on the other side of its winding from its left outer back contacts and right outer contacts of relay 607 to ground on conductor 608.

The next light negative impulse reoperates relay 602 which, on closing its contacts, reestablishes ground on the left contacts of relay 609 short-circuiting the winding of relay 607 thereby and causing it to release and also to hold relay 609 locally over its left winding. Although relay 607 has been released the short-circuit around the winding of relay 610 is still maintained through the right inner contacts of relay 609 to ground on conductor 608. When the second light negative impulse terminates, relay 602 releases and thereby causes the release of relay 609. The short-circuit around relay 610 is now removed causing this relay to operate and lock in series with relay 606 to ground on conductor 608.

The next group of impulses to be transmitted are those representing the thousands digit and which, it will be recalled, consist of a first light positive impulse, a second light negative impulse, a third blank impulse and a fourth light negative impulse. When the circuit is established for the light positive impulse relay 601 is caused to operate. This relay closes its contacts and connects ground on conductor 608 by way of the left back contacts of relay 607, left front contacts of relay 606, left back contacts of relay 611, conductor 700, left winding of relay 723 to battery. This relay operates and locks over both windings and right inner contacts, conductor 701, bottom contacts of relay 605 to the bottom inner contacts of relay 612. The termination of the light positive impulse causes the release of relay 601. When the circuit for the second and light negative impulse is established, relay 602 is operated as

described and causes the operation of relay 607. A circuit is now closed for relay 611 from battery, winding of relay 611, left back contacts of relay 613, left outer front contacts of relay 610 to ground on conductor 608 through the right outer front contacts of relay 607. The release of relay 602 at the termination of the impulse operates relay 609 in series with relay 607. The third impulse, being a blank impulse, the circuit conditions remain as they are. When the circuit for the fourth and light negative impulse is established, relay 602 reoperates, short-circuits relay 607 and holds relay 609 locally over its left winding. The short-circuit for relay 613 is still maintained over a previously described circuit to the right inner contacts of relay 609 to ground on conductor 608. At the termination of the impulse, relay 602 releases thereby causing the release of relay 609, the removal of the short-circuit around the winding of relay 613 and the operation of this last mentioned relay, causing it to lock in series with relay 611 over the right inner contacts of relay 611 to ground on conductor 608.

The third group of impulses represents the hundreds digit 3, and according to the chart of Fig. 10 consists of a first positive impulse, a second heavy negative impulse, a third blank impulse and a fourth light negative impulse. The closure of the trunk loop for the transmission of the first positive impulse operates relay 601. Relay 601 closes ground on its contacts by way of conductor 608, left back contacts of relay 607, left front contacts of relay 606, left front contacts of relay 611, middle back contacts of relay 614, conductor 704 to the right winding and battery of relay 716. Relay 716 operates and locks over both windings and left contacts to conductor 701 above described. The termination of the first impulse releases relay 601. The closure of the trunk loop for the transmission of the second and heavy negative impulse causes the operation of relays 603 and 602. Relay 602 operates relay 607 in the manner described while relay 603 closes ground by way of the contacts of relay 602, contacts of relay 603, right outer back contacts of relay 609, right front contacts of relay 610, right outer front contacts of relay 613, right inner back contacts of relay 615, conductor 703, through the left winding of relay 717 to battery. Relay 717 operates and locks over both windings and contacts to grounded conductor 701. Relay 602 also, in the meanwhile, causes the operation of relay 614 by a closure of the circuit from battery, through the winding of relay 614, left inner back contacts of relay 615, left outer front contacts of relay 613, left outer front contacts of relay 610 to ground on the right outer front contacts of relay 607. Relay 615 remains short-circuited in the manner described for other relays, such as relay 613. The termination of the impulse releases relays 603 and 602 causing, thereby, the operation of relay 609 in series with relay 607.

The third impulse being a blank impulse, the circuit conditions remain unchanged. The closure of the trunk loop for the transmission of the fourth and light negative impulse operates relay 602, releases relay 607, holds relay 609 and preserves the short-circuited condition around relay 615, and the termination of the impulse causes the release of relay 602, the release of relay 609, the removal of the short-circuit around the winding of relay 615, and its consequent operation and locking in series with relay 614 through the inner contacts of relay 614 to ground on conductor 608.

The next group of impulses to be transmitted will be those of the tens digit 4 and which, according to the chart of Fig. 10, consist of a first blank impulse, a second light negative impulse, a third positive impulse, and a fourth light negative impulse. The second impulse operates relay 602 which, in turn, operates relay 607 in the regular manner and relay 607 closes a circuit for relay 617 from battery, through the winding of relay 617, left inner back contacts of relay 618, left inner front contacts of relay 615, left outer front contacts of relay 613, left outer front contacts of relay 610 to ground on conductor 608 through the right outer contacts of relay 607. Relay 618 remains short-circuited during this time by ground on conductor 608 on the right side of the winding and operating ground for relay 617 on the left side of its winding. At the termination of the impulse relay 609 operates in series with relay 607. The third impulse operates relay 601 which closes ground on its contacts from conductor 608 to the left front contacts of relay 607, right outer contacts of relay 606, right outer contacts of relay 611, outer front contacts of relay 614, right outer front contacts of relay 617, left back contacts of relay 619, conductor 706, to the left winding of relay 711 to battery. Relay 711 operates and locks through both windings and right inner front contacts to ground on conductor 701. The termination of the third impulse releases relay 601 and the closure of the loop circuit for the fourth and light negative impulse reoperates relay 602 which shunts relay 607, holds relay 609 locally and maintains the short circuited condition of relay 618. At the termination of the impulse relay 609 releases and relay 618 operates and locks in series with relay 617 to ground on conductor 608 in the regular manner.

The next group of impulses are those relating to the units digit 6 and consist of a first positive impulse, a second light negative impulse, a third blank impulse and a fourth heavy negative impulse. The first positive impulse operates relay 601 and this relay

closes a circuit from ground on conductor 608, contacts of relay 601, left back contacts of relay 607, left front contacts of relays 606, 611, middle front contacts of relays 614 and 617, conductor 707, right winding of relay 712 to battery. Relay 712 operates and locks over both windings and left contacts to ground on conductor 701. The second and light negative impulse operates relay 602 which, in turn, operates relay 607 and a circuit is thereafter closed for relay 619 from battery and winding of relay 619, left back contacts of relay 621, left inner front contacts of relay 618, left inner front contacts of relay 615, left outer front contacts of relay 613, left outer front contacts of relay 610 to ground on the right outer contacts of relay 607. The termination of the impulse operates relay 609 in series with relay 607. The fourth impulse reoperates relay 602, but since the impulse is a heavy negative impulse, relay 603 will operate as well. Relay 602, in operating, releases relay 607 in the regular manner while relay 603 closes a ground from conductor 608, contacts of relay 602, contacts of relay 603, right outer front contacts of relay 609, left inner contacts of relay 610, left inner contacts of relay 613, left outer contacts of relay 615, left outer contacts of relay 618, conductor 708, left winding of relay 715 to battery. Relay 715 operates and locks with both windings in series to ground on conductor 701. The termination of the impulse releases relays 603 and 602 which, in turn, cause the release of relay 609 and the consequent operation and locking of relay 621 in series with relay 619, to ground on conductor 608.

The impulses have now been all transmitted. When relay 619 operated, battery was closed from its right outer contacts to the bank of lamps controlled through the contacts of relays 702, 709, 710 and 711. The operation of relay 617 closed ground on its left contacts to the winding of relay 724 which operated and closed battery through its right outer and left inner contacts to the bank of lamps controlled by relays 720, 721, 722, 723, 716, 717, 718 and 719, while the operation of relay 621 closes battery on its right middle contacts to the bank of lamps controlled by relays 712, 713, 714 and 715. Relay 623 also operates at this time due to a closure from battery through the winding of relay 623 to ground on the right outer contacts of relay 621. It will be evident that the thousands indicator closes a circuit for lamp No. 1 from battery on the right outer contacts of relay 724, lamp No. 1, left inner back contacts of relay 722, right outer back contacts of relay 720, left outer back contacts of relay 721 to ground on conductor 701 through the right inner front contacts of relay 723. In the hundreds indicator, a circuit is closed for lamp 3 from battery on the left inner contacts of relay 724, left outer back contacts of relay 719, left outer front contacts of relay 717, right outer front contacts of relay 716, lamp No. 3 to ground on conductor 701 through the right inner back contacts of relay 719. In the tens indicator a circuit is closed from battery on the right outer contacts of relay 619, lamp No. 4, right middle back contact of relay 702, left outer back contacts of relay 709, right front contacts of relay 711 to ground on conductor 701. In the units indicator a circuit is closed from battery through the right middle front contacts of relay 621, left inner front contacts of relay 715, lamp No. 6, right middle front contacts of relay 712, left outer back contacts of relay 713, right inner front contacts of relay 715 to ground on conductor 701. In the station's indicator a circuit is closed from battery on the left outer contacts of relay 623 lamp No. 0, left back contacts of relay 625, left back contacts of relay 626 to ground on the right outer contacts of relay 623. Thus the number displayed to the operator on the indicator is 01346, the 0 representing no stations.

When all of the impulses have been sent, the sender is released and ground potential is removed from conductor 420 and relay 203 becomes deenergized. Relay 203 releases and extends the tip and ring conductors of the trunk 103 through to the left winding of the repeating coil 201. Relay 202 is now operated in series with the calling line and closes a substitute holding circuit for the slow relay 204. In this manner the release of the connection is placed under the control of the calling subscriber's switchhook. Relay 203, in releasing, also opens the holding circuit of relays 205 and 206. Relay 206 releases and extends the tip and ring conductors of the trunk 207 through to the right winding of repeating coil 201.

Returning to the call indicator apparatus, at the time relay 621 operates a circuit is closed from ground, through the left outer contacts of relay 621, contacts of relay 636, winding of relay 620 to battery. Relay 620 operates and opens the circuits of relays 305 and 312. Relay 305 extends the tip and ring conductors of the trunk 207 through to the repeating coil 213 whereupon the following circuit is completed: battery, through the lower inner contacts of relay 300, conductor 301, right winding of relay 302, winding of relay 303, inner normal contacts of relay 304, thence over the tip side of the line, through the upper right winding of repeating coil 201, winding of polarized relay 214, lower winding of repeating coil 201 and returning over the ring side of the line, through the outer normal contacts of relay 304, left winding of relay 302 to ground. Relay 302 operates, causing in turn the operation of relay 306.

The operator on reading the number 01346 from the lamps of the call indicator, seizes the plug 314 and inserts it in the jack 315 of the called line 319. A circuit is now closed from ground through the winding of the sleeve relay 317, sleeve of the jack 315, sleeve of plug 314, winding of relay 300, right outer contacts of relay 306, contacts of relay 316, inner back contacts of relay 318, winding of relay 320 to battery. A branch of this circuit extends through the winding of relay 318 but this relay, being shunted, does not operate. A parallel circuit is also closed through the disconnect lamp 321, but since lamp 321 is shunted, it does not light. Relay 300 operates and, at its bottom front contacts, closes a circuit for the upper winding of relay 308. Relay 308 operates and opens the circuits of relays 605 and 309. Relay 309 disconnects the interrupter 311 from the lamp 307 and this lamp is extinguished. Relay 605 removes ground from the conductors 701 and 608 causing the release of all relays and the extinguishing of all illuminated lamps in the call indicator mechanism.

Relay 320 operates in the circuit above traced and closes a circuit from the source of ringing current, through the marginal relay 316, lower front contacts of relay 320, ring of the plug and jack, thence over the subscriber's line and returning through the tip of the jack and plug, upper front contacts of relay 300, upper front contacts of relay 320 to ground. When the subscriber responds to the ringing of his bell the marginal relay 316 operates, removes the shunt and permits the relay 318 to become energized. Relay 318 closes a circuit from battery through its inner front contacts and winding, and thence to ground through relay 300 and sleeve relay 317 whereby relay 320 is shunted out and releases. Relay 320 completes the tip and ring conductors through to the right windings of the repeating coil 313. Relay 322 operates in series with the called line and closes an obvious circuit for relay 304. Relay 304 serves to reverse the current over the line and also to include the left winding of repeating coil 313 in the talking circuit.

After the conversation is finished, the calling subscriber, by replacing his receiver on the switchhook, opens the circuit of relay 202, which in turn, opens the circuit of relay 204. After an interval relay 204 releases and removes ground from the conductor 111 whereby the line switch 100 and the district switch 200 restore the connection.

When the trunk at the mechanical office is released the circuit of relay 302 in the distant office is opened and the relay 306 consequently releases. Relay 306, at its right outer contacts, removes the shunt from around the lamp 321 and this lamp now lights to advise the operator that the connection is no longer required. She thereupon withdraws the plug 314 from the jack 315 and all energized relays associated with the cord circuits are released.

It has thus been explained how the impulse generating equipment associated with the register sender in the mechanical office transmits codes of impulses representing digits recorded on the registers to affect apparatus in the distant office. While only the four numerical digits characterizing the line number have been described in this system it will be understood of course, that the same mechanism may be employed for transmitting as many other digits as are necessary for the particular type of system concerned and for which registers are provided, as for example, in transmitting the code of impulses to a tandem call indicator office above mentioned.

What is claimed is:—

1. In an impulse transmitting system, the combination of an impulse circuit, a source of current, circuits for applying said source of current to said impulse circuit to produce currents of definite strength thereover, a plurality of relays arranged in pairs, registers, said registers being directly connected to contacts of certain of said pairs of relays, a trunk line, a relay controlled by said impulse circuit for extending said trunk line to said source of current, said trunk line also being extended to said registers by other of said pairs of relays, means for operating said control relay to intermittently reverse the connection of said trunk line to said source of current, and means for operating said plurality of pairs of relays to successively effect connection of said trunk line to said registers.

2. In an impulse transmitting system, the combination of a plurality of relays arranged in pairs, a trunk line, a plurality of registers directly connected to contacts of certain of said pairs of relays, an impulse circuit controlling the operation of said plurality of pairs of relays, and means controlled by said plurality of pairs of relays for extending said trunk line to said registers.

3. In an impulse transmitting system, an impulse circuit, relays arranged in pairs, circuits for operating a plurality of said pairs of relays, a plurality of said circuits being responsive to each impulse produced by said impulse circuit and each of the other of said circuits being responsive to every 2nd, 4th, 8th and 16th impulse respectively, a pair of conductors each connected to the contacts of the first and second relay respectively of one of said pairs of relays, a plurality of registers connected to contacts of certain other of said pairs of relays and means controlled by all of said relays arranged in pairs for extending one or the other of said conductors to one of said plurality of registers during each impulse.

4. In an impulse transmitting system, an impulse circuit, relays arranged in pairs, a pair of conductors each connected to the contacts of a first and second relay respectively of one of said pairs of relays, a plurality of registers connected to contacts of certain of said pairs of relays, circuits for operating a plurality of said pairs of relays, a plurality of said circuits being responsive to each impulse and each of the other of said circuits being responsive to each 2nd, 4th, 8th and 16th impulse respectively, and means during each impulse controlled by said relays arranged in pairs responsive to the preceding impulse for extending one or the other of said conductors to one of said plurality of registers.

5. In an impulse transmitting system, an impulse circuit, relays arranged in pairs, circuits for operating a plurality of said relays, a plurality of said circuits being responsive to each impulse of said impulse circuit and each of the other of said circuits being responsive to each 2nd, 4th, 8th and 16th impulse respectively, a trunk line, each conductor of said trunk line extending to the contacts of a first and second relay respectively of one of said pairs of relays, a source of current, a relay controlled by said impulse circuit for connecting said source of current to said trunk line to produce a current of definite strength thereover during certain impulses and to open said trunk line during certain other impulses, a plurality of registers connected to contacts of certain of said pairs of relays, each of said registers controlling a separate source of current when operated, means for operating said registers, and means controlled by said relays arranged in pairs for extending one or the other of said conductors of said trunk line to an operated register of said plurality of registers during each impulse to alter the current strength over said trunk line during certain impulses or to reverse the current flow during certain other impulses.

6. In an impulse transmitting system, an impulse circuit, means for starting said impulse circuit, relays arranged in pairs, circuits for operating said relays, each of said circuits being responsive to certain definite impulses and all of said relays arranged in pairs taking a definite setting for each impulse thereby, means controlled by a plurality of said relays arranged in pairs for stopping said impulse circuit after a definite number of impulses, a relay, means for operating said relay, and means controlled by said relay when operated for setting said relays arranged in pairs in accordance with the setting of said relays for a certain impulse whereby the number of impulses is reduced.

7. In an impulse transmitting system, an impulse circuit, means for starting said impulse circuit, relays arranged in pairs, circuits for operating said relays, each of said circuits being responsive to certain definite impulses and all of said relays arranged in pairs taking a definite setting for each impulse thereby, means controlled by a plurality of said relays arranged in pairs for stopping said impulse circuit after a definite number of impulses, a relay, means for operating said relay, means controlled by said relay when operated for setting said relays arranged in pairs in accordance with the setting of said relays for a certain impulse, and means, controlled by said operated relay and by said relays arranged in pairs for stopping said impulse circuit after a different number of impulses.

8. In a telephone system including a sender, an impulse circuit in said sender, means for starting said impulse circuit, relays arranged in pairs, circuits for operating said relays, each of said circuits being responsive to certain definite impulses and all of said relays arranged in pairs taking a definite setting for each impulse thereby, a relay, means in said sender for operating said relay, means controlled by said relay when not operated and a plurality of said relays arranged in pairs for stopping said impulse circuit after a definite number of impulses, and means controlled by said relay when operated and a plurality of said relays arranged in pairs for stopping said impulse circuit after a different number of impulses.

9. In a telephone system including a sender, an impulse circuit in said sender, means for starting said impulse circuit, relays arranged in pairs, circuits for operating said relays, each of said circuits being responsive to certain definite impulses and all of said relays arranged in pairs taking a definite setting for each impulse thereby, a first relay, means in said sender for operating said first relay, a second relay, means in said sender for operating said second relay, means controlled by said second relay for setting said relays arranged in pairs in accordance with the setting of said relays for a certain impulse, means controlled by said first relay when not operated and said second relay when operated and a plurality of said relays arranged in pairs for stopping said impulse circuit after a definite number of impulses, and means controlled by both said first and second relays when operated and a plurality of relays arranged in pairs for stopping said impulse circuit after a different number of impulses.

10. In a telephone system including a sender, an impulse circuit in said sender, a relay, means in said sender for operating said relay, means controlled by said relay to start said impulse circuit, other relays arranged in pairs, circuits for operating said other re-

lays, each of said circuits being responsive to certain definite impulses and all of said other relays arranged in pairs taking a definite setting for each impulse thereby, and means controlled by said relay and a plurality of said relays arranged in pairs for stopping said impulse circuit after a definite number of impulses.

11. In a telephone system including a sender an impulse circuit in said sender, relays arranged in pairs, circuits for operating said relays, each of said circuits being responsive to a certain definite impulse, a trunk line, each conductor of said trunk line extending to the contacts of a first and second relay respectively of one of said pairs of relays, switching means, a plurality of registers connected through said switching means to contacts of certain of said pairs of relays, means in said sender for operating said switching means and means for connecting said registers to certain other contacts of said pairs of relays when said switching means is operated.

12. In an impulse transmitting system, an impulse circuit comprising a polarized magnetic device having two windings, a magnetizing winding with cooperating circuit and an operating winding with cooperating condenser charging and discharging circuit for operating and releasing said device to produce impulses, a source of potential, a relay controlled by said impulse circuit, and a trunk line extending to contacts of said relay, said relay repeatedly reversing the connection of said source of potential to said circuit to produce impulses of alternate polarity over said trunk line.

In witness whereof, I hereunto subscribe my name this 2nd day of July, 1930.

EDGAR H. CLARK.