Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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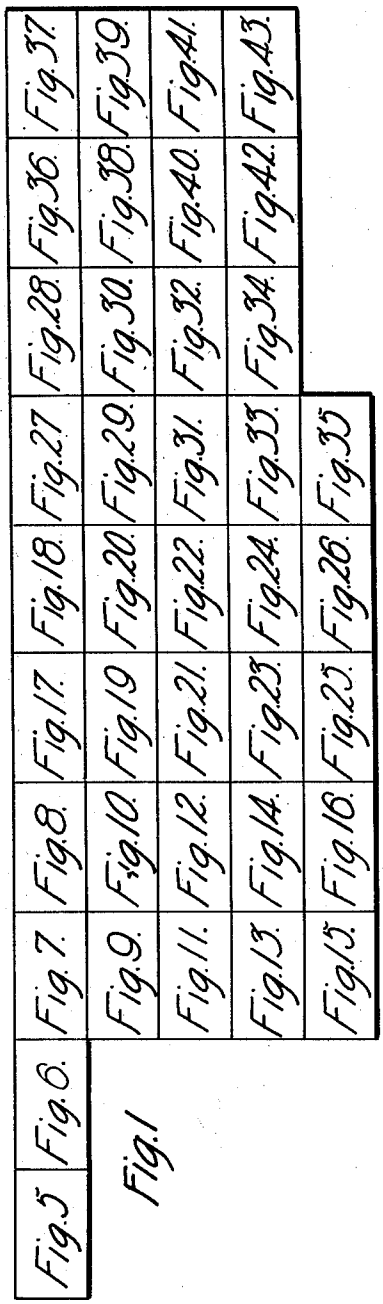


Fig.1

Fig.2

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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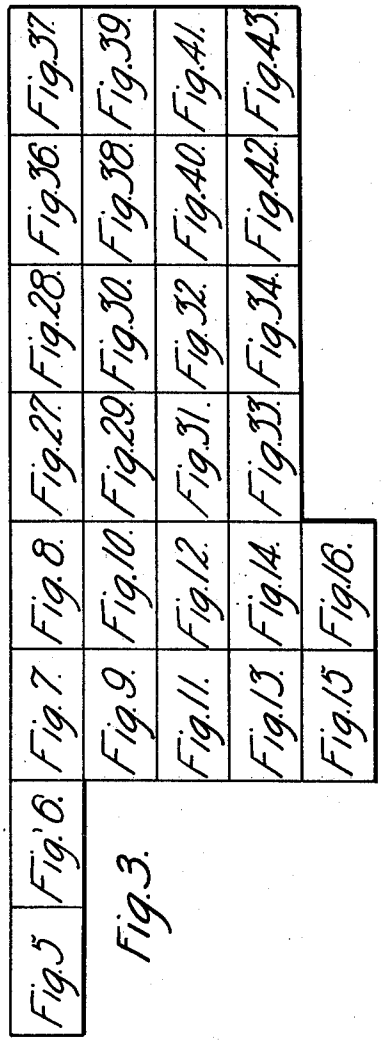


Fig. 3.

Fig. 4

Inventor:
Samuel B. Williams Jr.
by
W. A. Beatty. Att'y.

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S. B. WILLIAMS, JR

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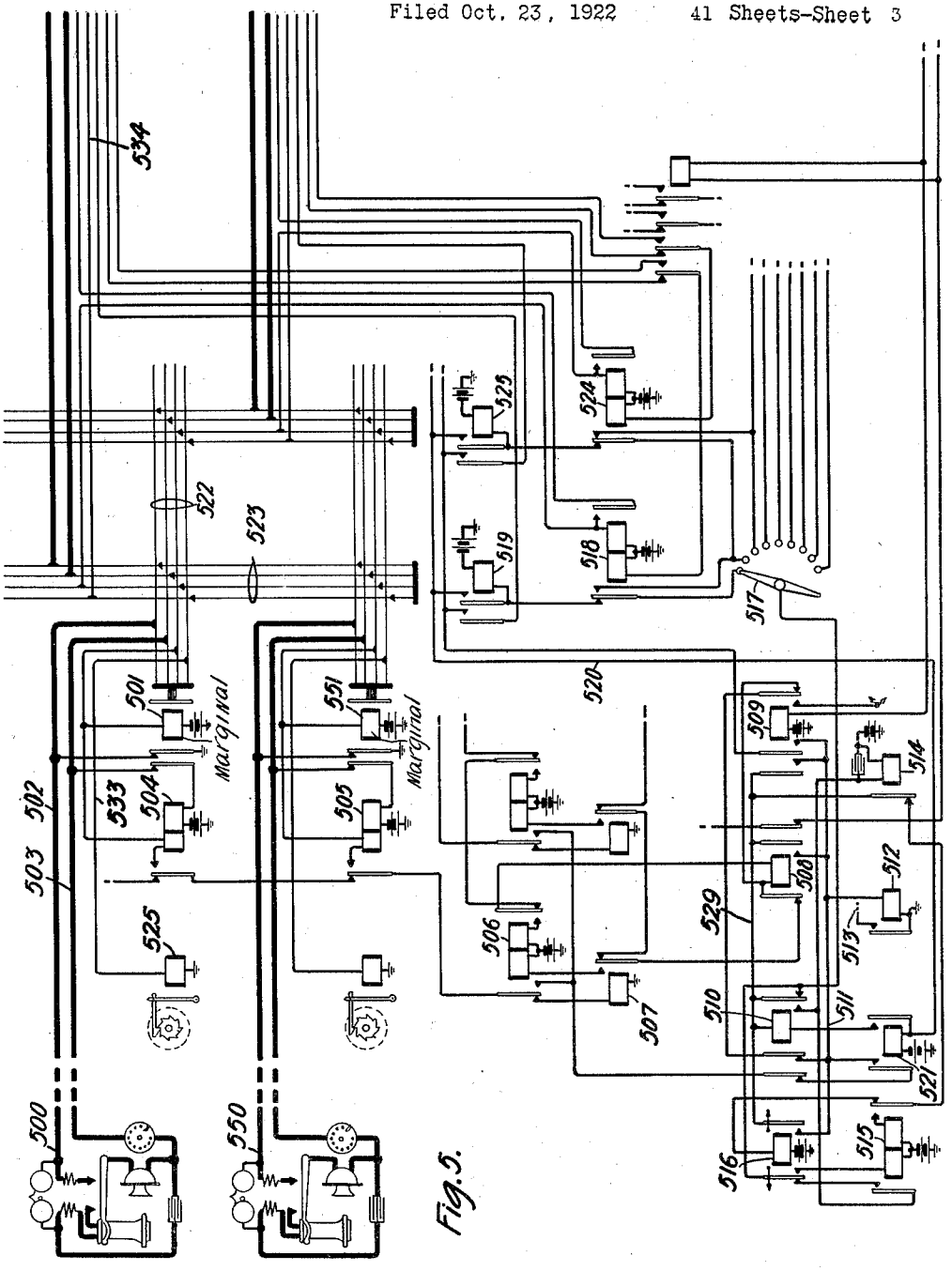


Fig. 5.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty, Att'y.

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S. B. WILLIAMS, JR

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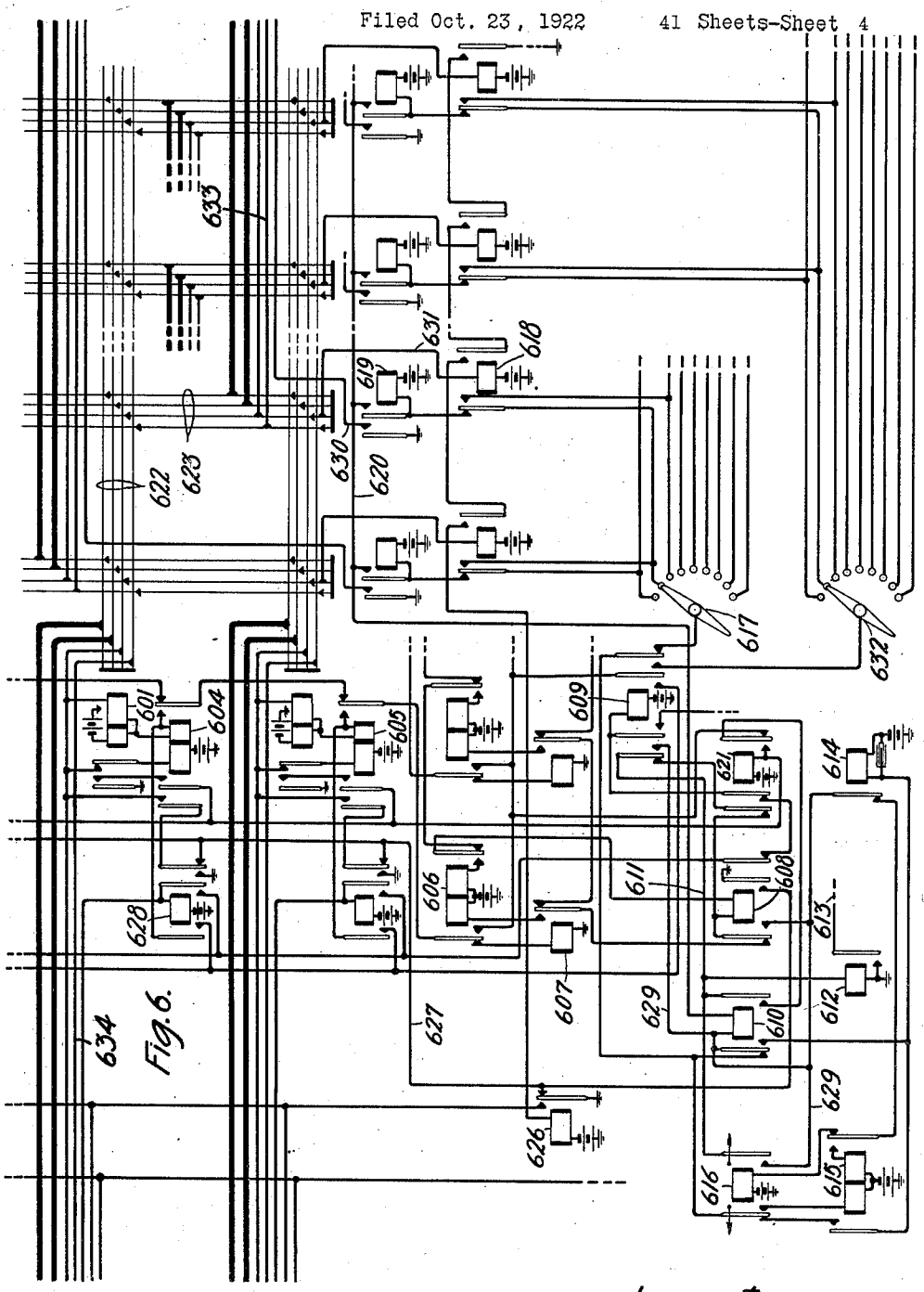


Fig. 6.

Inventor:
Samuel B. William Jr.
by W. A. Beatty. Att'y.

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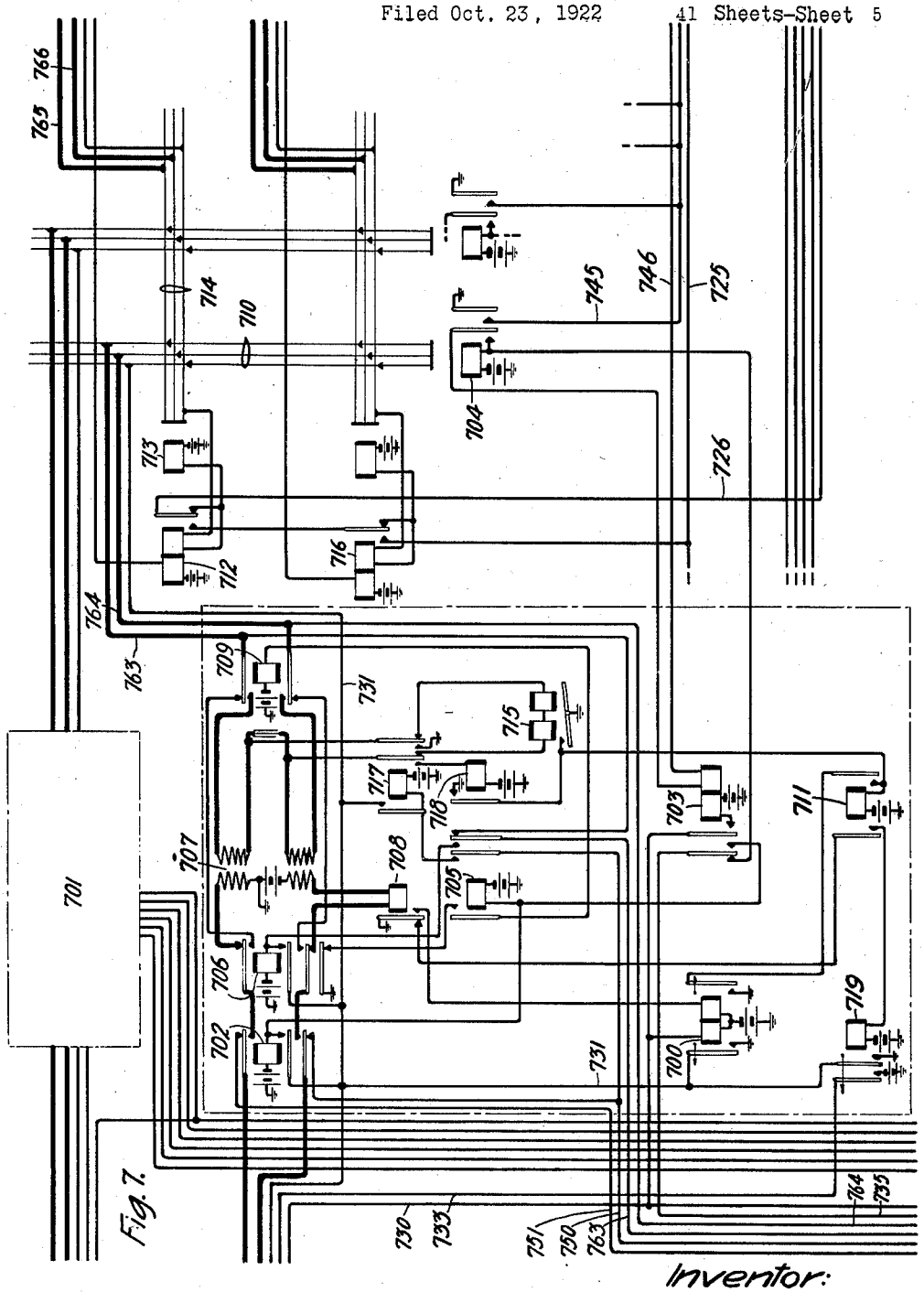


Fig. 7.

Inventor:
Samuel B. Williams Jr.
by W. L. Beatty. Att'y.

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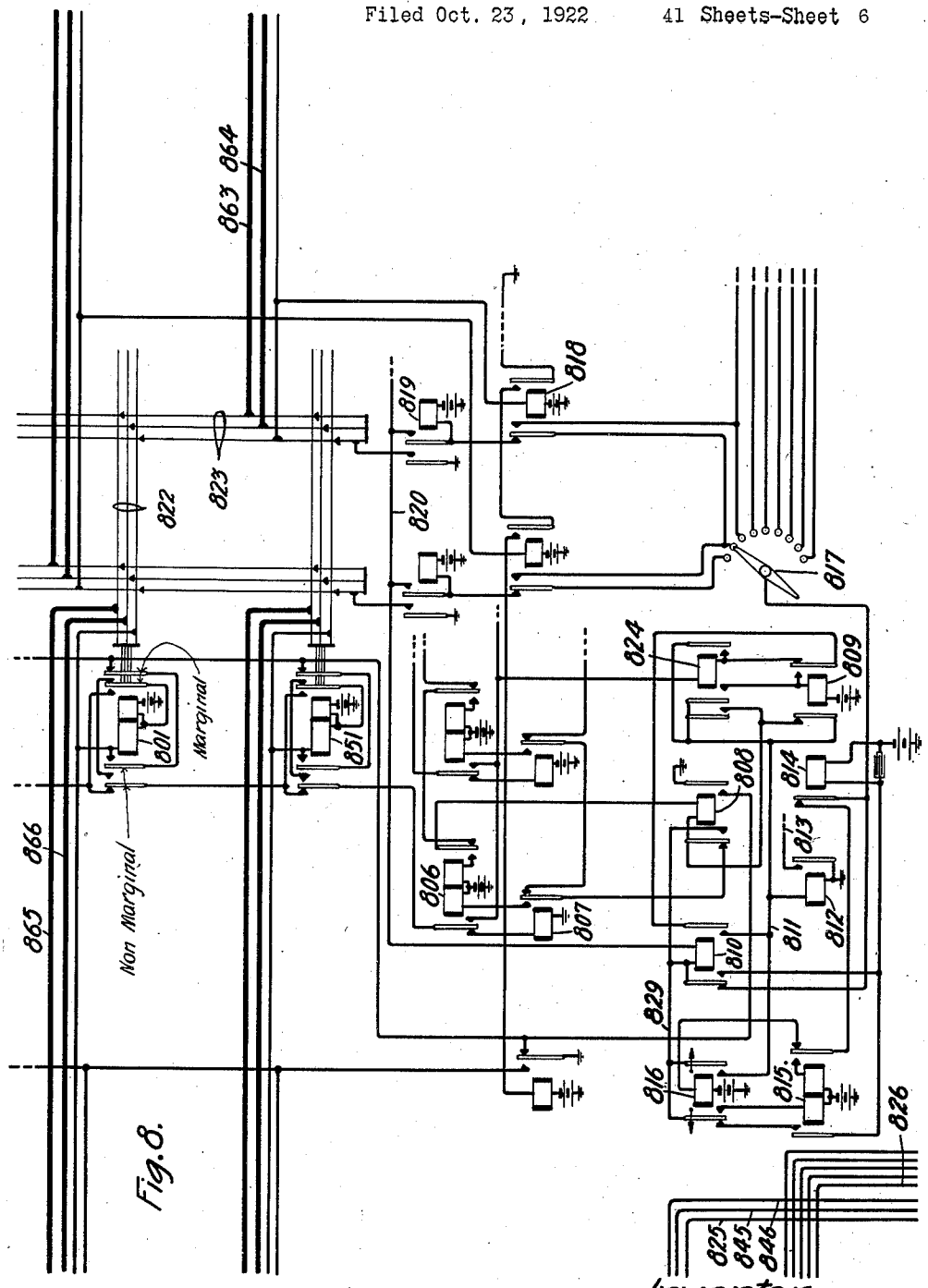


Fig. 8.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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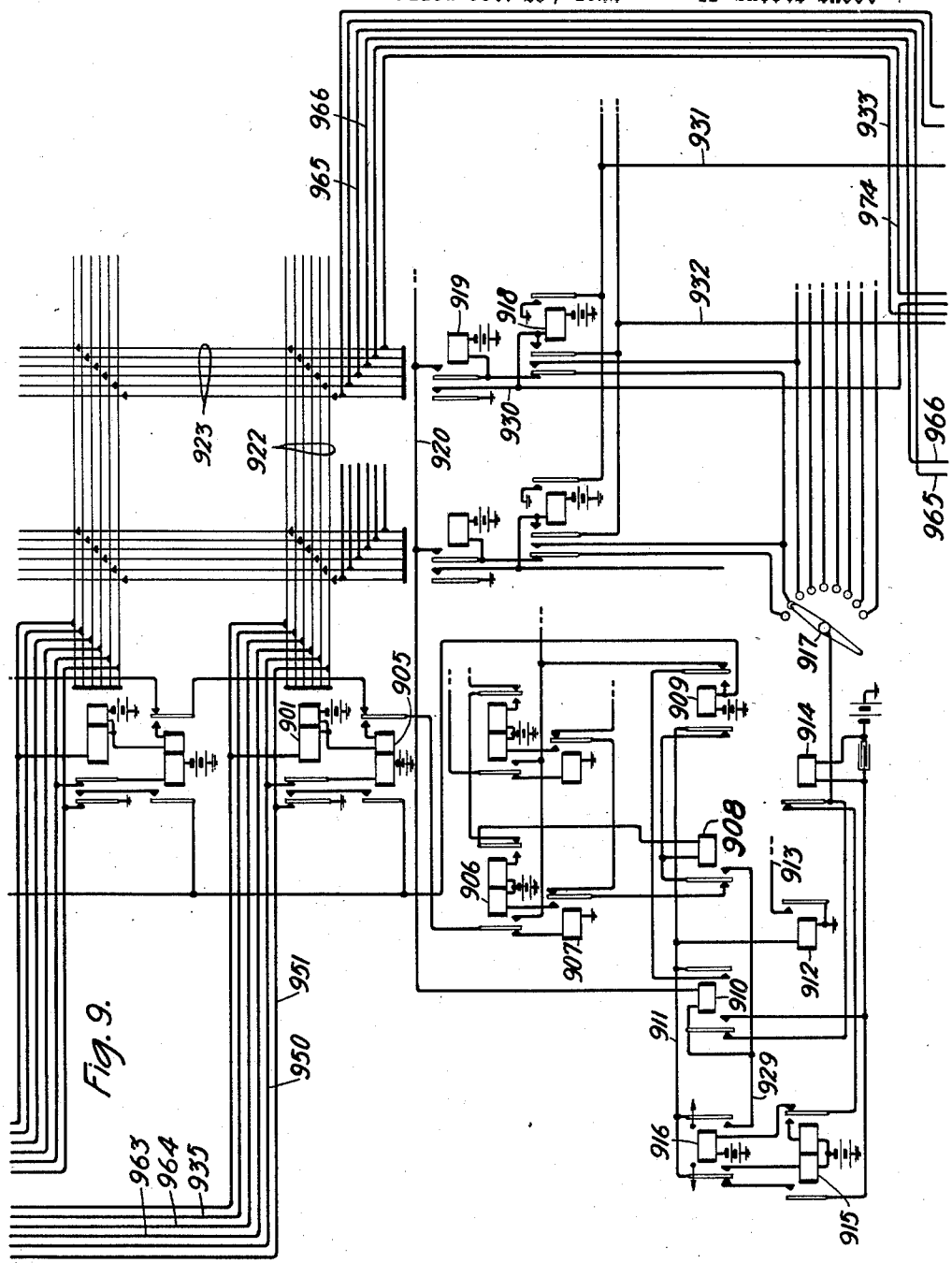


Fig. 9.

Inventor:
Samuel B. Williams Jr.
by W. E. Beattie Atty.

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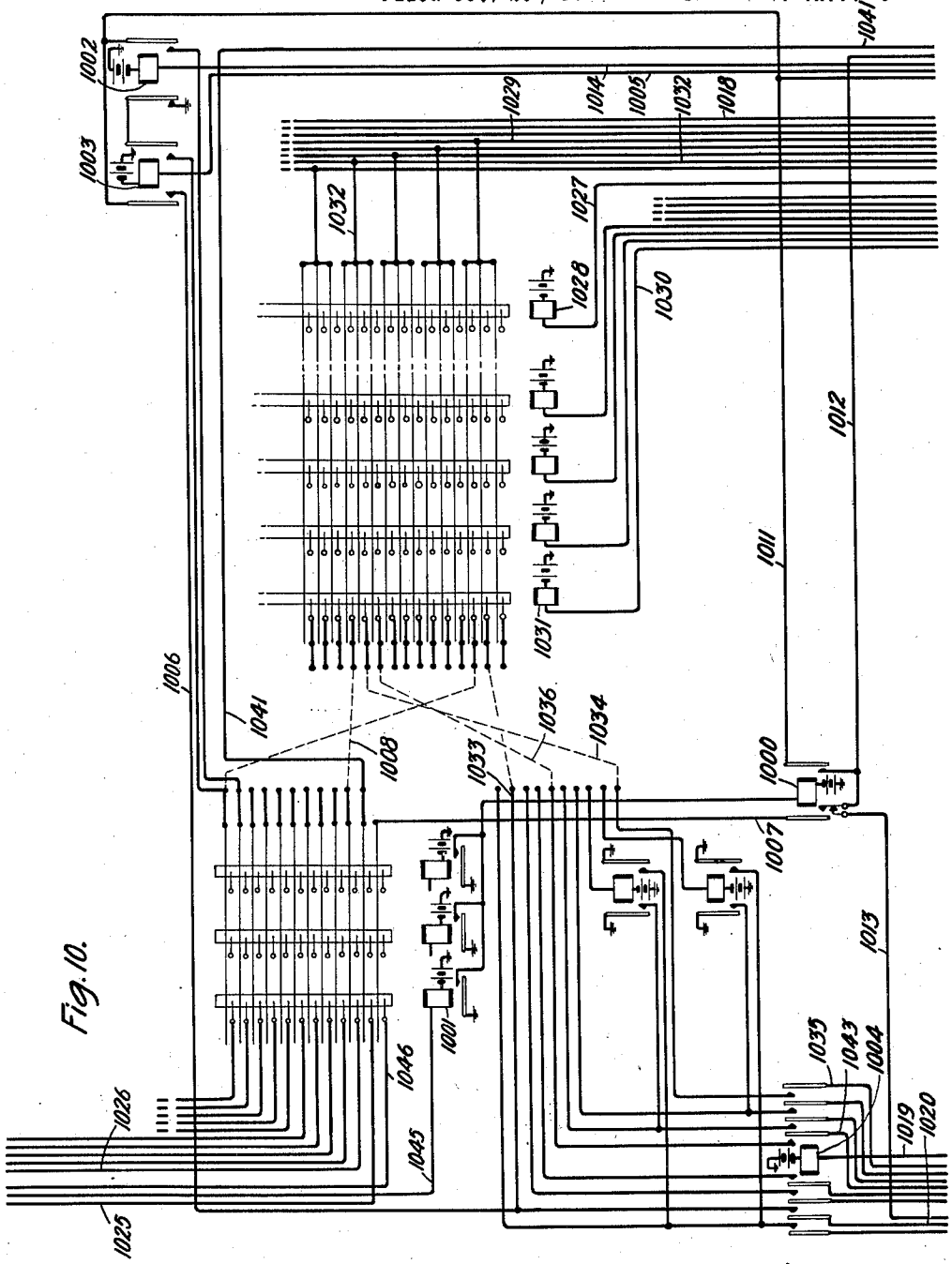


Fig. 10.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Atty.

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S. B. WILLIAMS, JR

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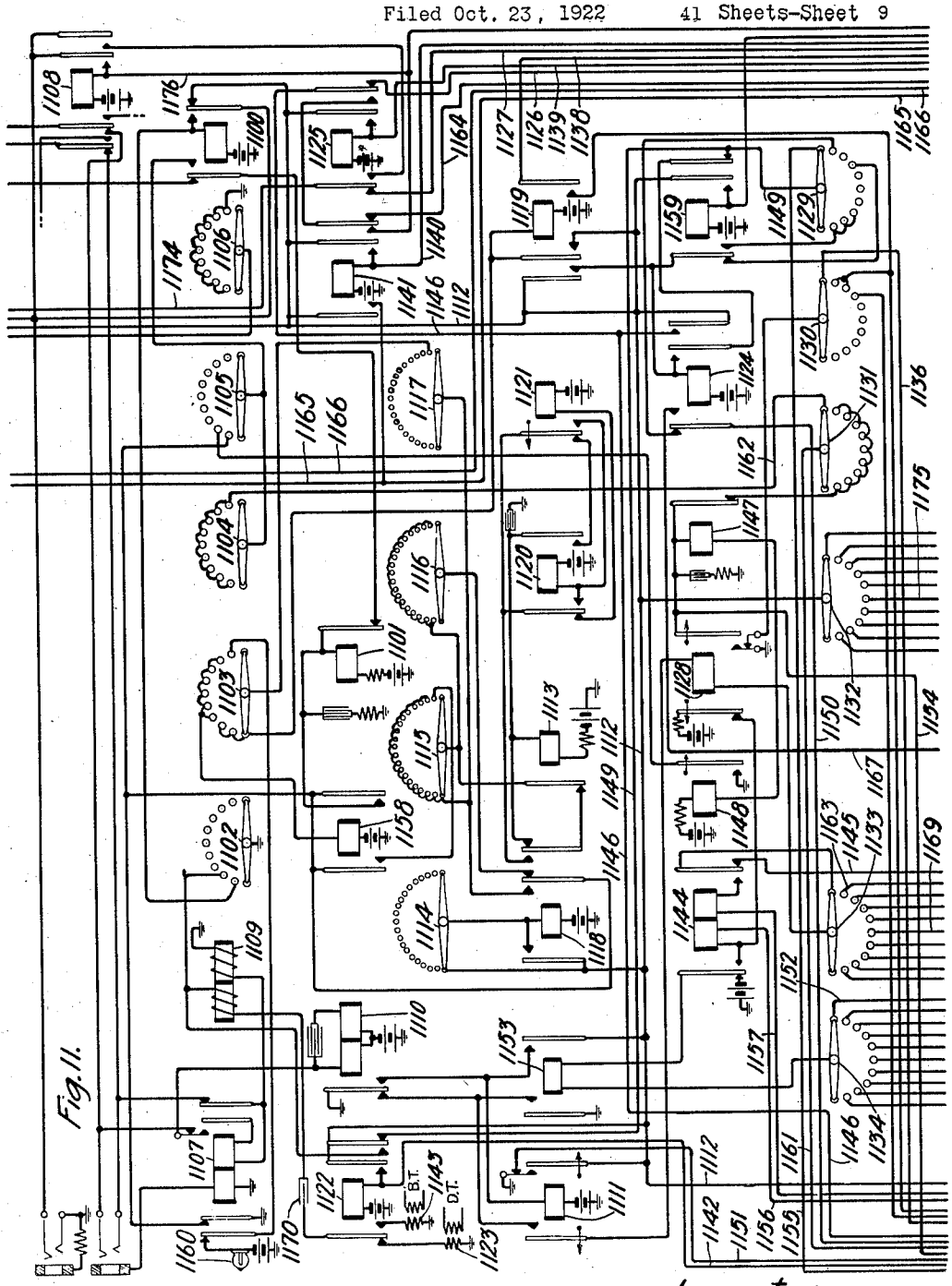


Fig. 11.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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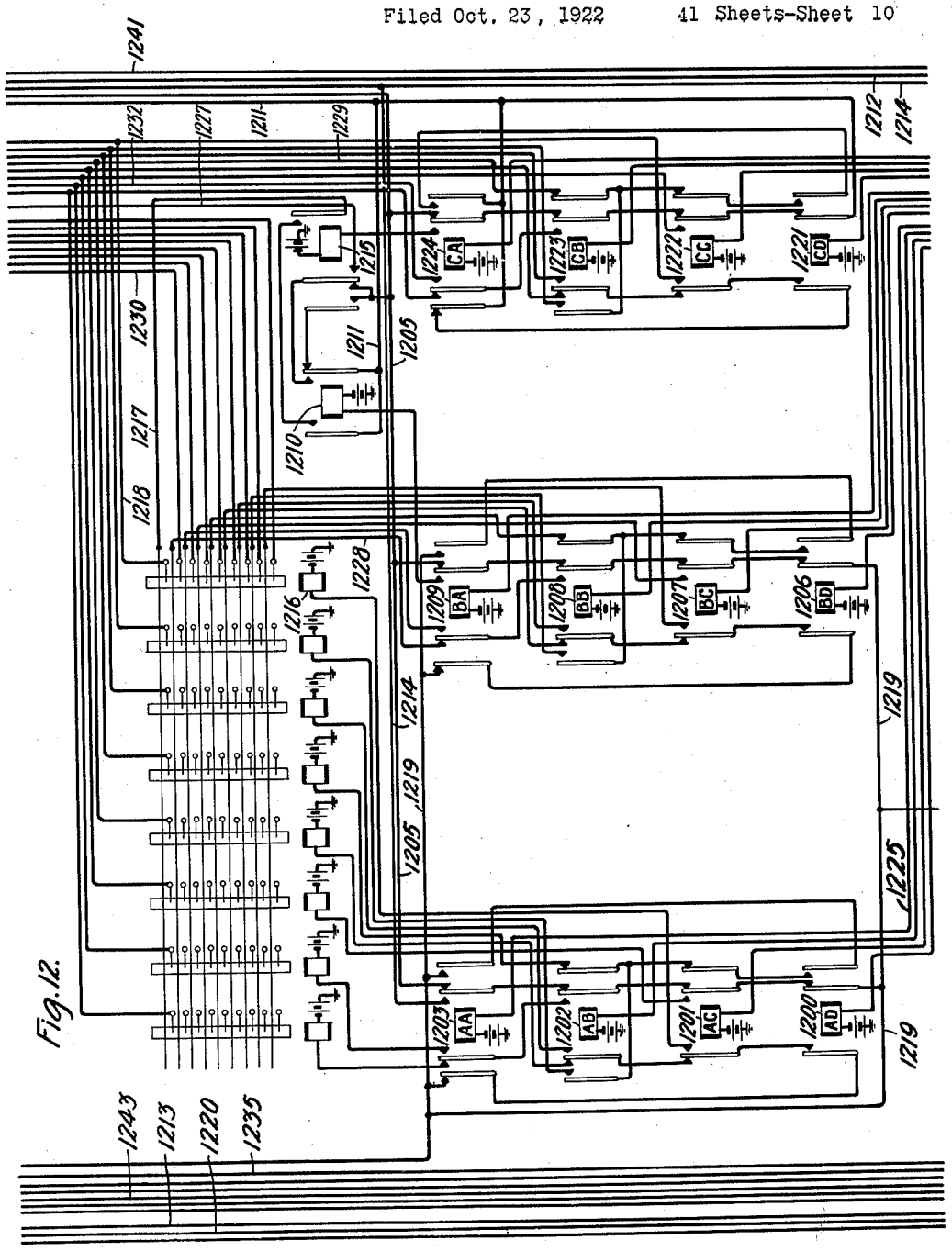


Fig. 12.

Inventor:
Samuel B. Williams Jr.
by W. C. Beatty Att'y.

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S. B. WILLIAMS, JR

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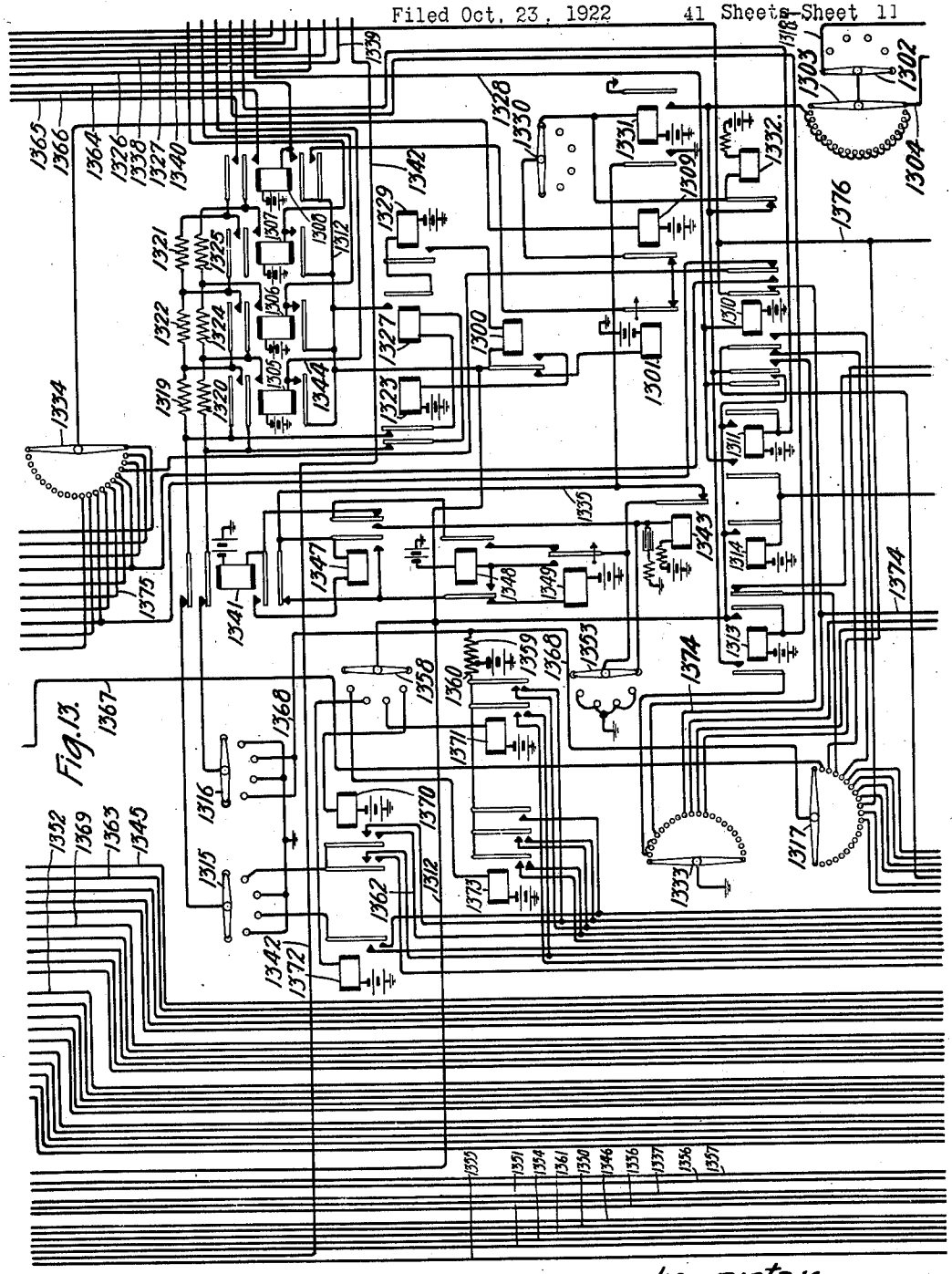


Fig. 13.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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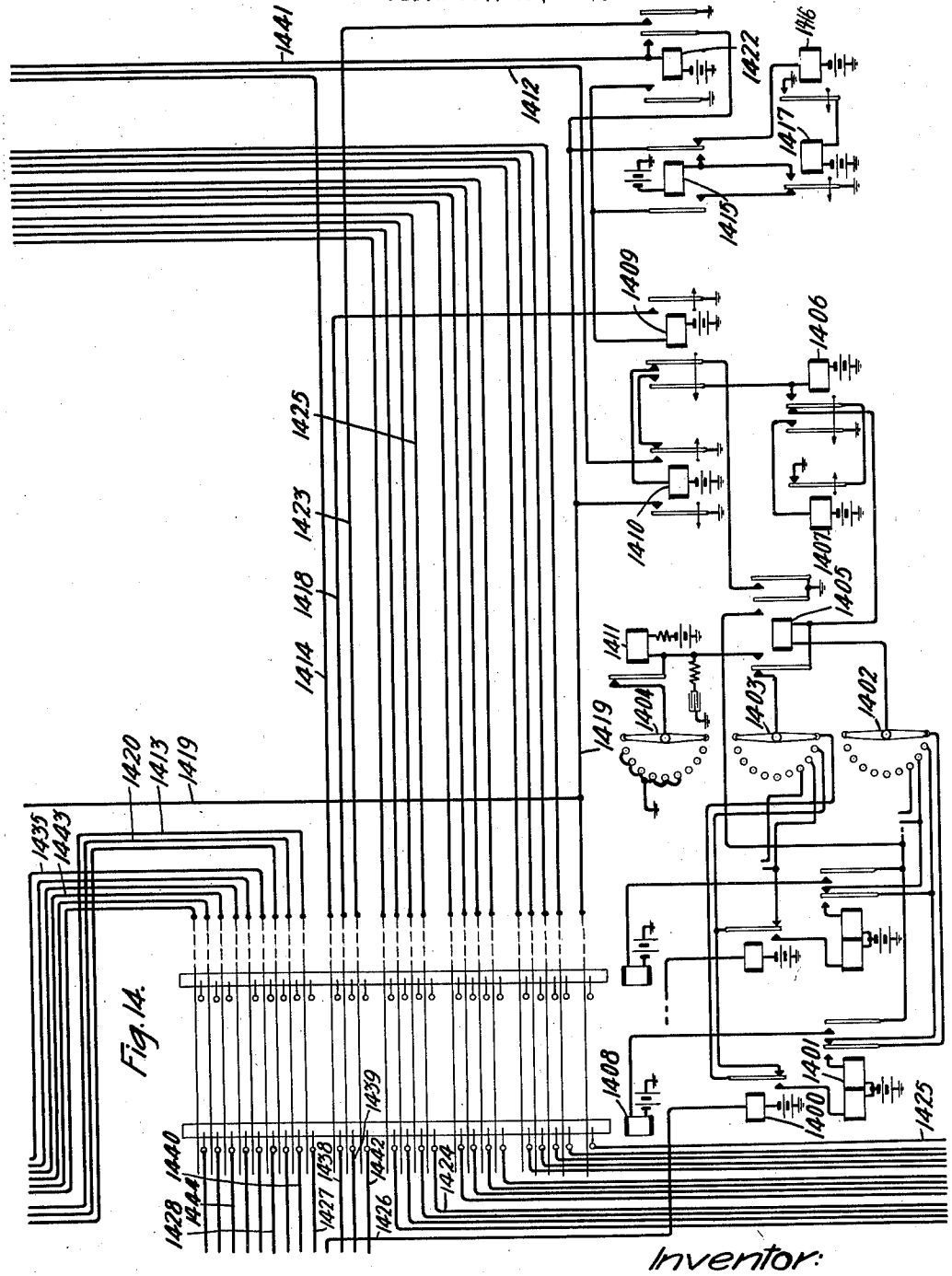


Fig. 14.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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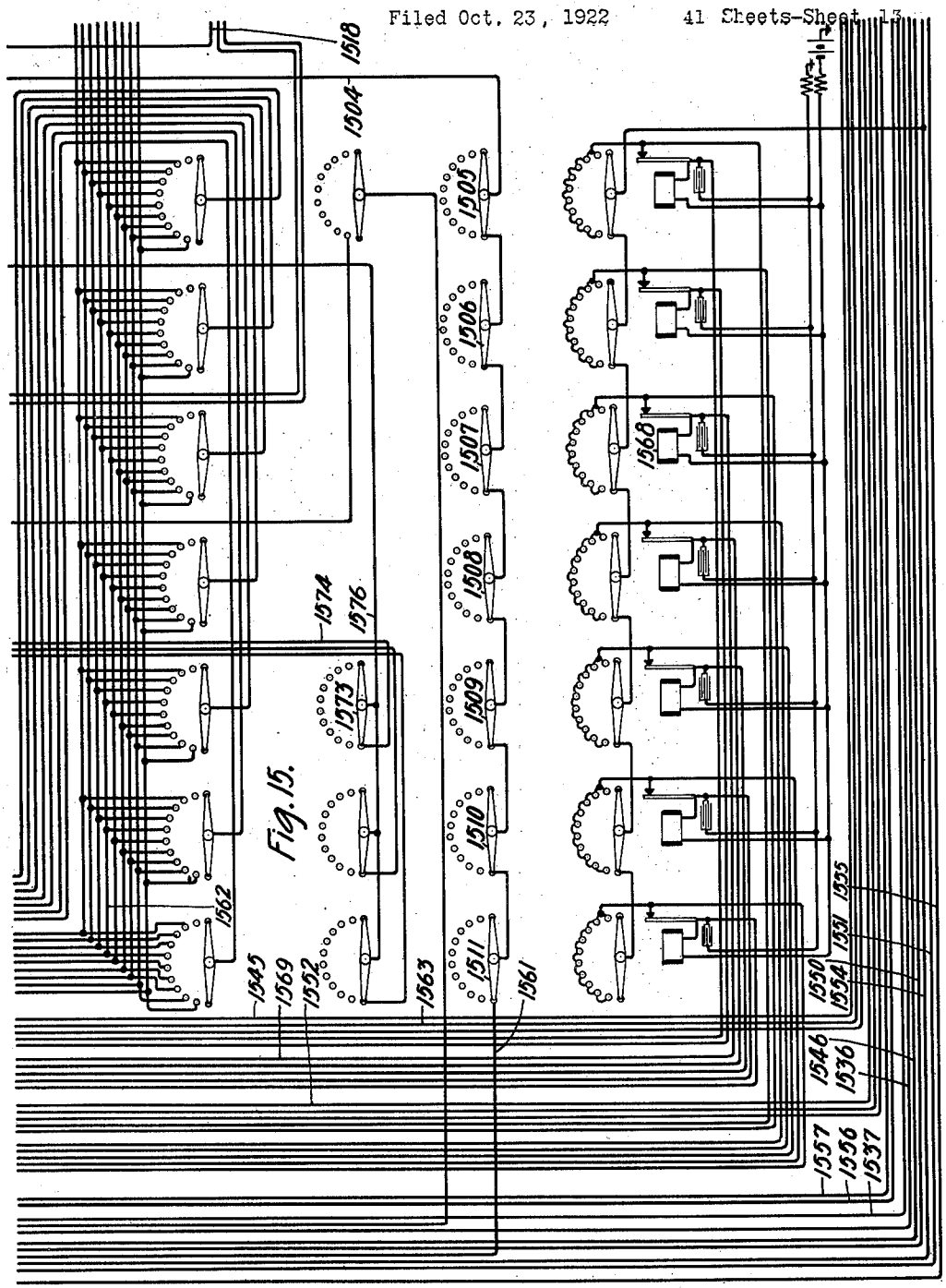


Fig. 15.

Inventor:
Samuel B. Williams Jr.
by W. L. Beatty Att'y

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S. B. WILLIAMS, JR

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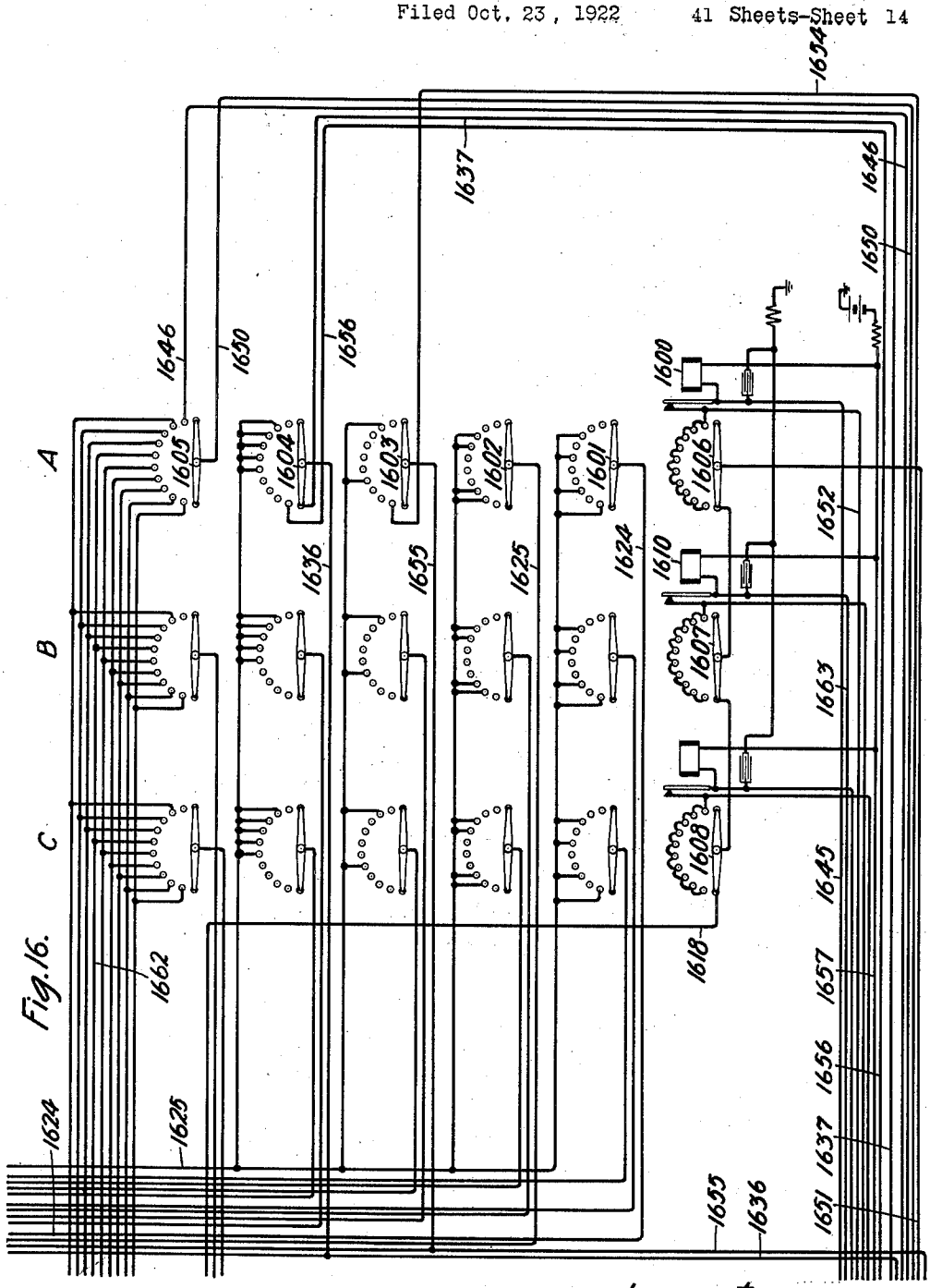


Fig. 16.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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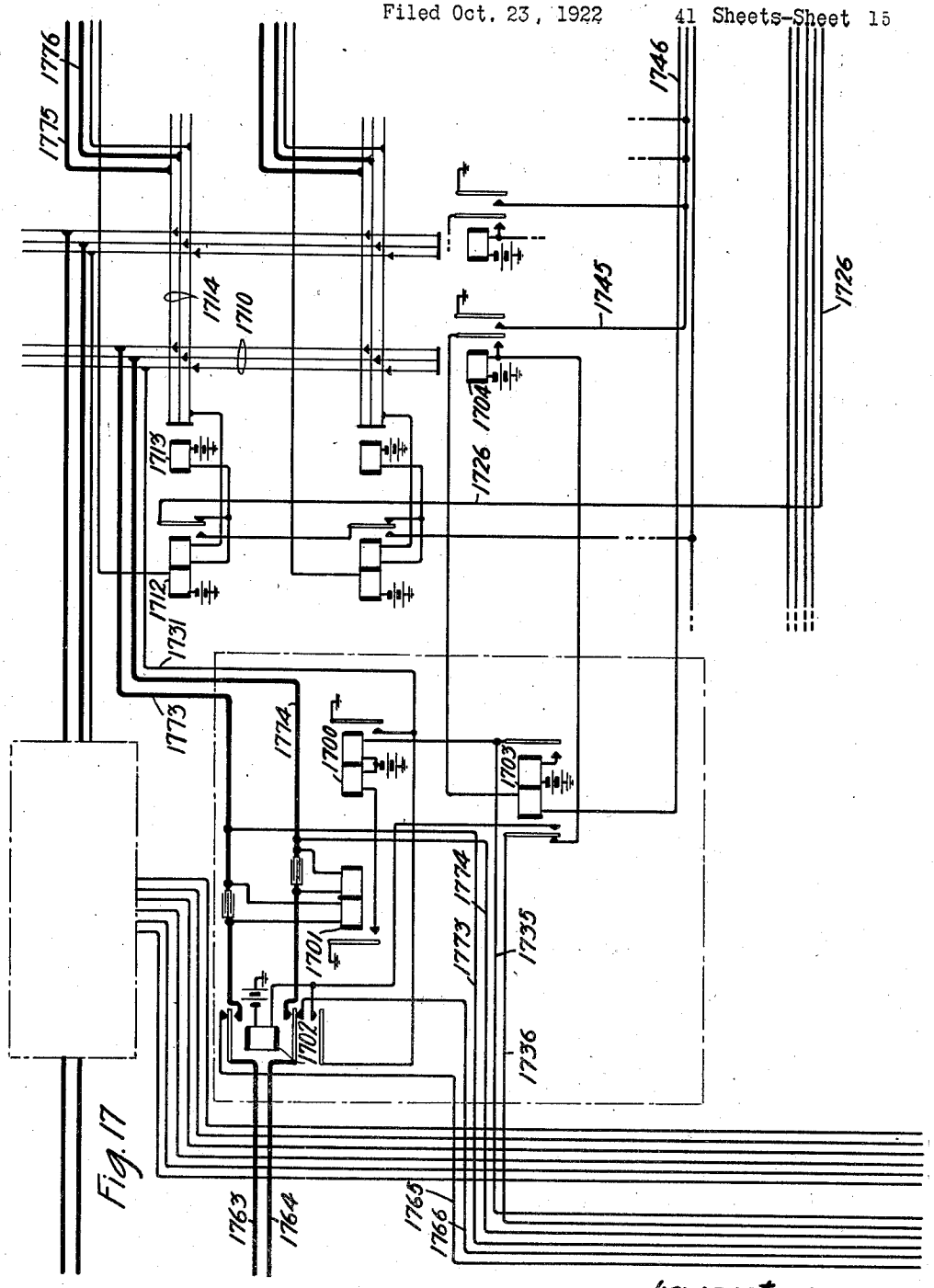


Fig. 17

Inventor:
Samuel B. Williams Jr.
by W. E. Beatty Att'y.

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S. B. WILLIAMS, JR

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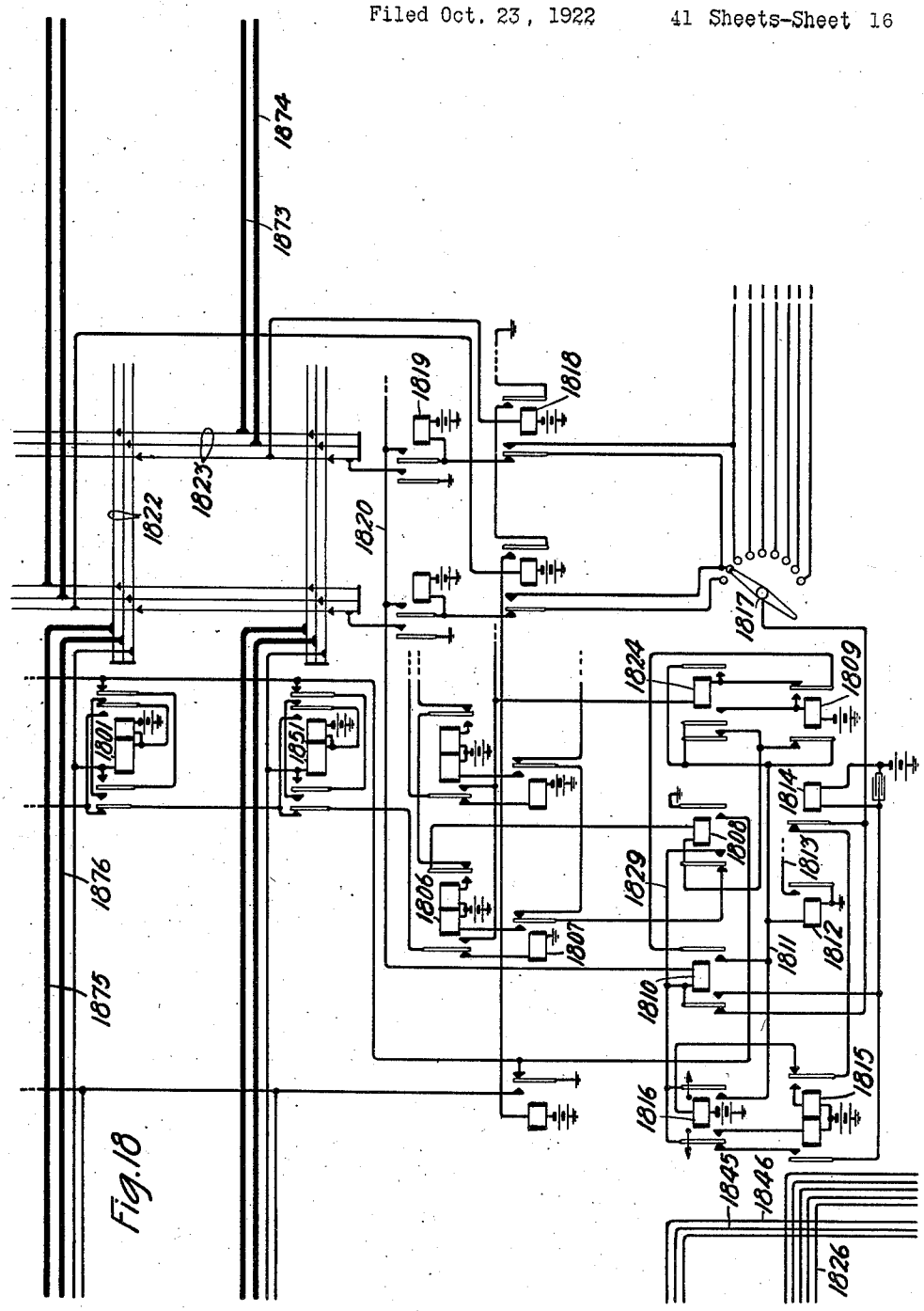


Fig. 18

Inventor:
Samuel B. Williams Jr.
by W. E. Beatty. Atty.

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S. B. WILLIAMS, JR.

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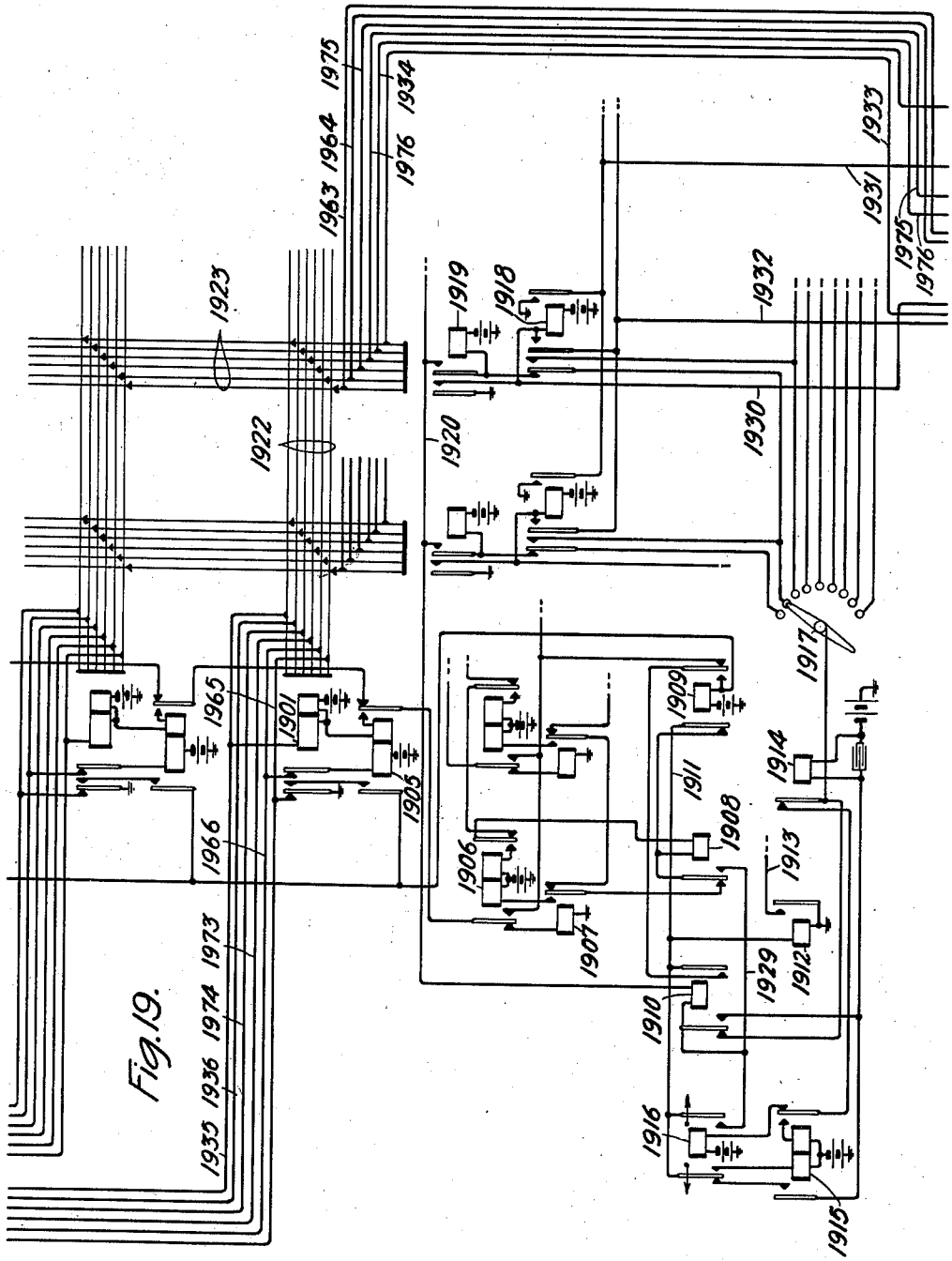


Fig. 19.

Inventor:
Samuel B. Williams Jr.
by W. E. Beatty
Att'y.

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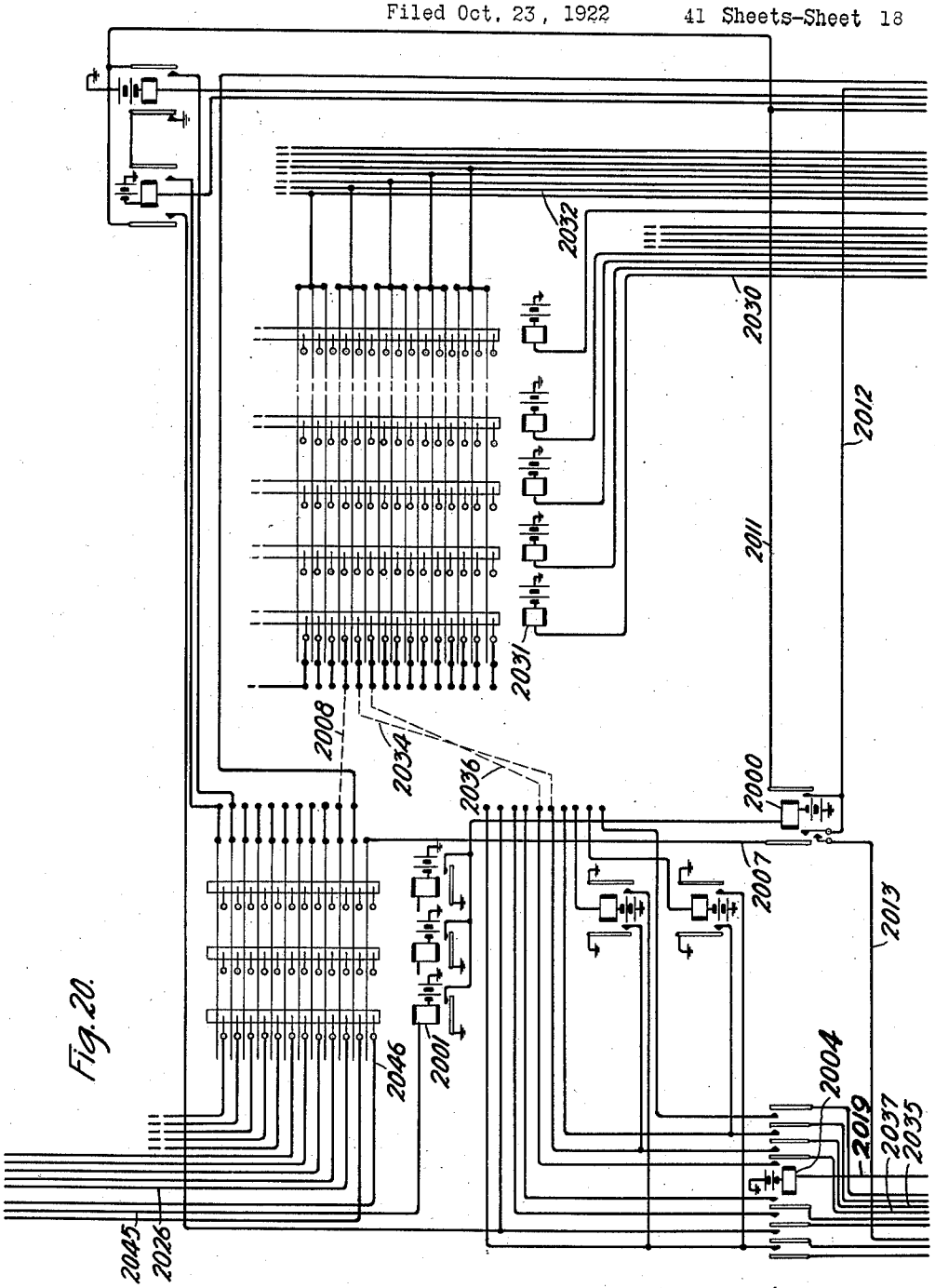


Fig. 20.

Inventor:
Samuel B. Williams Jr.
by W. E. Beatty Att'y.

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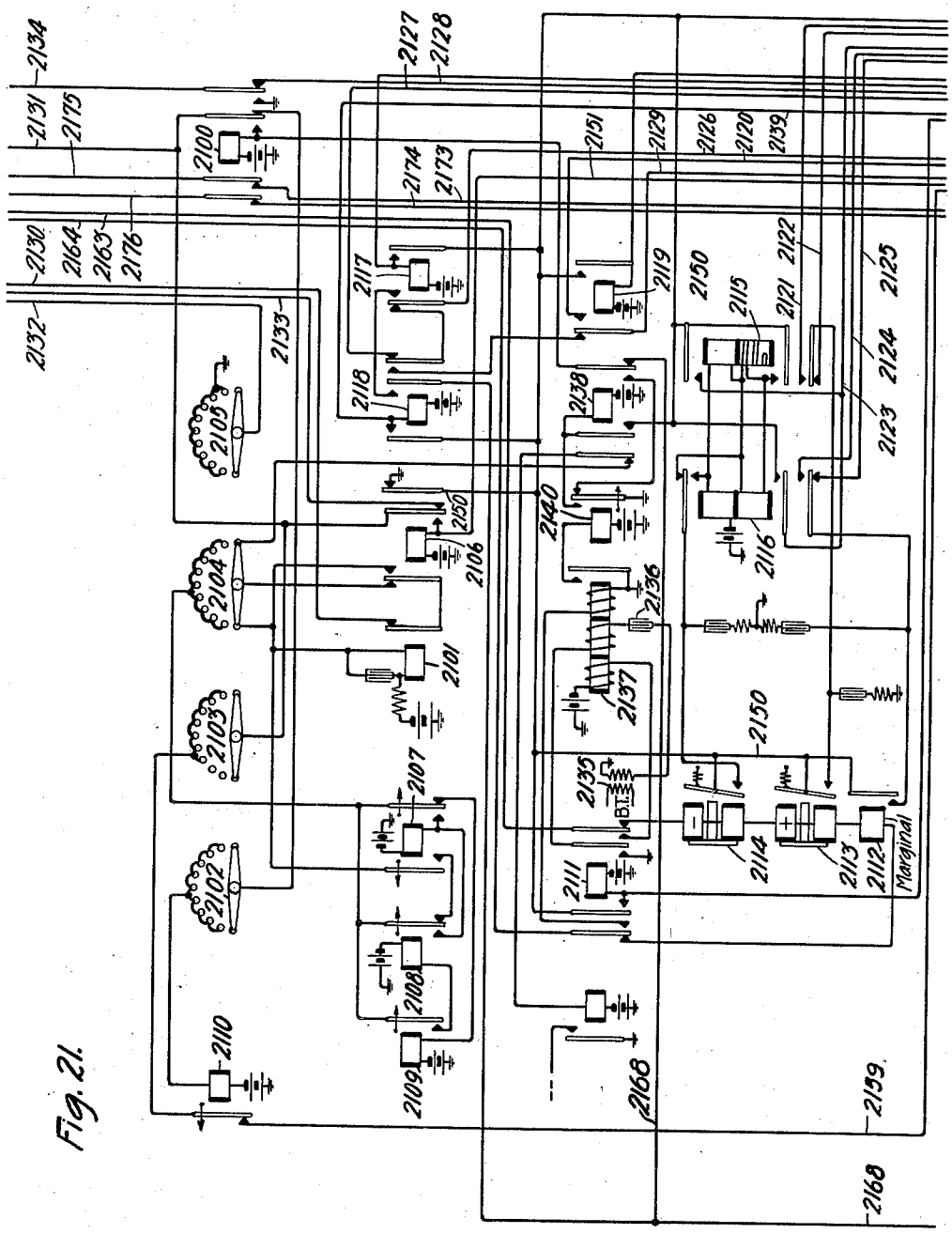


Fig. 21.

Inventor:
Samuel B. Williams Jr.
by W. L. Beattie. Att'y.

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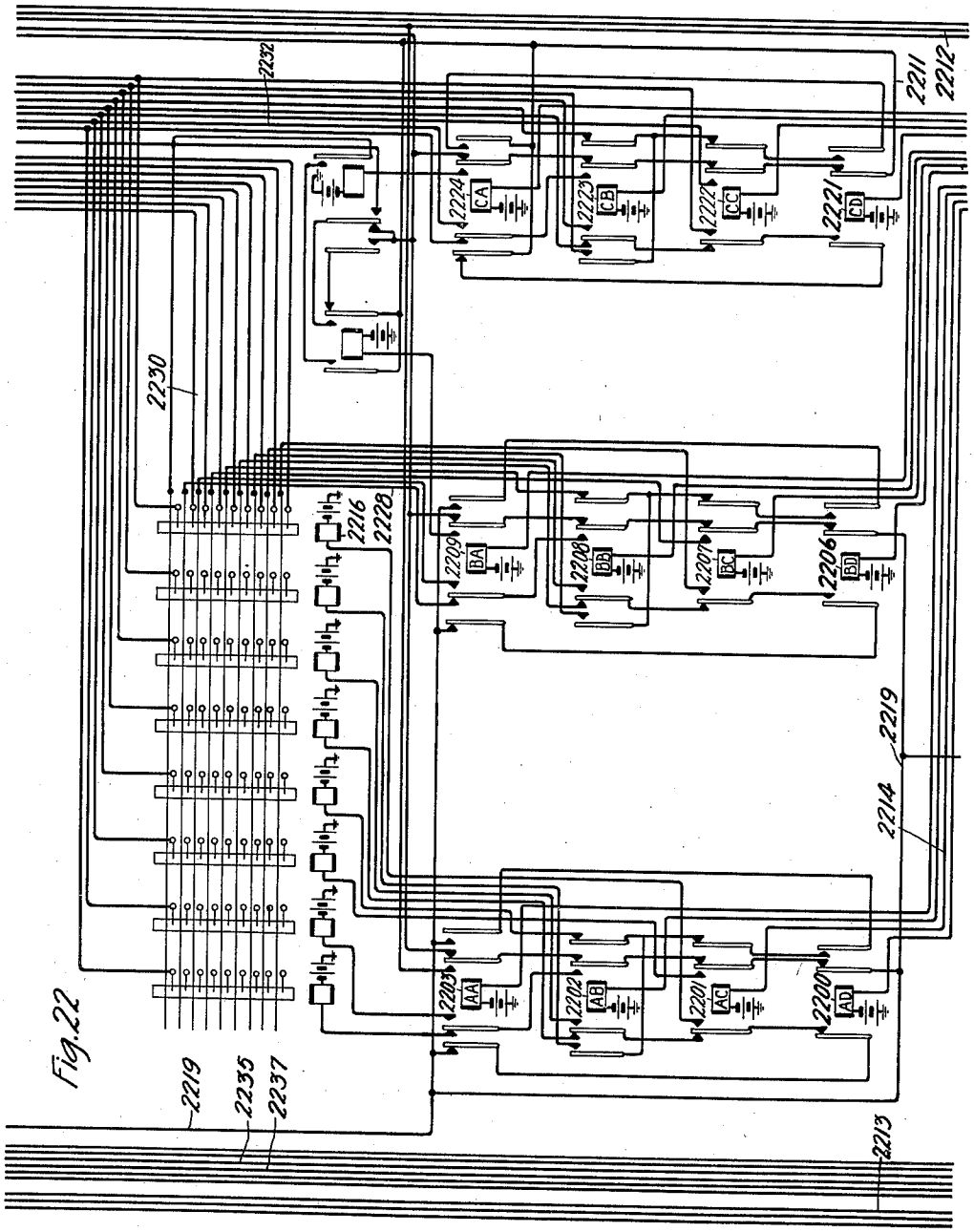


Fig. 22

Inventor:
Samuel B. Williams Jr.
by
W. G. Beattie Att'y.

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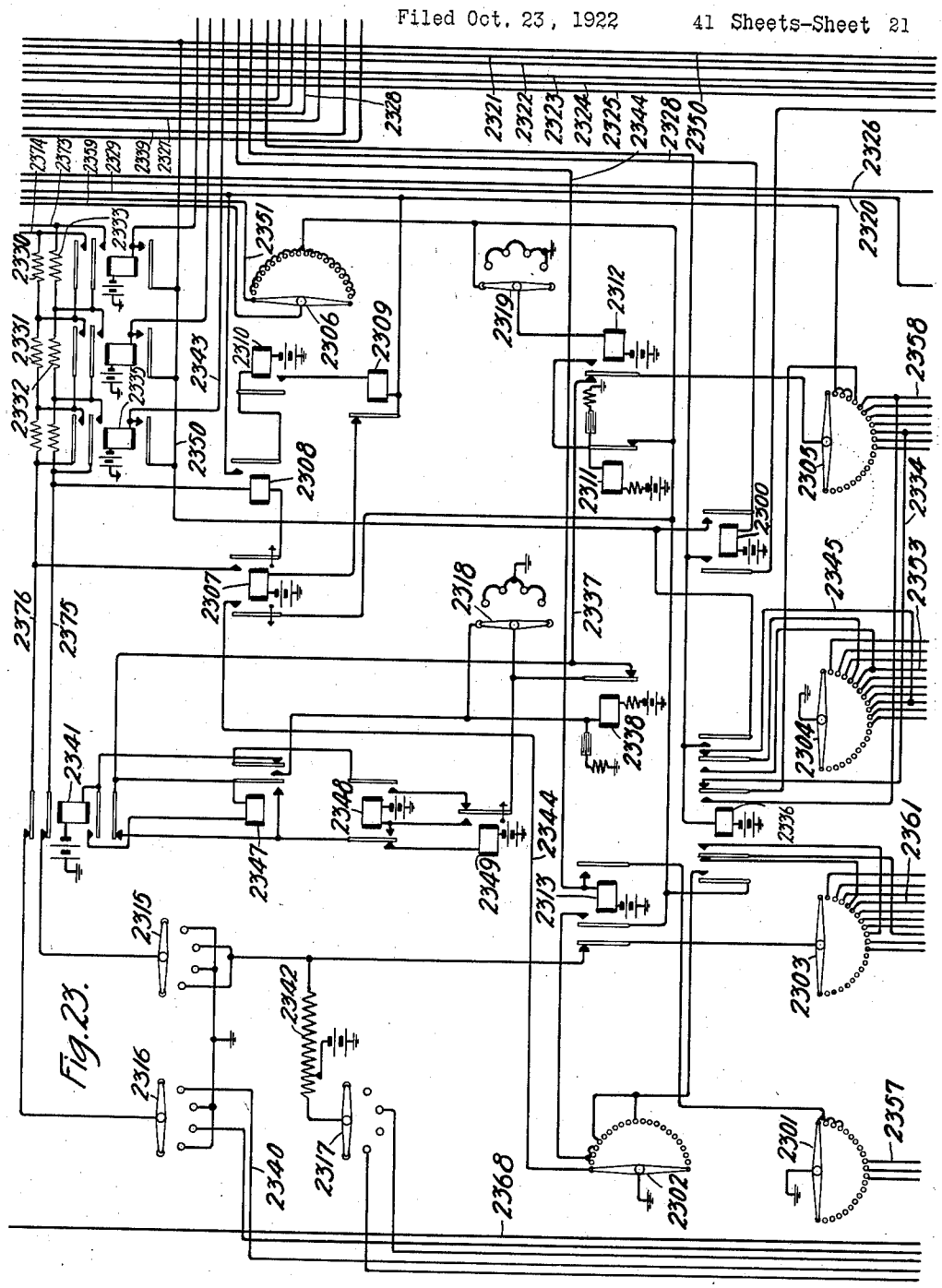


Fig. 23.

Inventor:
Samuel B. Williams Jr.
by W. L. Beatty. Att'y.

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S. B. WILLIAMS, JR

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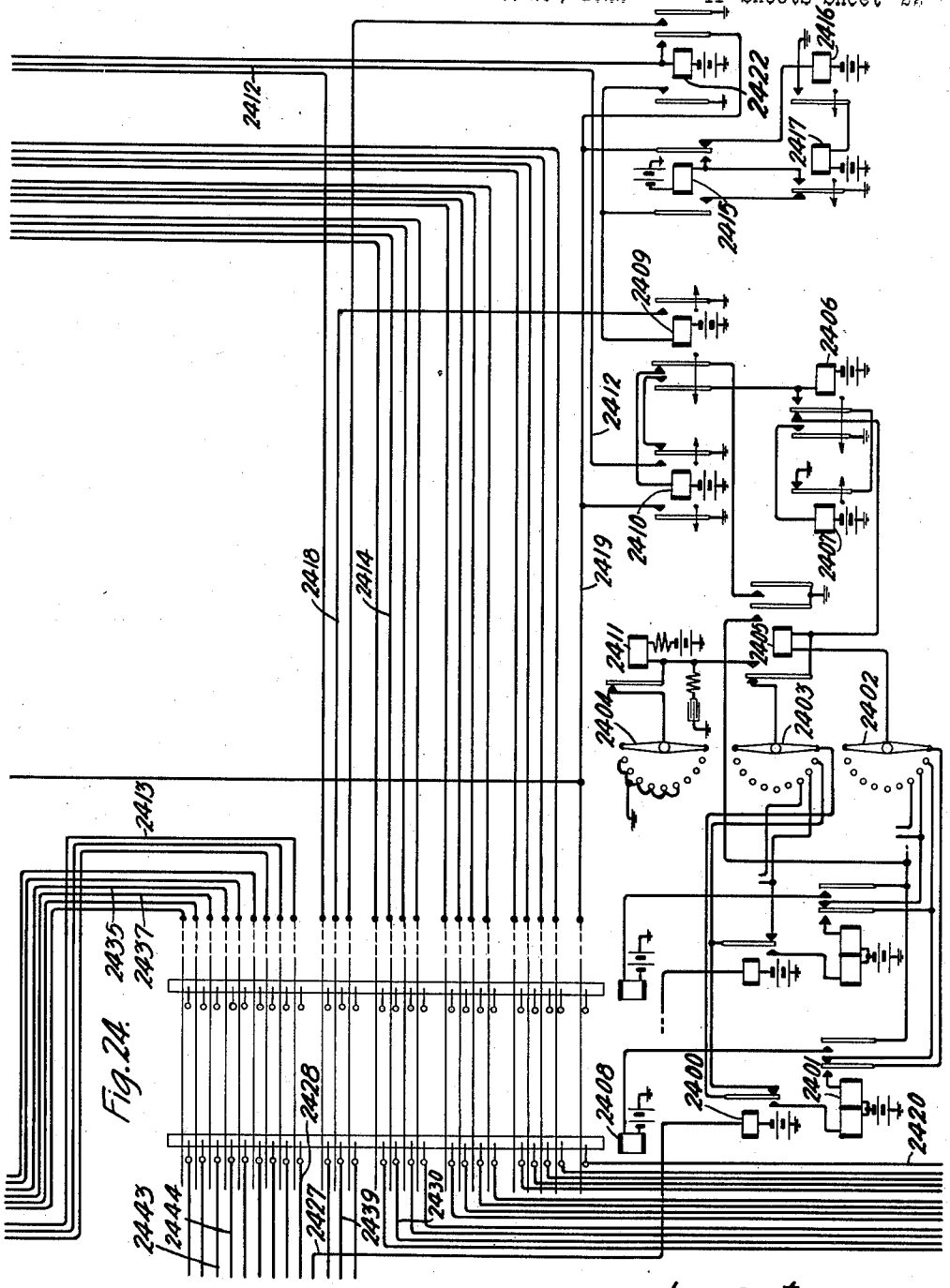


Fig. 24.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty
Att'y.

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S. B. WILLIAMS, JR

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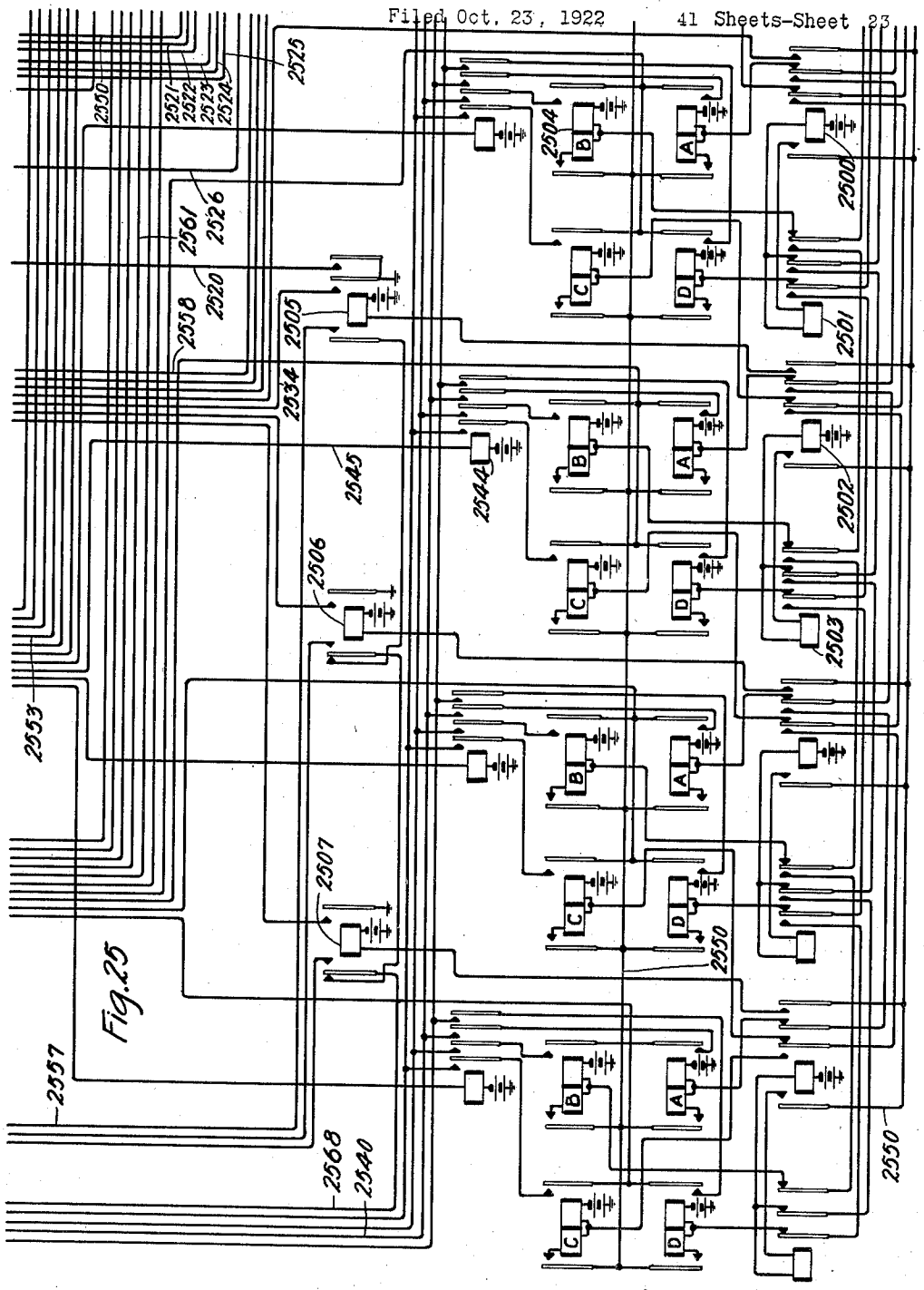


Fig. 25

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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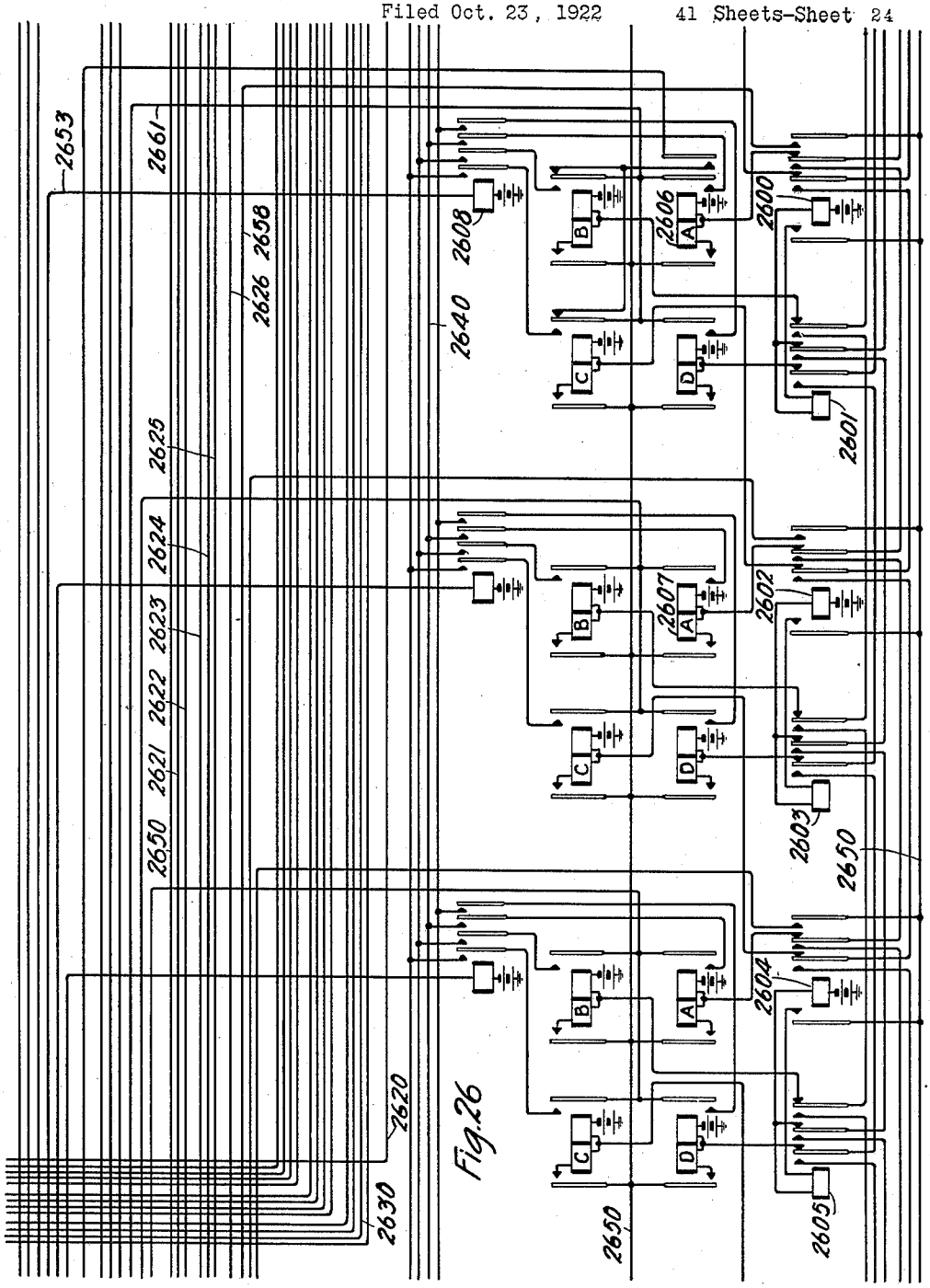


Fig. 26

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Att'y.

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S. B. WILLIAMS, JR

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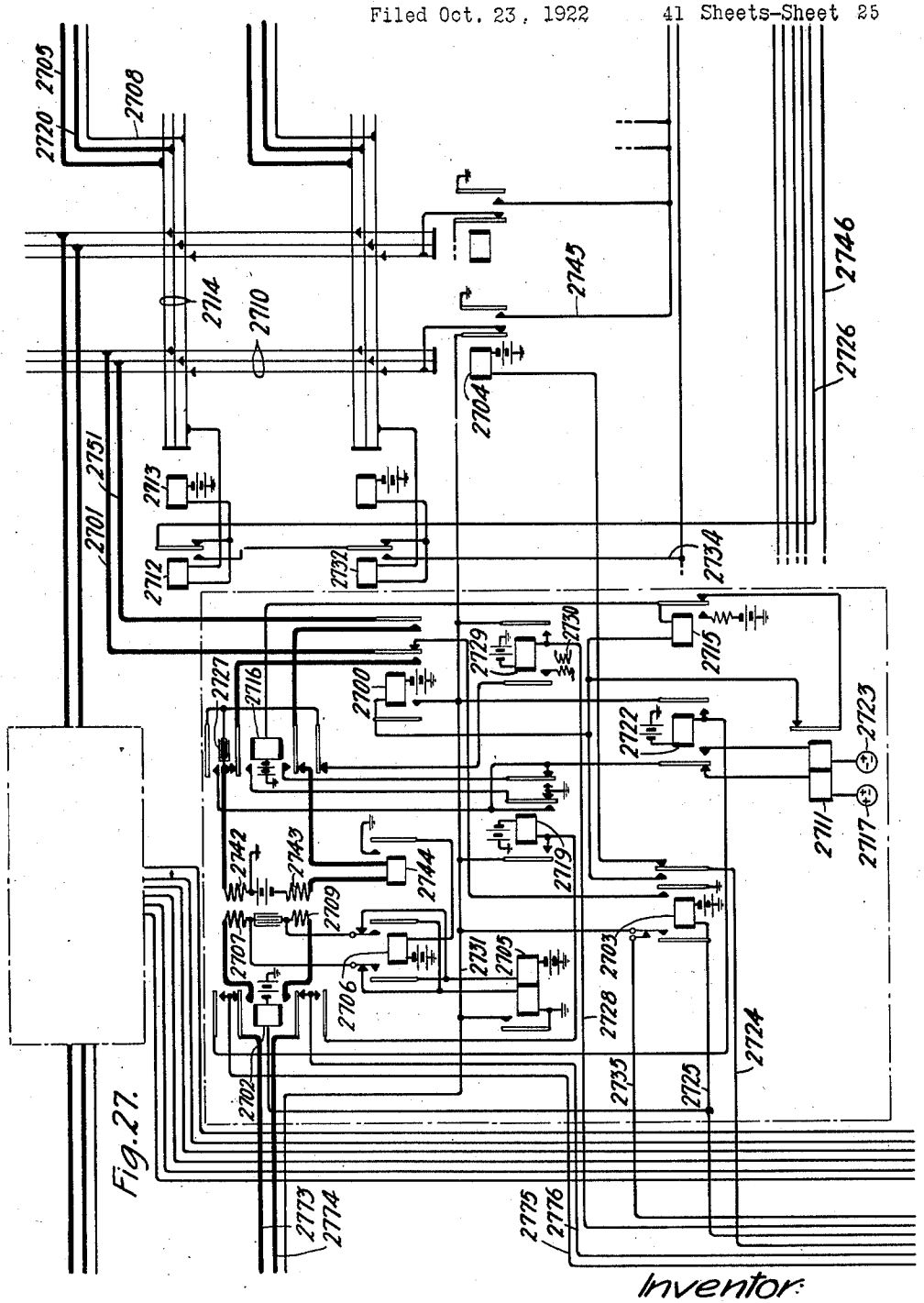


Fig. 27.

Inventor:
Samuel B. Williams. Jr.
by W. H. Beattie. Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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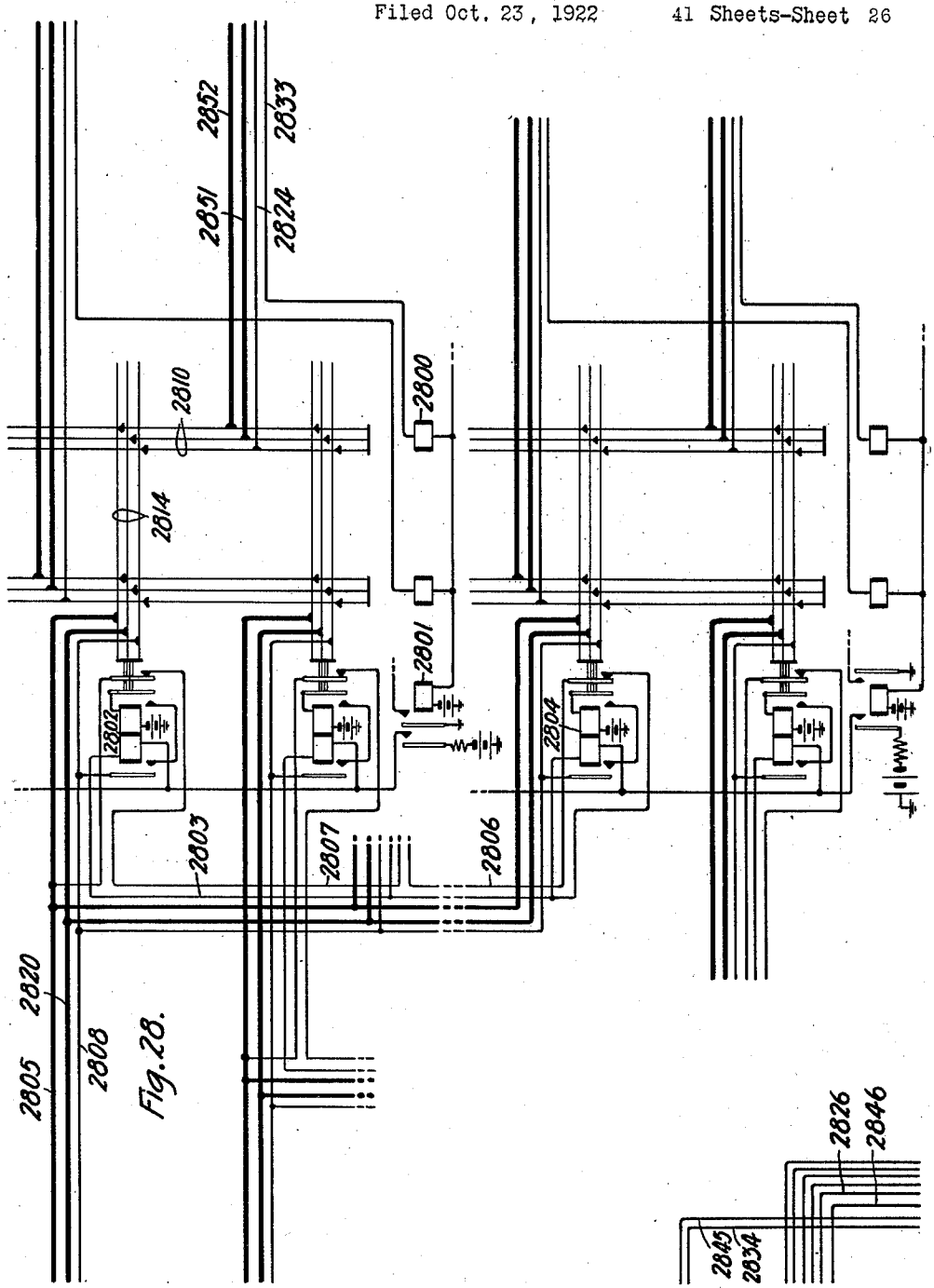


Fig. 28.

Inventor:
Samuel B. Williams Jr.
by W. L. Beatty Att'y.

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S. B. WILLIAMS, JR

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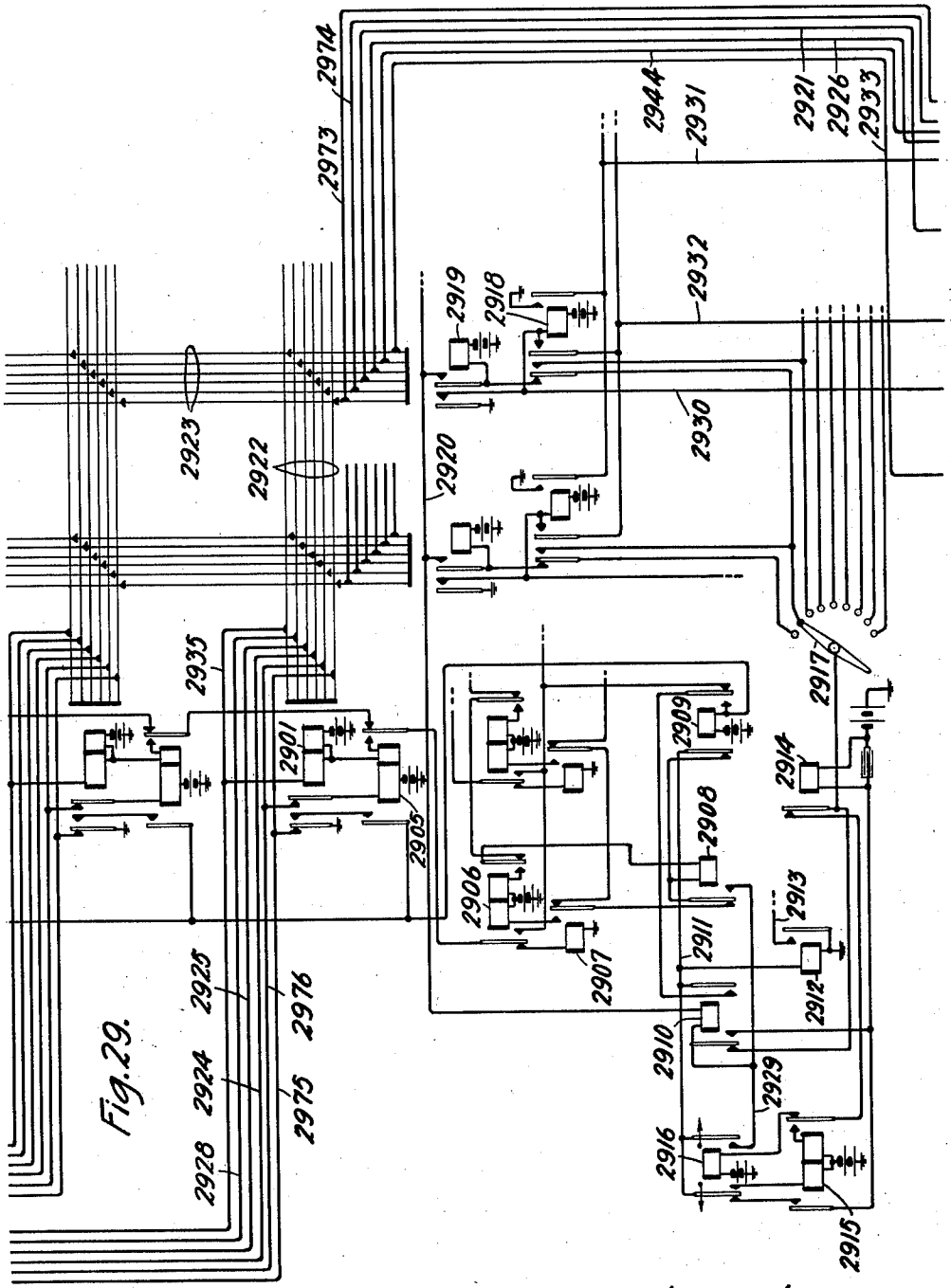


Fig. 29.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Att'y.

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S. B. WILLIAMS, JR

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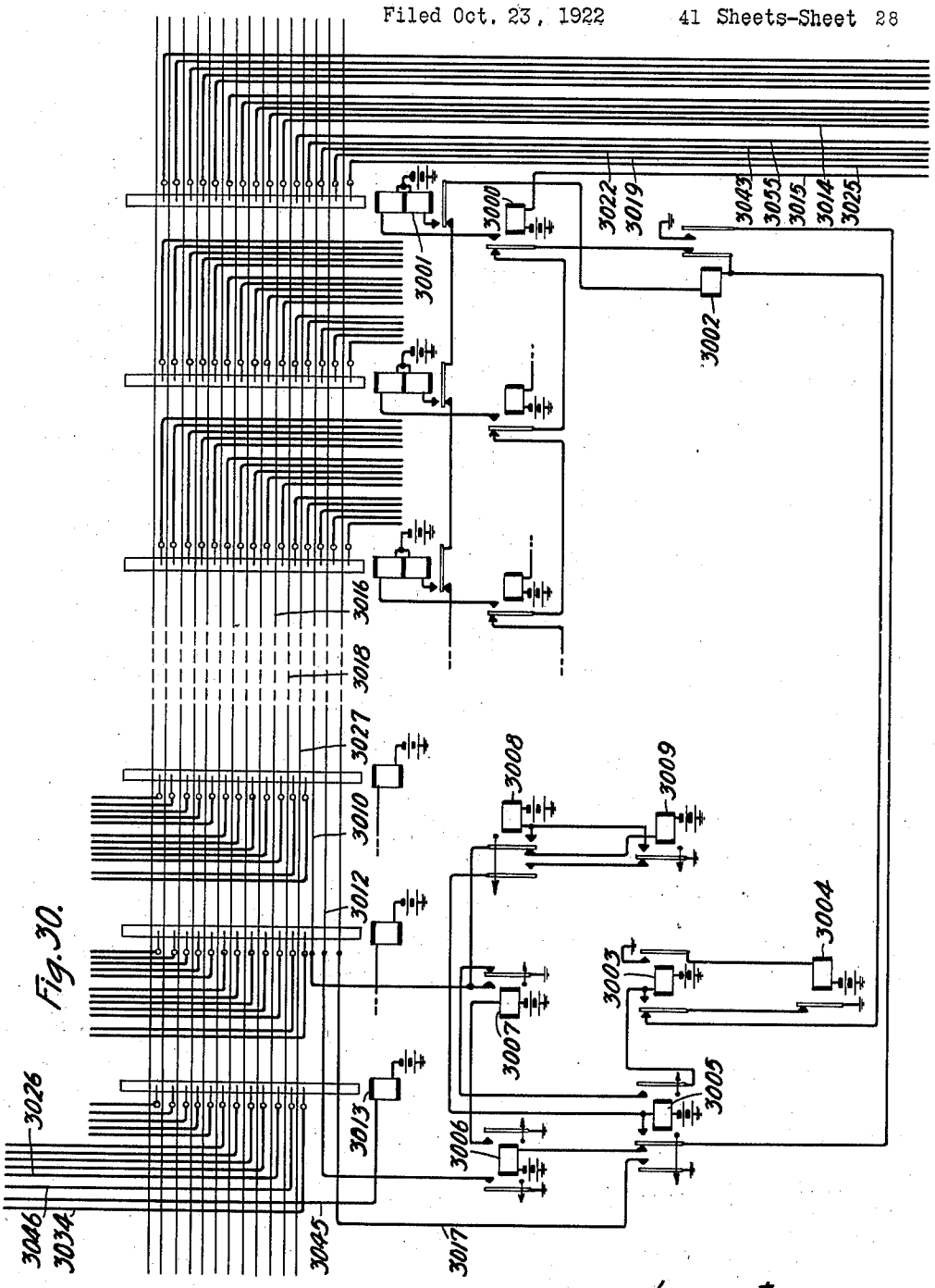


Fig. 30.

Inventor:
Samuel B. Williams Jr.
by W. L. Beatty. Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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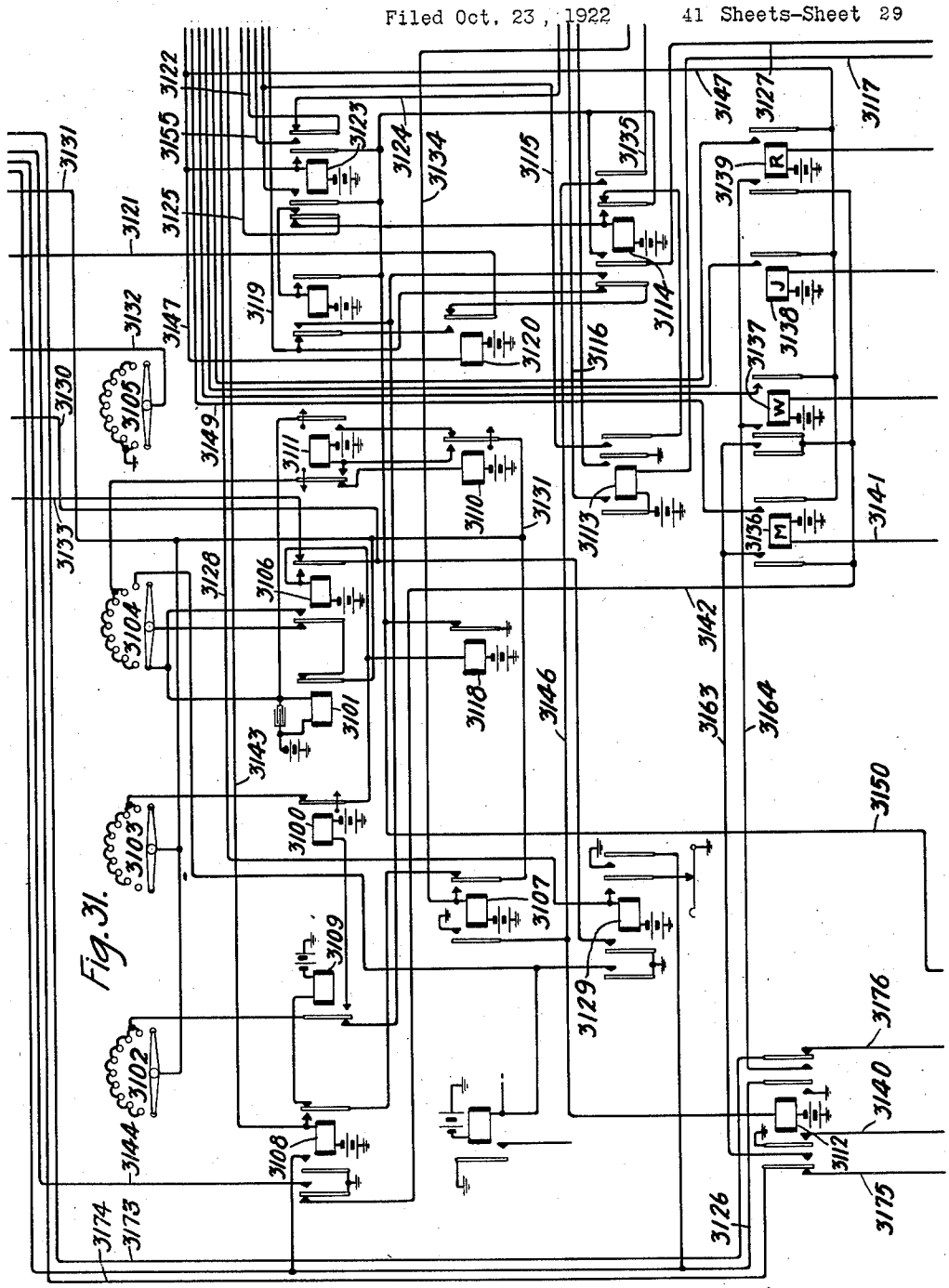


Fig. 31.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Atty.

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S. B. WILLIAMS, JR

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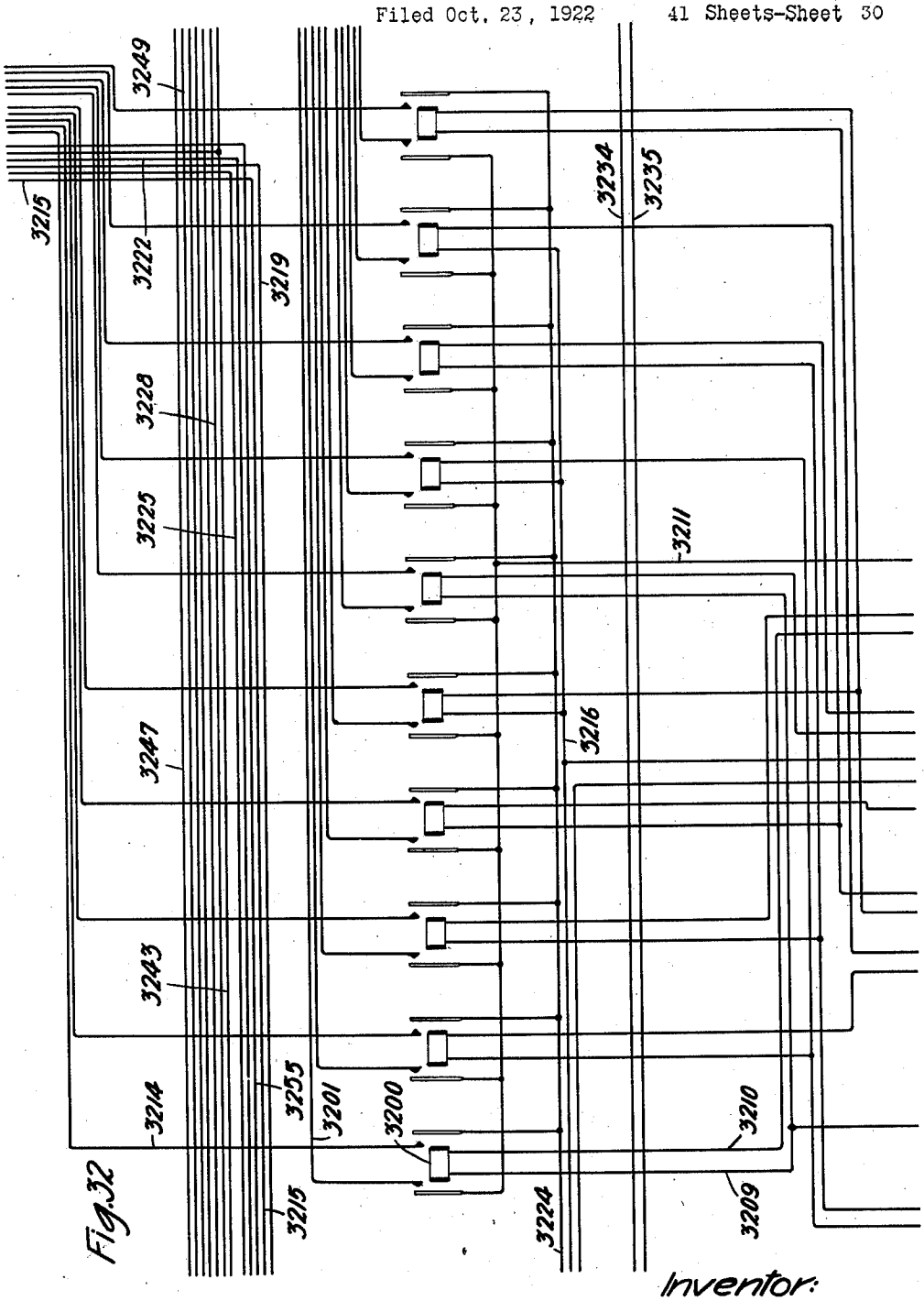


Fig. 32

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Atty.

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S. B. WILLIAMS, JR

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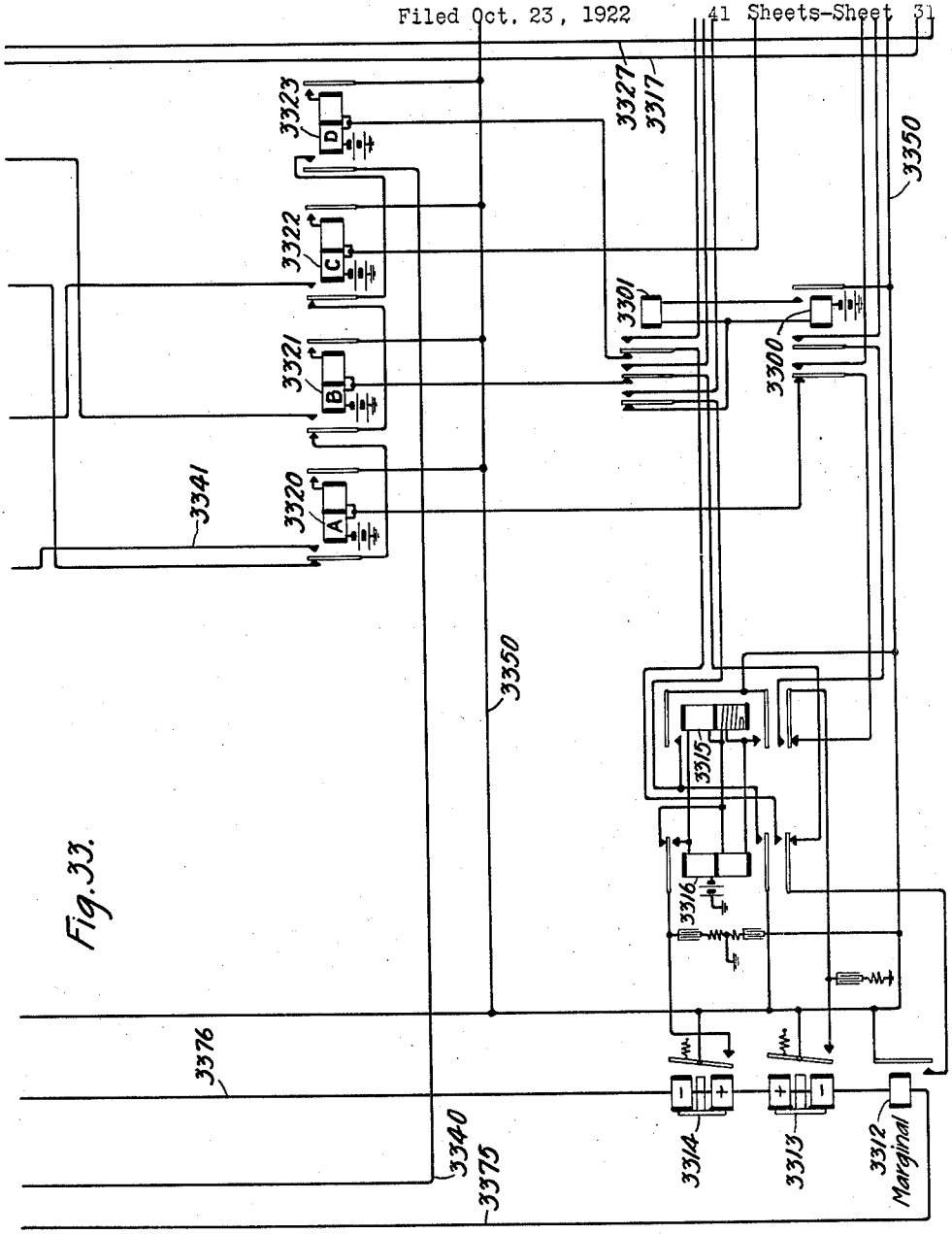


Fig. 33.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Att'y.

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S. B. WILLIAMS, JR

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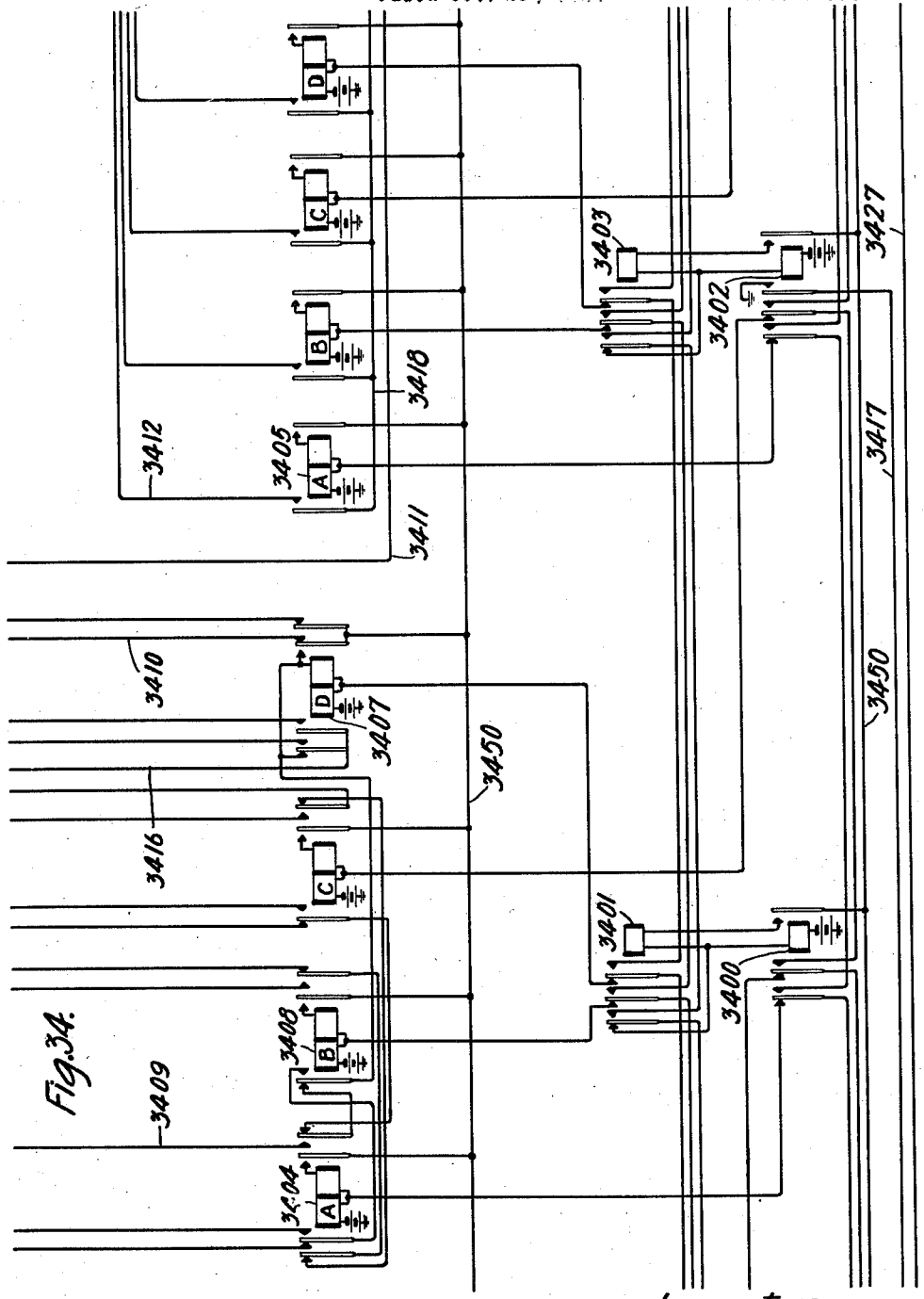


Fig. 34.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty. Att'y.

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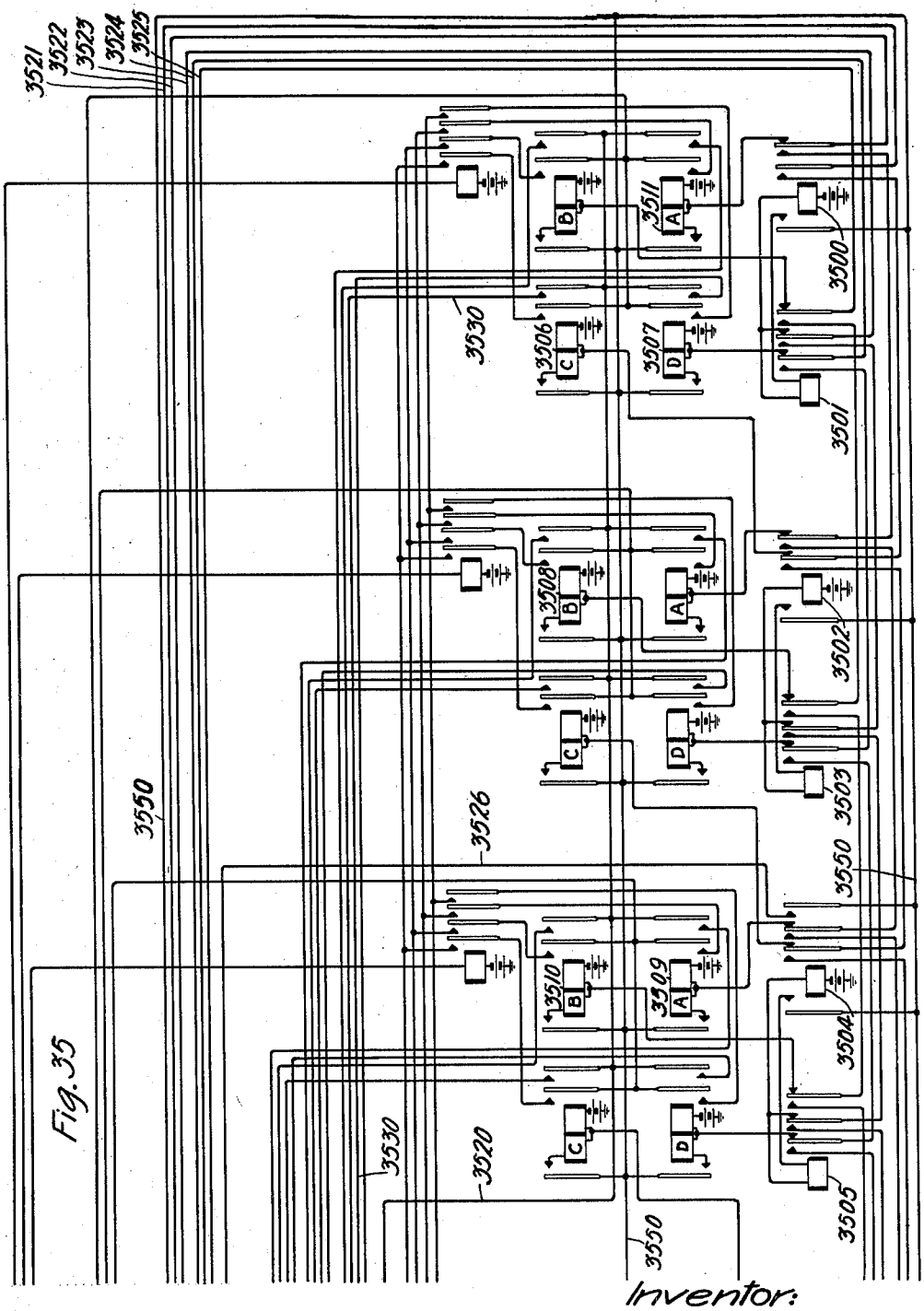


Fig. 35

Inventor:
Samuel B. Williams Jr.
by W. C. Batty Att'y.

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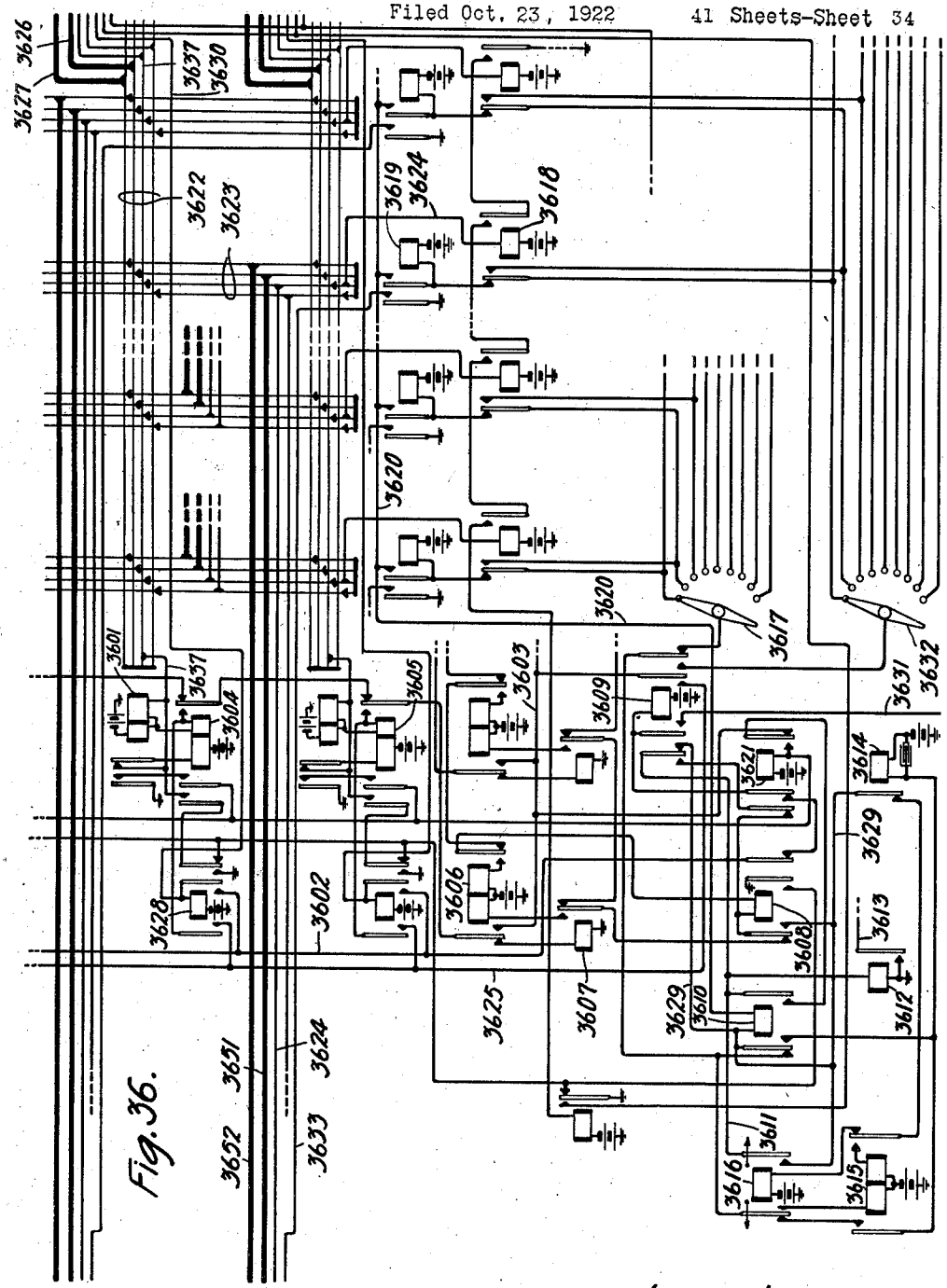


Fig. 36.

Inventor:
Samuel B. Williams Jr.
by W. E. Beatty.
Att'y.

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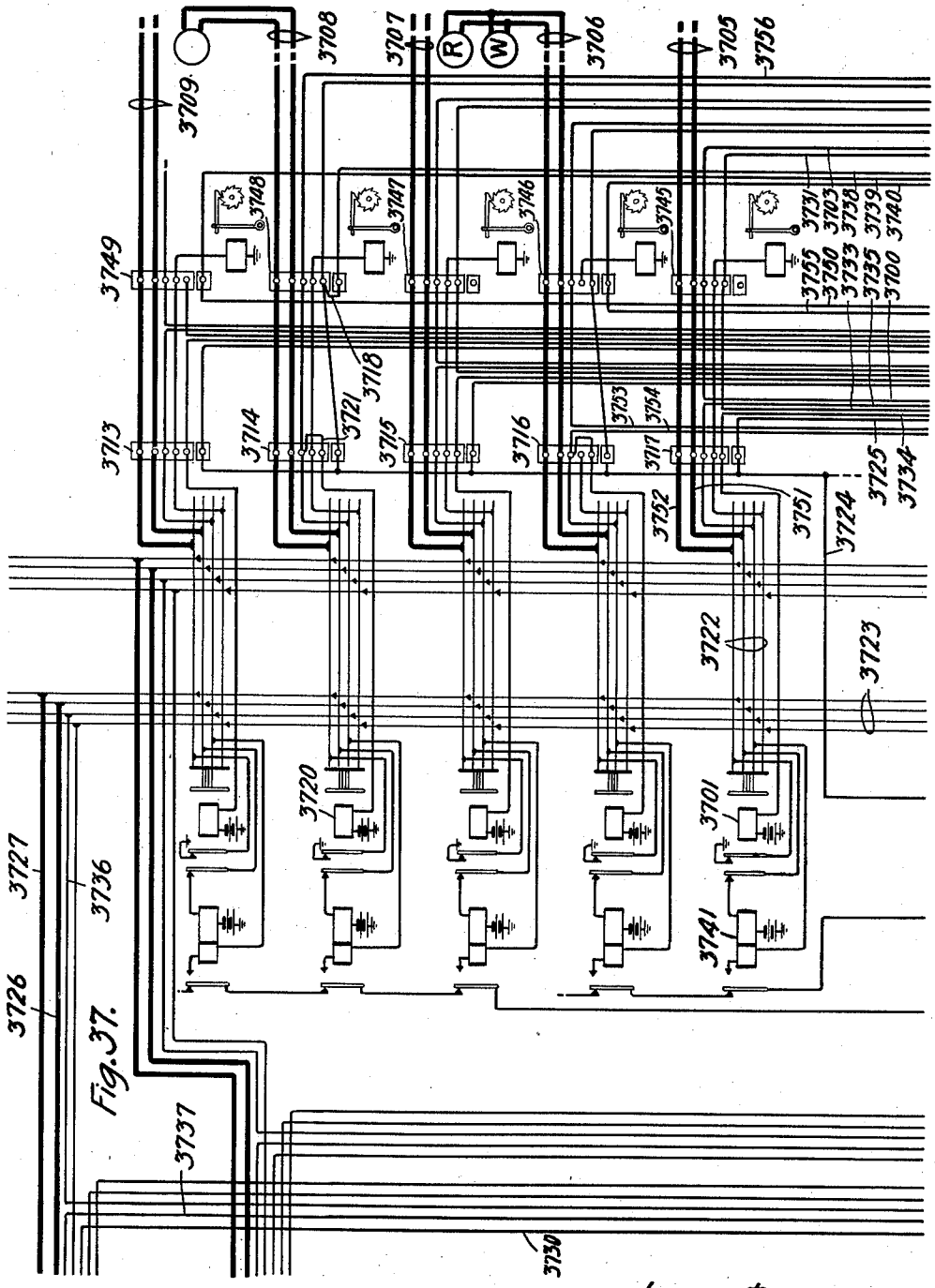


Fig. 37.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Atty.

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S. B. WILLIAMS, JR

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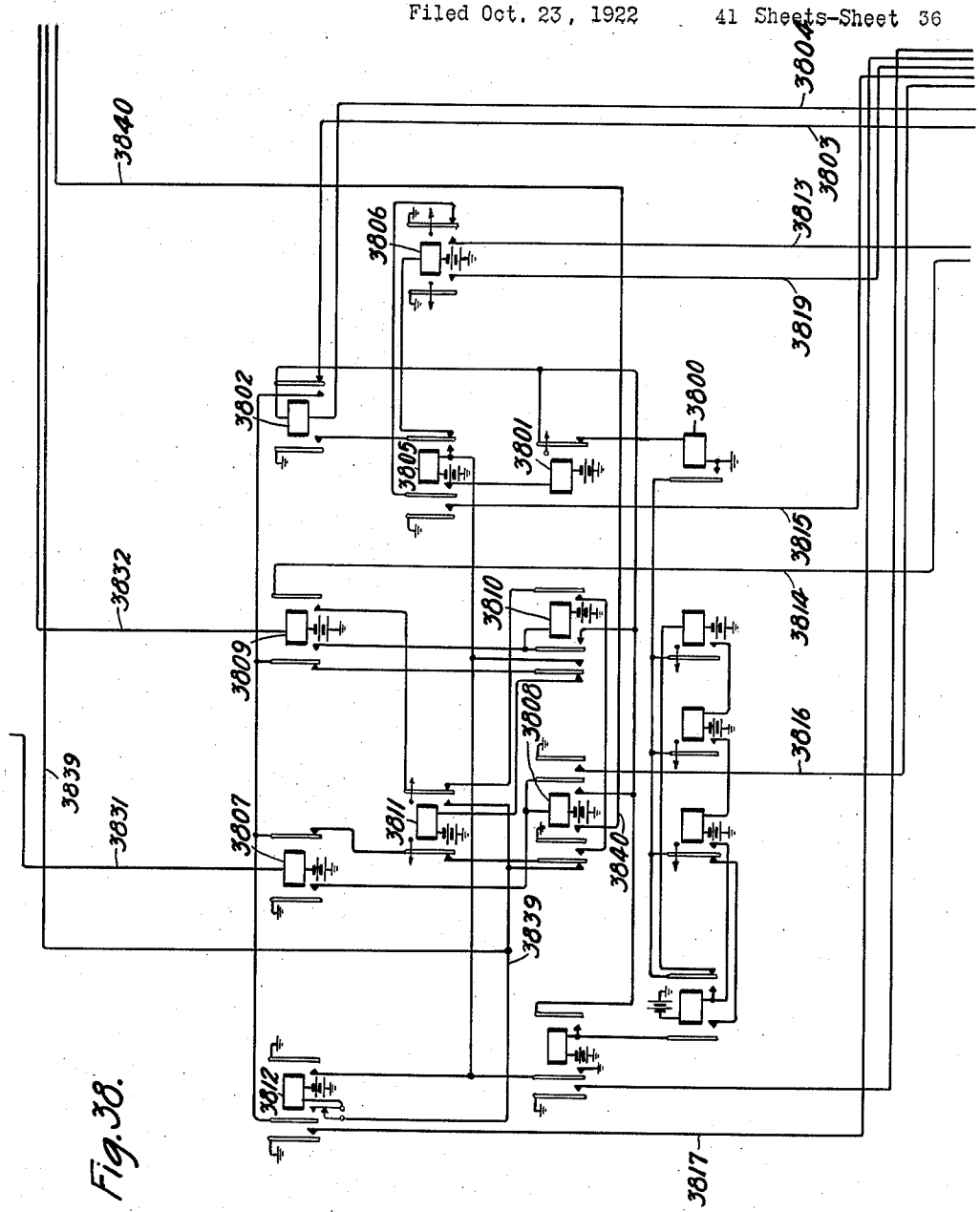


Fig. 38.

Inventor:
Samuel B. Williams Jr.
by W. A. Beatty Atty.

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S. B. WILLIAMS, JR

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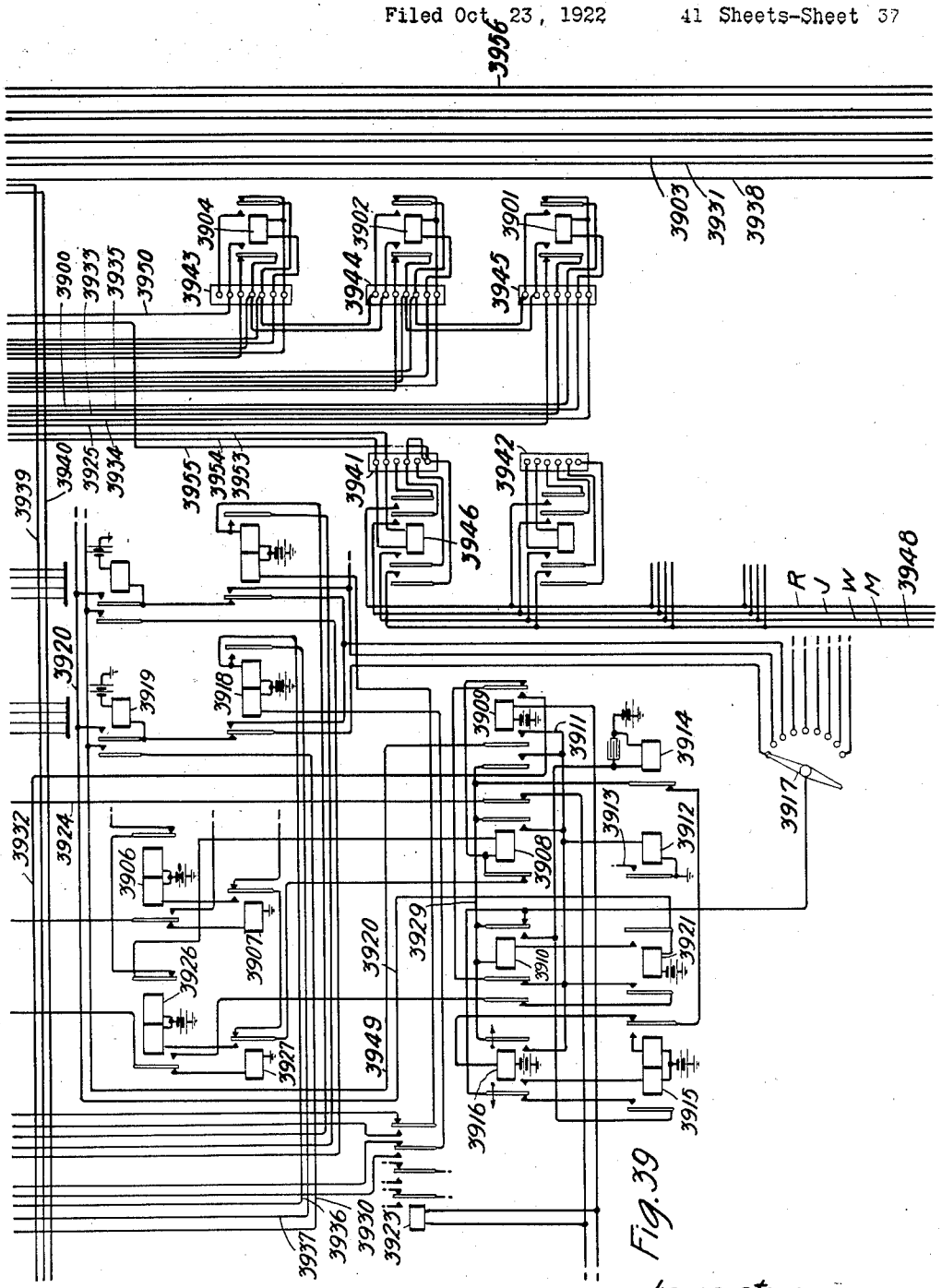


Fig. 39

Inventor:
Samuel B. Williams Jr.
by
W. A. Beatty Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

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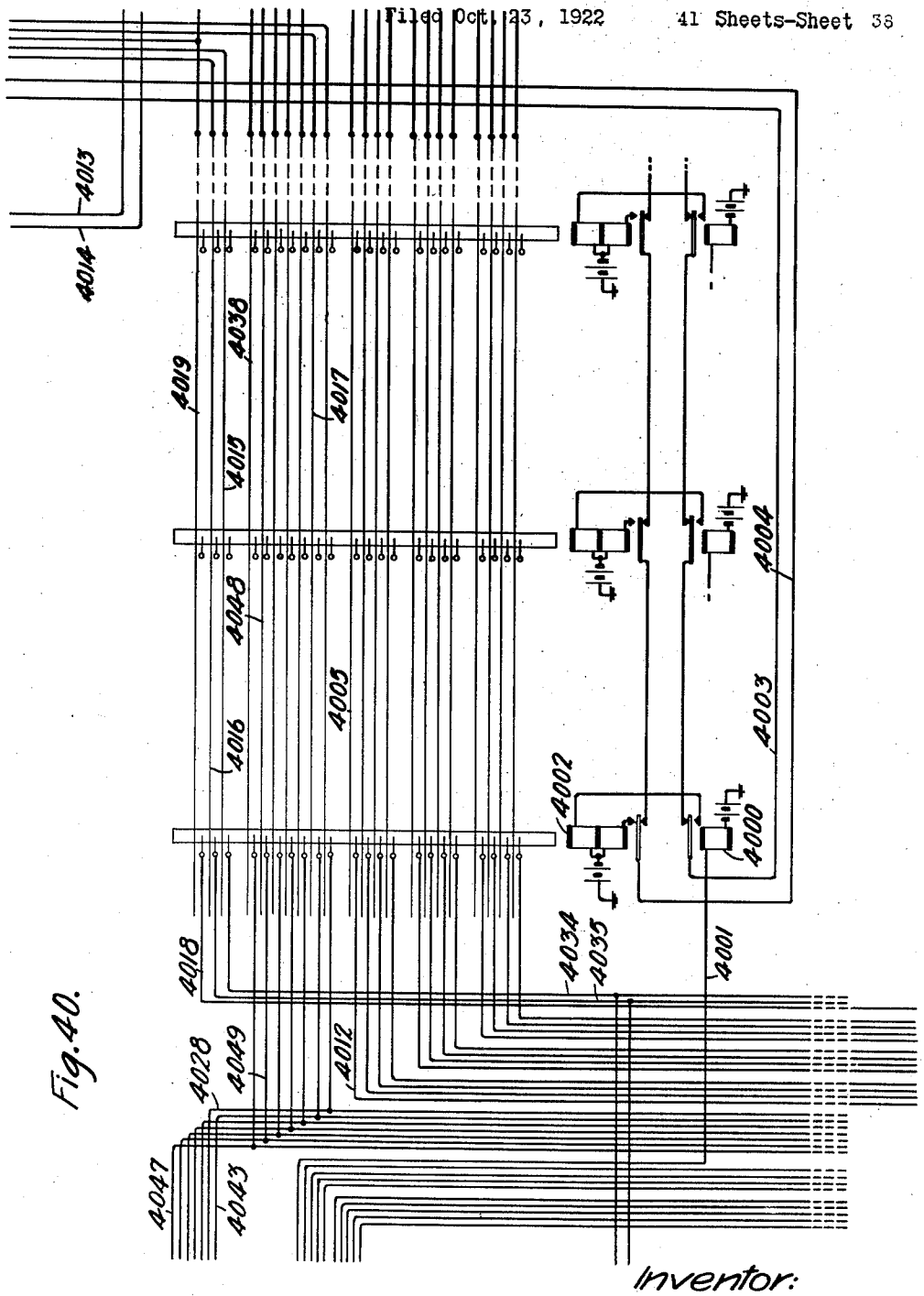


Fig. 40.

Inventor:
Samuel B. Williams Jr.
by
W. A. Beatty. Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

TELEPHONE SYSTEM

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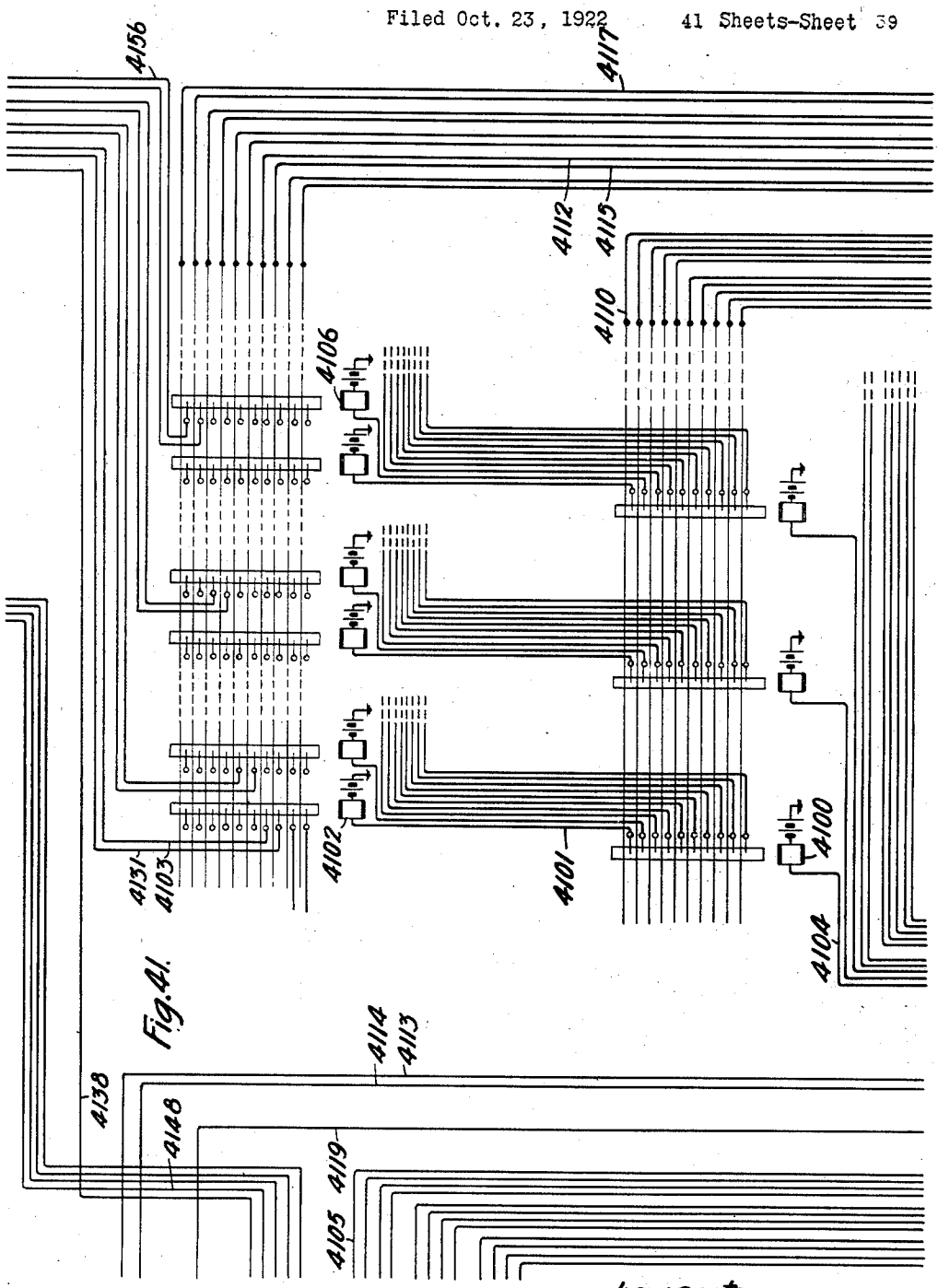


Fig. 41.

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Samuel B. Williams Jr.
by W. E. Beatty Att'y.

Feb. 10, 1925. 1,525,787

S. B. WILLIAMS, JR

TELEPHONE SYSTEM

Filed Oct. 23, 1922 41 Sheets-Sheet 40

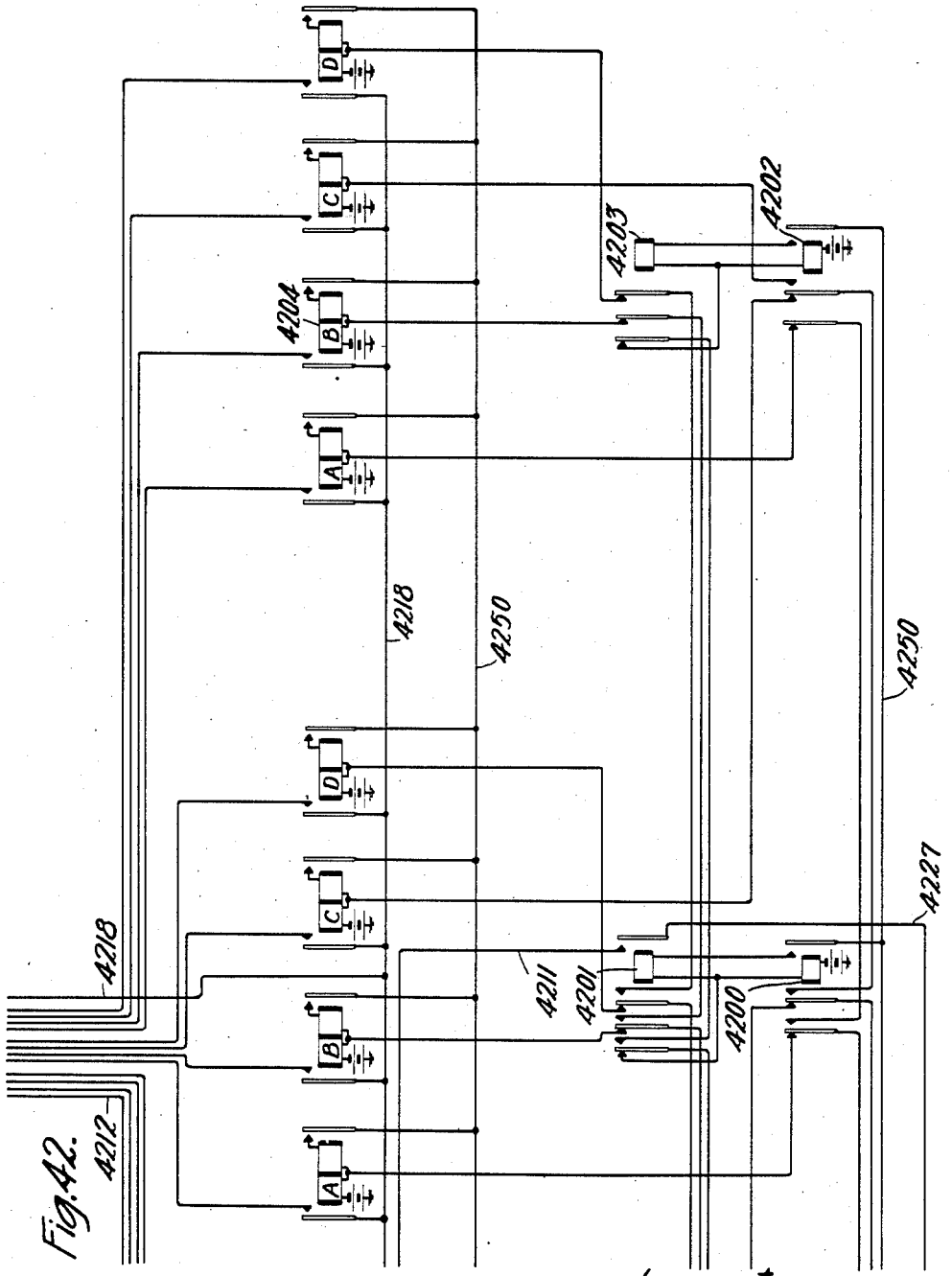


Fig. 42.

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TELEPHONE SYSTEM

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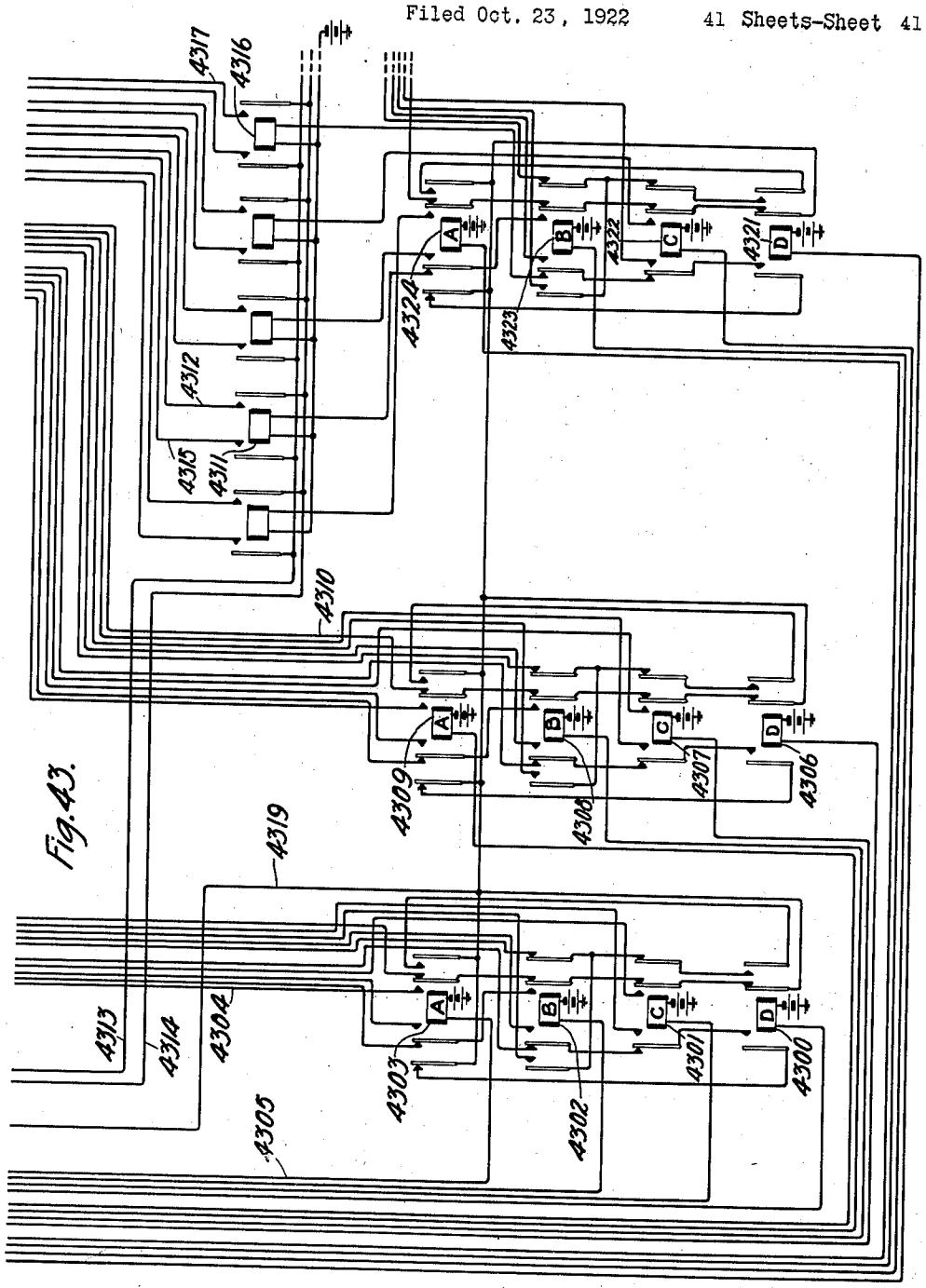


Fig. 43.

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by W. A. Beatty Atty.

Patented Feb. 10, 1925. 1,525,787

UNITED STATES PATENT OFFICE.

SAMUEL B. WILLIAMS, JR., OF BROOKLYN, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE SYSTEM.

Application filed October 23, 1922. Serial No. 596,178.

To all whom it may concern:

Be it known that I, SAMUEL B. WILLIAMS, Jr., a citizen of the United States, residing at Brooklyn, in the county of Kings, State of New York, have invented certain new and useful Improvements in Telephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone systems and particularly to coordinate machine switching systems.

It is the object of this invention to provide an exchange system of large capacity which will utilize a minimum of apparatus and which will operate rapidly and efficiently.

It is more specifically the object of this invention to provide a coordinate machine switching system wherein rapid operation is obtained through the entire elimination of trunk hunting operations and wherein the senders are simplified by employing auxiliary apparatus less numerous than the senders for performing several functions heretofore performed by the senders.

A further object is to provide a system of definite capacity in line numbers and indefinite capacity in lines.

A feature of the present invention resides in means for serving an indefinite number of lines in an exchange of definite capacity as measured by the possible number of line numbers available. For instance, in an exchange working on the decimal basis and equipped with apparatus responding to four digit designations, but ten thousand lines number are available. In the present system, however, through the use of unnumbered lines, this capacity may be increased many times. This is accomplished by furnishing service to a subscriber such as one employing a private branch exchange over a group of lines, at least one of which is a numbered line and the rest of which may be unnumbered lines.

Subscribers' lines radiating from the exchange are all connected to equivalent terminal sets and from there cross-connected to other terminal sets associated with a switching device. In this manner lines widely scattered in the switching device may be closely grouped on the outgoing terminal rack. This arrangement places the line switches on a non-numerical basis.

The switching devices for extending connections to called lines are under control of a device known as a marker. In the present instance, connection is made to a called line by marking it, that is, setting up a condition similar to a calling condition, whereby the same switches used for extending a line when calling, are now used to extend the called line to a predetermined point. The agency used is a marker wire individual to the line.

One marker wire may serve a plurality of lines, each of which may or may not have its own individual marker wires. Those lines which do have marker wires are known as numbered lines, and those which do not are known as unnumbered lines.

A plurality of lines may be associated in a group by extending the marker wire of the first through a starter wire circuit to equivalent points of the others, and these lines may be promiscuously scattered, or closely associated, and groups thus formed may comprise one numbered line and a plurality of unnumbered lines, or several numbered lines and several unnumbered lines, or may even exclusively comprise numbered lines.

Another feature of the present invention resides in the use of a common sender for controlling a marker at each of several selective stages and therethrough controlling the switching devices comprising the essential elements of such switching stages.

Another feature of this invention is the provision of means for setting the sender at one office, controlling a marker, and therethrough setting a switch, in accordance with a part only of the designation recorded in the sender and then transferring the record to the sender of another office.

One feature of this invention is the provision of means in the marker for translating a part of the record in the sender and in response thereto transmitting a class of service indication back to the sender to control the subsequent action of the said sender.

Another features resides in the means in the sender responsive to the discovery of a busy condition for transmitting a busy tone to the calling line.

Other features will appear hereinafter.

The drawings consists of thirty-nine sheets numbered Fig. 5 to Fig. 43, inclusive, showing the circuits in diagrammatic form

which are employed in one embodiment of this invention. Two additional sheets are also employed to show the manner in which the separate circuit diagrams are matched to form complete circuit arrangements illustrating different kinds of connections which may be established. Fig. 1 shows the arrangement of the circuit diagrams (Figs. 5 to 43 inclusive) when an interoffice connection through a mechanical switching center is established. Fig. 2 shows the same figures similarly placed, but containing, instead of the figure numbers, the title of the subject matter disclosed therein. This figure is employed to replace the usual description of the figures, since it is thought that such a device will better convey an understanding of the present arrangement than giving a mere list of such titles. As an illustration, the block corresponding to Fig. 5 is entitled "Subscriber's line and primary line switch" and illustrates the arrangement employed in this invention by the showing of two calling subscribers' lines, and the primary line switch used in extending the said lines. This figure also illustrates the master switch which is in fact a necessary part of the primary line switch. Fig. 3 is similar to Fig. 1 with the exception that Figs. 17 to 26, inclusive, and Fig. 35 are omitted, and is presented to illustrate the arrangement employed in establishing a local connection. Fig. 4 has the same relation to Fig. 3 that Fig. 2 has to Fig. 1.

The telephone system of this invention makes use of the Reynolds cross-bar switch, the essential elements of which are shown in the Reynold's Reissue Patent No. 14,236, December 26, 1916. Perhaps a more modern form of this switch is shown in the patent to Reynolds 1,306,124, issued June 10, 1919. The particular difference between the form of switch used herein and that shown in the last mentioned Reynolds patent is that no releasing magnet is employed at present, but only the line bar magnet and the trunk bar magnet as the sole means for operating the switch. The operation of such a switch comprises essentially three operations, the first of which is the energization of the trunk bar magnet and the consequent movement of the trunk bar with its plurality of contact sets. The second operation consists in the energization of the line bar magnet with the consequent movement of the line bar carrying a plurality of sets of contacts, each corresponding to a set of contacts on a different trunk bar. The movement of these two bars in the sequence noted causes the operation of the set of contacts at the crossing point of the two bars. Thereafter the trunk bar magnet is deenergized and the trunk bar returns to normal position carrying back all of the contact sets except those engaged by the particular line bar which has been moved. The connection through this switch is maintained through the continued energization of the line bar magnet.

Mention is made hereinafter of certain alarm circuits. Where a conductor is grounded and where such connection is maintained for a predetermined length of time an alarm will operate. An appropriate circuit of this nature is shown in the patent to Sperry, 1,406,236 issued February 14, 1922.

In general, the operation of this system is as follows: Upon the initiation of a call the calling line will be extended by means of a primary line switch to a trunk leading to a secondary line switch, whereupon the secondary line switch will further extend the line to the trunk leading to a district selector. Associated with the trunk leading to the district selector is a sender selector which immediately operates and attaches one of a plurality of common senders to the calling line. The operation of these three switches is automatic and practically instantaneous. The subscriber is notified of the proper operation of these switches by receiving a dial tone whereupon he will proceed to record the number of the desired called subscriber's line in the sender by manipulating the dial switch on his telephone instrument. In the present embodiment of this invention provision is made for the use of seven digit numbers, the first three digits of which constitute an office code. As soon as the first three digits have been received by the sender and recorded on an appropriate register, the apparatus associated with the sender is automatically set into operation and the record set up on the three office registers is transmitted through a marker and a translator to perform two functions. The first is to cause the proper operation of the district selector to extend the calling line through the district selector in the direction indicated by the office code. The second function is to send a class of service indication from the marker back to the sender to control the subsequent action of the sender.

Upon the complete operation of the district selector a line switch associated with the district selector is operated to extend the calling line to an office selector in the case of an interoffice call, or to an incoming selector in the case of a local call. In the case of an interoffice call upon the extension of the calling line to the office selector, an office sender selector is automatically operated to extend the trunk to an office sender, whereupon the record in the district sender is transferred by means of well known relay call indicator impulses to the office sender. Here again the office code is employed to cause the proper operation of the office switch and the sending of another class of service indication to the office sender. Upon the setting of the office switch, a line switch

associated therewith is automatically operated to extend the trunk to an incoming switch whereupon another sender selector is automatically operated to further extend the trunk to an incoming sender circuit. The record now established in the office sender is transferred in part (the office code now being omitted) to the said incoming sender. When the record is complete in the incoming sender, then a section marker controlled by the thousands digit is operated to extend the trunk from the incoming selector to a switch known as the "in trunk line switch." Simultaneously therewith a line marker is controlled by the hundreds, tens and units digits and a marker wire individual to the called line is grounded. The grounding of the marker wire individual to the called line sets up a condition on the called line similar to a calling condition so that the primary line switch to which the called line is wired is caused to operate and extend the called line to a secondary line switch. The secondary line switch thereupon automatically operates, but in this case extends the line to an in-trunk rather than an out-trunk. The in-trunk leads to the in-trunk line switch where the line extended from the calling line is thus connected with the line extended from the called line.

In case of a local call the operation is the same with the exception that no office switch is used and when the district selector extends a calling line to a trunk leading to an incoming selector the record on the district sender is transferred to the incoming sender registers.

In case the called line is found to be busy upon the operation of the line marker, then an indication is sent back to the incoming sender which thereupon controls the sending of a busy tone from means located in the incoming switch.

Upon the operation of the district sender or the office sender to extend a calling line through the district switch to a trunk in a particular group of trunks or through the office switch to a trunk in a particular group of trunks and when all of the trunks in such particular group are found to be busy then means in the associated sender is operated to send an all trunks busy tone back to the calling subscriber.

It is believed that the invention will be more fully understood from the following detailed description.

The subscriber at substation 500 initiates a call by removing his receiver from its switchhook, whereupon a circuit is established from ground, the inner left-hand armature and back contact of line bar magnet 501, conductor 502, over the loop of the calling substation, conductor 503, back contact and outer left-hand armature of line bar magnet 501, right-hand high resistance winding of line relay 504 to battery. Line relay 504 is energized in this circuit and attracts its armatures, whereupon a circuit is established from battery through the winding of line bar magnet 501, the left-hand low resistance winding of line relay 504, the front contact and armature of relay 504, the back contact and armature of relay 505 (belonging to the same group), left-hand armature and back contact of group relay 506, winding of group relay 507 to ground. Relay 507 is energized in this circuit and attracts its armature. The winding of relay 507 included in this circuit, however, introduces sufficient resistance to prevent the energization of line bar magnet 501 at this time. Upon the energization of group relay 507 a circuit is established from battery, the left-hand winding of group relay 506, the front contact and armature of relay 507, the back contact and left-hand armature of the primary master switch starter relay 508, back contact and right-hand armature of relay 509, inner left-hand armature and back contact of relay 510, conductor 511, winding of alarm relay 512 to ground. Relay 512 becomes energized in this circuit and connects ground through its armature and contact to conductor 513 which leads to an alarm circuit which may be of the type shown and described in the patent to Sperry, No. 1,406,236, granted February 14, 1922. Under normal conditions the action of the master switch and the cross bar line switch shown in Fig. 5 will be completed in a very short interval of time and the alarm circuit connected to conductor 513 will not completely operate. Under abnormal conditions as when no outgoing trunks are available or there is some defect in the circuit, this ground will remain on conductor 513 and cause the actuation of the alarm circuit, whereupon an attendant may inspect the apparatus and remedy the difficulty.

Relay 506 is also energized in the circuit including relay 512 just described and, upon energizing, completes a circuit from battery through the right-hand winding of relay 506, the front contact and right-hand armature of relay 506, winding of starter relay 508 and thence over the circuit described through the winding of relay 512 to ground. Relay 506 also opens the circuit of relay 507 which becomes deenergized and in retracting its armatures opens the original energizing circuit of relay 506. Relay 508, however, becomes energized in the locking circuit of relay 506 and opens the original energizing circuit of relay 506 at another point. Upon the energization of relay 508 a circuit is established from ground through the winding of relay 512, conductor 511, front contact and inner right-hand armature of relay 508, conductor 529, right-hand ar-

mature and back contact of relay 510, preference switch wiper 517 and its first position contact, left-hand armature and back contact of relay 518, winding of trunk bar magnet 519 to battery and ground. The trunk bar magnet 519 attracts its armatures and operates the trunk bar 523, whereupon a circuit is established from the ground which is thus connected to magnet 519, through the inner left-hand armature and front contact of magnet 519, conductor 520, winding of relay 521, to battery and ground. Relay 521 attracts its armatures and extends this ground to the winding of relay 510, but since the other terminal of the winding of relay 510 is connected to ground on conductor 529, relay 510 does not become energized at this time. Upon the energization of relay 521 a connection is extended from ground, the winding of relay 512, conductor 511, the front contact and left-hand armature of relay 521, the back contact and outer left-hand armature of relay 510, the front contact and left-hand armature of group relay 506, the armature and back contact of line relay 505, the armature and front contact of line relay 504, the left-hand low resistance winding of relay 504, the winding of line bar magnet 501 to battery and ground. Since this circuit includes only the low resistance winding of relays 512 and 504 and the winding of the line bar magnet 501, the latter becomes energized at this time and connection is made between the corresponding contacts of line bar 522 and trunk bar 523.

It should be here noted that if another line belonging to the same group as, for instance, the line leading to station 550 initiates a call before the operations which are now being described are completed and this other line precedes the first in order along the starter wire, then this other will "steal" the connection as the relay 505 will switch the starter wire from the line bar magnet 501 to the line bar magnet 551. This, however, will delay the extension of the original call only a small fraction of a second so that no actual harm will result.

The ground extended to the winding of line bar magnet 501 is now extended through the third conductor and the corresponding contacts of line bar 522 and trunk bar 523, through the third conductor of the outgoing trunk whence it is further extended to the right-hand winding of relay 518 and thence to battery causing the energization of relay 518 which results in the opening of the original energizing circuit of trunk bar magnet 519. Trunk bar magnet 519 does not become deenergized at this time, however, as it is now connected in multiple with the winding of relay 521 and this multiple circuit is included in series with the winding of relay 510 so that relay 510 becomes energized at this time and both relay 521 and magnet 519 are maintained energized.

At this point the energizing circuit for line bar magnet 501 is opened at the outer left-hand armature and contact of relay 510, but as will be shown hereinafter ground is by this time projected back over the third conductor of the outgoing trunk to the right-hand armature of relay 518 to maintain this relay energized and to further extend this ground back over the third conductor and through the corresponding contacts of trunk bar 523 and line bar 522 to the winding of line bar magnet 501 to maintain this magnet energized to hold the connection. The energization of relay 510 opens the circuit of relay 508 at the inner left-hand armature and back contact of relay 510 and relays 508 and 506 become deenergized.

It should be noted at this point that upon the energization of relay 510 a circuit is established from ground, through the winding of relay 512, the front contact and inner right-hand armature of relay 508, conductor 529, the right-hand armature and front contact of relay 510, winding of magnet 514, to battery and ground. Magnet 514 becomes energized and prepares to move the wiper 517 on to its next contact. Upon the deenergization of relay 508, just described, this circuit would be opened but for the operation of the timing relays 515 and 516, which is as follows: Upon the first energization of relay 508, a circuit is closed from ground, winding of relay 512, conductor 511, front contact and inner right-hand armature of relay 508, armature and back contact of magnet 514, right-hand armature and back contact of relay 515, winding of relay 516 to battery and ground. Relay 516 becomes energized in this circuit and establishes a circuit from the ground on conductor 511, through the front contact and inner right-hand armature of relay 508, conductor 529, the right-hand armature and back contact of relay 510, the left-hand armature and front contact of relay 516, the left-hand winding of relay 515 to battery and ground. Relay 515 now becomes energized and opens the original energizing circuit of relay 516, at the same time locking up through its right-hand winding, its front contact and right-hand armature to the ground which caused the original energization of relay 516. Relay 516 is now deenergized and after a short interval retracts its armatures.

Under ordinary conditions relay 510 will have become energized and relay 508 will have become deenergized before relay 516 retracts its armatures and, therefore, the ground connection between conductor 511 and conductor 529 which was originally established over the front contact and inner right-hand armature of relay 508 is main-

tained over the front contact and right-hand armature of slow-to-release relay 516 until this relay becomes deenergized. When relay 516 retracts its armatures, therefore, ground is removed entirely from conductor 529 resulting in the deenergization of relays 510 and 521 and the deenergization of trunk bar magnet 519. Trunk bar magnet 519 returns the trunk bar 523 to normal position leaving only the contacts corresponding to the line bar 522 in operated position. The deenergization of relay 510 opens the original energizing circuit of magnet 514 and this magnet becomes deenergized and thereupon moves the wiper 517 on to its next contact.

Relays 515 and 516 also operate under abnormal conditions upon the failure of a trunk bar to operate to move the wiper 517 forward to pick out an operative trunk. Under such abnormal conditions relay 510 will fail to operate so that upon the deenergization of relay 516, a circuit is established from the ground on conductor 511, the front contact and inner right-hand armature of relay 508, conductor 529, right-hand armature and back contact of relay 510, left-hand armature and back contact of relay 516, front contact and left-hand armature of relay 515, winding of magnet 514 to battery and ground. This circuit is closed only for an instant directly upon the deenergization of relay 516, for upon the energization of magnet 514 the holding circuit of relay 515 is opened and this relay becoming deenergized opens the circuit of magnet 514 thus causing the preference switch wiper 517 to be stepped forward on to its next contact. In this manner wiper 517 will advance step by step until the calling line is properly extended as hereinbefore described.

Upon the energization of line bar magnet 501 and the consequent operation of line bar 522, relay 518 is energized as described and through its front contact and right-hand armature it extends the ground for energizing line bar magnet 501, over the third conductor of the outgoing trunk to the secondary line switch shown in Fig. 6. Here this ground is extended through the back contact and inner left-hand armature of line bar magnet 601, through the left-hand high resistance winding of line relay 604, to battery and ground. Relay 604 becomes energized in this circuit and extends a ground from the armature and back contact of relay 626, conductor 627, back contact and outer right-hand armature of relay 628, the outer left-hand armature and front contact of line relay 604 to the third conductor of the trunk. Thus, at the instant that connection is made between the corresponding contacts of line bar 522 and trunk bar 523, relay 518 is energized, line relay 604 becomes energized and line relay 604 immediately extends a ground back toward the primary line switch to hold relay 518 energized.

Upon the energization of line relay 604, a circuit is established from battery through the left-hand low resistance winding of line bar magnet 601, the right-hand low resistance winding of line relay 604, the front contact and right-hand armature of line relay 604, the back contact and right-hand armature of line relay 605, the left-hand armature and back contact of group relay 606, winding of group relay 607 to ground. Relay 607 becomes energized in this circuit, but its resistance is such that it prevents the energization of line bar magnet 601 at this instant. Relay 607 in energizing establishes a circuit from battery, the left-hand winding of group relay 606, the front contact and armature of relay 607, the back contact and left-hand armature of starter relay 608, the back contact and outer left-hand armature of relay 621, the back contact and outer left-hand armature of relay 609, conductor 611, winding of alarm relay 612 to ground. Alarm relay 612 becomes energized in this circuit and extends a ground to an alarm circuit in the same manner as relay 512 in the primary master switch. Group relay 606 also becomes energized in this circuit and opens the original energizing circuit of relay 607, but before this relay can become deenergized and open the circuit for relay 612 a substitute circuit is closed from battery through the right-hand winding of relay 606, front contact and right-hand armature of relay 606, winding of starter relay 608, and thence over the circuit described to the ground on conductor 611. Relay 608 becomes energized in this circuit and extends ground through the winding of relay 612, conductor 611, outer left-hand armature and back contact of relay 609, outer left-hand armature and back contact of relay 621, left-hand armature and front contact of relay 608, conductor 629, left-hand armature and back contact of relay 610, outer right-hand armature and back contact of relay 609, preference switch wiper 617, left-hand armature and back contact of relay 618, winding of trunk bar magnet 619 to battery and ground. The trunk bar 623 is thereby actuated. At the same time trunk bar magnet 619 extends the ground which caused its energization over its inner left-hand armature and front contact to conductor 620, whence it is extended to the winding of relay 610, but this relay having its other terminal connected to ground on conductor 611, is short-circuited at this time and does not become energized.

Trunk bar magnet 619 in operating extends ground through its outer left-hand armature and front contact to conductor

630 which is now extended over conductor 730, through the left-hand winding of relay 700 to battery and ground. Relay 700 becomes energized and through its left-hand armature places a ground on conductor 731, which is the third conductor of the outgoing trunk connected to trunk bar 623 and this is extended through conductor 631 to the winding of advance relay 618, and thence to battery and ground. Relay 618 becomes energized in this circuit and opens the original energizing circuit of magnet 619. This removes the ground from one terminal of relay 610, and consequently, relay 610 now becomes energized in a circuit from battery, the winding of trunk bar magnet 619, the inner left-hand armature and front contact of magnet 619, conductor 620, winding of relay 610, conductor 629, front contact and left-hand armature of relay 608, back contacts and outer left-hand armatures of relays 621 and 609, conductor 611, winding of relay 612 to ground. Relay 610, therefore, becomes energized and establishes a circuit from battery through the left-hand low resistance winding of line bar magnet 601, right-hand low resistance winding of line relay 604, front contact and right-hand armature of relay 604, the back contact and right-hand armature of line relay 605, the left-hand armature and front contact of group relay 606, back contact and right-hand armature of relay 621, front contact and right-hand armature of relay 610, conductor 611, winding of relay 612 to ground. Line bar magnet 601 thereby becomes energized and connection is made between the corresponding contacts of line bar 622 and trunk bar 623. The ground on conductor 631 is now extended through the corresponding contacts of the trunk bar 623 and line bar 622, the right-hand high resistance winding of line bar magnet 601, the left-hand low resistance winding of this magnet to battery and ground. It should be noted that a direct ground placed on the free terminal of this line bar magnet does not cause sufficient current to flow to energize this magnet, but will provide sufficient current to maintain this magnet energized after it has once attracted its armatures. The energization of relay 610 establishes a circuit from ground, winding of relay 612, conductor 611, outer left-hand armatures and back contacts of relays 609 and 621, the left-hand armature and front contact of relay 608, conductor 629, left-hand armature and front contact of relay 610, winding of stepping magnet 614 to battery and ground. Stepping magnet 614 is energized and prepares to move wipers 617 and 632 forward.

The energization of line bar magnet 601 closes a circuit from ground, outer left-hand armature and front contact of magnet 601, front contact and inner left-hand armature of line relay 604, winding of relay 621 to battery and ground. This circuit is established only momentarily for upon the energization of line bar magnet 601, the original energizing circuit of line relay 604 is opened at the inner left-hand armature and back contact of magnet 601 and the holding circuit of relay 604 including the right-hand low resistance winding of this relay is broken shortly thereafter. Relay 621 becomes energized in this circuit and locks up to the ground on conductor 611 extending through the right-hand armature and front contact of relay 610. The energization of relay 621 opens the original energizing circuit of relay 608, but this relay is maintained energized until relay 616 becomes deenergized. The maintaining circuit just spoken of may be traced from ground on conductor 611, through the right-hand armature and front contact of relay 616, the front contact and left-hand armature of relay 608, winding of relay 608 and the right-hand winding of relay 606 to battery. The circuit for relay 616 is closed upon the first energization of relay 608 through the establishment of a circuit from ground, winding of relay 612, conductor 611, the outer left-hand armatures and back contacts of relays 609 and 621, the left-hand armature and front contact of relay 608, the armature and back contact of magnet 614, the right-hand armature and back contact of relay 615, winding of slow-to-release relay 616 to battery and ground. Relay 616 becoming energized establishes a circuit for the energization of relay 615 from the ground on conductor 611, the outer left-hand armature and back contacts of relays 609 and 621, the left-hand armature and front contact of relay 608, conductor 629, the left-hand armature and back contact of relay 610, the left-hand armature and front contact of relay 616, the left-hand winding of relay 615 to battery and ground. Relay 615 now becomes energized and opens the circuit for relay 616 at the same time locking up through its own righthand winding. In a short interval relay 616 becomes deenergized and it being assumed that the operations hereinbefore described have already been completed, now the maintaining circuit for relay 608 is opened and this relay becomes deenergized, whereupon relay 610, magnet 614 and magnet 619 become deenergized. Magnet 614 being deenergized moves brushes 617 and 632 on to their next contacts. Magnet 619 becoming deenergized returns trunk bar 623 to its normal position leaving only the contacts associated with line bar 622 operated.

Under abnormal conditions relays 615 and 616 will operate to step the wipers 617 and 632 forward until an idle trunk has been found.

The deenergization of trunk bar magnet

619 now opens the original energizing circuit of holding relay 700, but this is maintained in a manner which will be hereinafter described.

In Fig. 7 two trunks leading from the secondary line switch of Fig. 6 to the district selector of Fig. 7 are shown, the lower one being shown in full and the upper one being indicated by a broken line rectangle 701 which will include apparatus and circuits corresponding in detail to those included within the larger broken line space below.

As soon as the calling line is extended through the secondary line switch to the tip and ring conductors leading to Fig. 7, a circuit is established from battery through the left-hand high resistance winding of line relay 905 (Fig. 9), inner left-hand armature of line bar magnet 901, conductors 950 and 750, back contact and outer lower armature of relay 702, over the ring conductor of the calling line, through the loop of the calling line, tip conductor of the calling line, the upper armature and back contact of relay 702, conductors 751 and 951, back contact and outer left-hand armature of line bar magnet 901 to ground. Line relay 905 is energized in this circuit and thereby completes a circuit from battery through the right-hand low resistance winding of line bar magnet 901, right-hand low resistance winding of line relay 905, front contact and right-hand armature of line relay 905, left-hand armature and back contact of group relay 906, winding of group relay 907 to ground. Relay 907 becomes energized in this circuit but its resistance is such that it prevents the energization of line bar magnet 901 at this instant.

Relay 907, upon energizing, establishes a circuit from battery, left-hand winding of group relay 906, front contact and armature of relay 907, back contact and left-hand armature of starter relay 908, back contact and left-hand armature of relay 909, conductor 911, winding of alarm relay 912, to ground. Alarm relay 912 becomes energized in this circuit and extends a ground over conductor 913 to an alarm circuit in the same manner as relay 512 in the primary master switch. Group relay 906 also becomes energized in this circuit and opens the original energizing circuit of relay 907, but before this relay can become deenergized and open the circuit for relay 912, a substitute circuit is closed from battery through the right-hand winding of relay 906, front contact and right-hand armature of relay 906, winding of starter relay 908 and thence over the circuit described to the ground on conductor 911. Relay 908 becomes energized in this circuit and extends ground through the winding of relay 912, conductor 911, left-hand armature and back contact of relay 909, left-hand armature and front contact of relay 908, conductor 929, left-hand armature and back contact of relay 910, preference switch wiper 917 and its second contact, outer left-hand armature and back contact of relay 918, winding of trunk bar magnet 919 to battery and ground. The trunk bar 923 is thereby actuated. At the same time trunk bar magnet 919 extends the ground which caused its energization over its inner-left-hand armature and front contact to conductor 920, whence it is extended through the winding of relay 910, conductor 929, front contact and left-hand armature of relay 908, back contact and left-hand armature of relay 909, conductor 911, winding of relay 912 to ground. Thus, relay 910 having ground on each of the terminals of its winding is short-circuited at this time and does not become energized.

Trunk bar magnet 919 in operating extends ground through its outer left-hand armature and front contact to conductor 930 and thence to the winding of relay 918 which becomes energized. Relay 918, upon energizing, extends a ground from its front contact and right-hand armature to conductor 931 which is thereupon extended through the back contact and left-hand armature of relay 1100, back contact, armature and winding of magnet 1101 to battery and ground. Magnet 1101 controls wipers 1102, 1103, 1104, 1105 and 1106 and upon its energization and deenergization in the circuit just described it moves all of them to their first position contacts. Thereupon a circuit is extended from ground, wiper 1102 and its first position contact, winding of relay 1100 to battery and ground. Relay 1100 is energized in this circuit and opens the energizing circuit for magnet 1101. A substitute circuit, however, is now provided for magnet 1101 extending from battery, winding of magnet 1101, armature and back contact of magnet 1101, left-hand armature and front contact of relay 1100, wiper 1105 and its first position contact, back contact and inner left-hand armature of relay 1107 to ground. Thereupon magnet 1101 becomes energized and moves wipers 1102 to 1106, inclusive, forward to their second contacts, whereupon the circuit of magnet 1101 is again opened.

In the meantime, relay 1100 has become locked in a circuit including battery, its winding, its front contact and right-hand armature, conductor 930, front contact and inner left-hand armature of relay 918, conductor 932, wiper 1106 to the ground connection which is multipled to all of its contacts. Relay 918 is also locked up in this circuit.

Upon the energization of relay 918 the original energizing circuit of trunk bar magnet 919 is opened. This removes the ground from one terminal of relay 910 and

consequently relay 910 now becomes energized in a circuit from battery, through the winding of trunk bar magnet 919, inner left-hand armature and front contact of magnet 919, conductor 920, winding of relay 910, conductor 929, front contact and left-hand armature of relay 908, back contact and left-hand armature of relay 909, conductor 911, winding of relay 912 to ground. Relay 910, therefore, becomes energized and establishes a circuit from battery through the right-hand low resistance winding of line bar magnet 901, right-hand low resistance winding of line relay 905, front contact and right-hand armature of relay 905, left-hand armature and front contact of group relay 906, back contact and right-hand armature of relay 909, front contact and right-hand armature of relay 910, conductor 911, winding of relay 912 to ground. Line bar magnet 901 thereby becomes energized and connection is made between the corresponding contacts of line bar 922 and trunk bar 923.

The subscriber's line is now extended through the contacts of line bar 922 and trunk bar 923 corresponding to conductors 950 and 951, respectively, thus extending the calling subscriber's line to the two left-hand armatures of relay 1108 and from thence in the case of the outer left-hand armature of relay 1108, through the back contact and outer right-hand armature of relay 1107, right-hand winding of induction coil 1109 to ground and in the case of the inner left-hand armature of relay 1108 through the normal contacts of the inner right-hand armature of relay 1107, the left-hand winding of line relay 1110, to battery and ground. Relay 1110 is thus brought under direct control of the calling subscriber's line. Upon energizing relay 1110 extends ground through its armature and front contact and the winding of the slow releasing relay 1111 and thence to battery and ground. Relay 1111 becomes energized in this circuit and connects ground through its right-hand armature to conductor 1112.

Conductor 1112 is a holding wire and extends in many directions. The first function of the ground placed on this holding conductor is to extend a ground to conductor 933 and thence through the corresponding contacts of trunk bar 923 and line bar 922 to the left-hand winding of holding relay 700 which maintains ground on the holding wire of the trunk between the secondary line switch of Fig. 6 and the sender selector switch of Fig. 9. This ground is thus extended to the left-hand high resistance winding of line bar magnet 901 thence through the right-hand low resistance winding of this magnet to battery whereby the line bar magnet 901 is maintained energized hereafter. Ground on this conductor is also extended to conductor 930 and thence through the left-hand winding of holding relay 700 which being slow to release, has not up to this instant retracted its armatures. Thus the relay 700 is maintained energized and the connection of ground to the conductor 731 remains continuous.

Ground placed on conductor 1112 is extended to conductor 1312 through the armature and back contact of relay 1300, the winding of relay 1301 to battery and ground and this relay becomes energized. Its function will be explained hereinafter.

Ground placed on conductor 1112 is also extended through the first position contact of the switch controlled by magnet 1113 and thence through wiper 1114 to the winding of relay 1118 and thence to battery and ground. Relay 1118 becomes energized in this circuit and locks to ground on conductor 1112 through its armature and front contact.

The switch controlled by magnet 1113 comprises wipers 1114, 1115, 1116 and 1117, and its function is to measure the time interval which is allowed for the subscriber to begin sending impulses. If the subscriber has seized the sender control circuit of Fig. 11 by energizing relay 1110, and fails to send any impulse until wiper 1117 has rotated from the normal position in which it is shown to its last contact, a circuit is established from ground, armature and back contact of relay 1107, inner right-hand armature and front contact of relay 1118, wiper 1117 and its last position contact, wiper 1103 and its second position contact, winding of relay 1119 to battery and ground. Relay 1119 becomes energized and locks through its front contact and innermost left-hand armature to ground on conductor 1112. The result of the energization of relay 1119 will be explained hereinafter.

The manner in which the time measure switch is controlled by magnet 1113 is as follows: Upon the energization of relay 1118 a ground is extended from the inner left-hand armature and back contact of relay 1107, inner right-hand armature and front contact of relay 1118, wiper 1115 and its first position contact, armature and back contact of magnet 1113, outer right-hand armature and front contact of relay 1118, left-hand armature and back contact of relay 1120, winding of relay 1121 to battery and ground. Relay 1121 becomes energized and extends this same ground through its armature and front contact to the winding of relay 1120 which thereby becomes energized, locks to the ground on its left-hand armature, and opens the circuit for relay 1121. Relay 1121, however, being slow to release does not retract its armature for a definite period of time. When this does happen, however, the ground on the armature of relay 1121 is extended through its back contact and thence through the front

contact and right armature of relay 1120 to the winding of magnet 1113 to battery. Magnet 1113, becoming energized through this circuit, prepares to step the brushes 1114, 1115, 1116 and 1117 on to their second position contacts and at the same time opens the circuit of relay 1120. Relay 1120 becomes deenergized and thereby opens the circuit of magnet 1113. When magnet 1113 restores its armature to normal position it advances the brushes one step and a circuit for relay 1121 is again established whereupon the energization of relay 1121 results in the energization of relay 1120 and this same cycle of operations is repeated and the brushes 1114 to 1117 are stepped forward step by step so that at the end of a definite period of time the brush 1117 will arrive at its last contact.

If, after the brushes 1114 to 1117 are stepped off their normal contacts, the calling subscriber should abandon the connection and by releasing relay 1110 thereby release relay 1111 and remove the ground from conductor 1112, relay 1118 would retract its armatures. In this case, however, a ground is extended over the inner right-hand armature and back contact of relay 1118, wiper 1116 and the contact on which it rests, thence through the armature and back contact of magnet 1113, the outer right-hand armature and back contact of relay 1118, winding of magnet 1113 to battery and ground. Thus, the magnet 1113 being included in a self-interrupting circuit will quickly step the brushes 1114 to 1117 inclusive forward until the normal position is reached, whereupon this circuit is broken at wiper 1116.

It should be noted here that the calling subscriber's line is connected on the one hand through the left-hand winding of line relay 1110, and on the other hand through the right-hand winding of coil 1109. The other winding of coil 1109 is included in a circuit from ground, wiper 1102, left-hand winding of coil 1109, condenser 1170, left-hand armature and back contact of relay 1122, secondary winding of dial tone transformer 1123 to ground. The dial tone is thus induced in the right-hand winding of coil 1109 and thence projected over the calling line to advise the calling subscriber that conditions are now ready for dialing the designation of the called subscriber.

Going back now for an instant over the operation of the sender selector in Fig. 9, it will be noted that upon the energization of the line bar magnet 901, that the corresponding contacts of line bar 922 and 923 become engaged and ground is projected through the appropriate contacts for holding the line bar magnet 901 energized. Upon the energization of relay 910 which establishes the energizing circuit for line bar magnet 901, a circuit is established from ground, winding of relay 912, conductor 911, back contact and left-hand armature of relay 909, left-hand armature and front contact of relay 908, conductor 929, left-hand armature and front contact of relay 910, winding of stepping magnet 914 to battery and ground. Stepping magnet 914 is energized and prepares to move wiper 917 forward.

The energization of trunk bar magnet 901 now closes a circuit from ground, outer left-hand armature and front contact of trunk bar magnet 901, front contact and left-hand armature of line relay 905, winding of relay 909 to battery and ground. Relay 909 becomes energized in this circuit and locks up through its right-hand armature and front contact and the right-hand armature and front contact of relay 910 to ground on conductor 911. By attracting its armature relay 909 thus opens the original circuit for the energization of relay 908, but this relay is now maintained energized through the right-hand armature and front contact of relay 916. In the manner hereinbefore described it will be noted that upon the first energization of relay 908 a circuit is closed from ground through the winding of relay 912, conductor 911, the left-hand armature and back contact of relay 909, the left-hand armature and front contact of relay 908, conductor 929, the left-hand armature and back contact of relay 910, the armature and back contact of magnet 914, the right-hand armature and back contact of relay 915, the winding of relay 916 to battery and ground. Relay 916 becomes energized and in attracting its armature connects ground from conductor 911, through its left-hand armature and front contact to the left-hand winding of relay 915 which now becomes energized and opens the energizing circuit for relay 916 at the same time locking up through its right-hand winding and its front contact and right-hand armature to the ground which originally caused the energization of relay 916. After a short interval relay 916 retracts its armatures and the circuit movement heretofore described having now taken place the holding circuit of relay 908 and group relay 906 is now opened. Ground being removed from conductor 929 allows relay 910 and magnets 914 and 919 to become deenergized. Magnet 914 in retracting its armatures moves the preference switch wiper 917 forward to its next position. Magnet 919 becoming deenergized returns trunk bar 923 to normal position leaving only the contacts corresponding to line bar 922 in operative position.

Under abnormal conditions the timing relays 915 and 916 operate to move the wiper 917 forward in a manner similar to that heretofore described.

The connection is now in a stable condition awaiting the sending of impulses by the calling subscriber.

Permanent signal.

When the calling subscriber seizes the sender control circuit of Fig. 11 in the manner described and fails to send any impulses until the time measure switch, controlled by magnet 1113 has moved to its last position, then relay 1119 is energized, as heretofore described. This results in switching the calling line to a special operator's position whose duty it is to ascertain the cause of the delay and to report trouble if this proves to be the case. The first result of the energization of relay 1119 is the connection of ground from conductor 1112 through the outer left-hand armature and front contact of relay 1119, winding of relay 1124 to battery, whereupon relay 1124 becomes energized. This relay extends ground from conductor 1112 through its outer right-hand armature and front contact, the outer right-hand armature and back contact of relay 1125, conductor 1126, conductor 1326, conductor 1426, winding of relay 1400 to battery. Relay 1400 is energized in this circuit with the following results: A circuit is completed from battery, left-hand winding of relay 1401, front contact and armature of relay 1400, first contact and wiper 1403, back contact and left-hand armature of relay 1405, back contact and inner left-hand armature of relay 1406, armature and back contact of relay 1407 to ground. Relay 1401 is energized in this circuit and thereupon locks up in a circuit from battery, the right-hand winding of relay 1401, front contact and inner right-hand armature of relay 1401, first contact and wiper 1402, winding of relay 1405, back contact and inner left-hand armature of relay 1406, armature and back contact of relay 1407 to ground. Relay 1405 now becomes energized in this circuit. At this stage, a ground is projected from the inner right-hand armature and front contact of relay 1405, outer right-hand armature and front contact of relay 1401, winding of magnet 1408 to battery and ground. Magnet 1408 becomes energized in this circuit and actuates the multiple contacts shown diagrammatically above it. A ground is also extended from the outer right-hand armature and front contact of relay 1405, the inner left-hand armature and back contact of relay 1409, winding of relay 1410 to battery and ground. Relay 1410 becomes energized in this circuit. Relay 1405 also closes a circuit from ground, armature and back contact of relay 1407, inner left-hand armature and back contact of relay 1406, left-hand armature and front contact of relay 1405, winding of magnet 1411 to battery and ground. Magnet 1411 controls the three wipers 1402, 1403 and 1404 and upon its energization prepares to move them one step forward.

The energization of relay 1410 closes a circuit from ground, right-hand armature and front contact of relay 1410, conductor 1412, conductor 1212, conductor 1012, normal contacts of the left-hand armature of relay 1000, conductor 1013, conductor 1213, conductor 1413, corresponding contacts of the multi-contact relay controlled by magnet 1408, conductor 1427, conductor 1327, conductor 1127, back contact and left-hand armature of relay 1125, conductor 1174, conductor 974, corresponding contacts of line bar 922 and trunk bar 923, conductor 935, conductor 735, outer left-hand armature and back contact of relay 703, winding of trunk bar magnet 704 to battery. Trunk bar magnet 704 becomes energized in this circuit and upon its energization, extends ground from its outer right-hand armature and front contact to conductor 745, conductor 845, conductor 1045, winding of magnet 1001 to battery and ground. Magnet 1001 controls a multi-contact device shown diagrammatically above it and in the circuit just described, it becomes energized and actuates these contacts. Magnet 1001 closes a circuit from ground, its lower armature and front contact, winding of relay 1000 to battery and ground. Relay 1000 becomes energized and extends the ground from conductor 1012 through the alternate contacts of its left-hand armature through the corresponding contacts controlled by magnet 1001 to conductor 1046, and thence over conductor 846, conductor 746, the right-hand winding of relay 703, the inner right-hand armature and front contact of magnet 704, winding of magnet 704 to battery. The ground which was extended to this magnet to cause its energization is disconnected upon the establishment of the circuit just described through the movement of the left-hand armature of relay 1000. Relay 703 becomes energized in this circuit and opens the original energizing circuit of magnet 704 but this magnet now remains energized in series with the right-hand winding of relay 703 and the ground extended thereto from conductor 1012.

Upon the energization of relay 1119 a circuit is also established from ground, the normal contacts and the right-hand armature of relay 1128, wiper 1130 and its normal contact, conductor 1136, conductor 1336, conductor 1536, conductor 1636, wiper 1604 and its normal contact, conductor 1637, conductor 1537, conductor 1337, conductor 1137, front contact and right-hand armature of relay 1119, conductor 1138, conductor 1338, conductor 1438, corresponding contacts of the multiple contact arrangement controlled by magnet 1408, conductor 1414, conductor

1214, conductor 1014, winding of relay 1002 to battery and ground. Relay 1002 becomes energized in this circuit and extends ground from conductor 1012 through the front contact and right-hand armature of relay 1000, the right-hand armature and front contact of relay 1002, corresponding contacts of the multiple contact device controlled by magnet 1001, and thence to a conductor performing the same functions as conductor 726.

The conductor grounded by the permanent signal relay 1002 and which corresponds to conductor 726 is not shown on Fig. 7 on account of lack of space. Instead we will describe the results of grounding conductor 726, as these results will be exactly the same with one exception that a different trunk outgoing from the district selector of Fig. 7 will be selected.

Upon the grounding of conductor 726 a circuit is completed from ground, over conductor 726, the right-hand armature and back contact of relay 712, winding of magnet 713 to battery. Magnet 713 becomes energized and actuates the line bar 714 which thereupon engages the corresponding contacts of trunk bar 710 and extends the talking conductors to the non-numerical switch of Fig. 8. The ground on conductor 731 is now extended through the corresponding contacts of trunk bar 710, line bar 714, through the right-hand winding of relay 712, winding of magnet 713 to battery and ground. When in a short interval the ground is removed from conductor 726, relay 712 becomes energized and the energization of magnet 713 is maintained over the connection from conductor 731.

Let us now go back for a moment to the operations taking place in the marker in Fig. 14. Upon the energization of magnet 1408 the operations above described were initiated and the circuit movement was completed during the operation of this magnet. Simultaneously with the operation of magnet 1408 relay 1410 is energized as hereinbefore described. This results in the establishment of a circuit from ground through the left-hand armature of relay 1410, right-hand armature and back contact of relay 1415, winding of relay 1416 to battery and ground. Relay 1416 becomes energized and extends ground from its front contact and armature to the winding of relay 1417. Relay 1417 in turn becomes energized and extends the ground from its armature and front contact to the winding of relay 1415. Relay 1415 becomes energized and locks to the ground supplied from the left-hand armature and front contact of relay 1410, whereupon the circuit for the energization of relay 1416 is opened and this relay retracts its armature after a short interval. This results in the deenergization of relay 1417 which being also a slow-to-release relay consumes a definite time before it retracts its armature. Upon the retraction of its armature a circuit is closed from ground, armature and back contact of relay 1417, front contact and left-hand armature of relay 1415, winding of relay 1409 to battery and ground. Relay 1409 becomes energized and opens the original energizing circuit of relay 1410, but this latter relay being slow to release does not immediately retract its armatures.

In the meantime a circuit is established from ground through the right-hand armature and front contact of relay 1409, conductor 1418, corresponding contacts of the multicontact device controlled by magnet 1408, conductor 1439, conductor 1339, conductor 1139, winding of relay 1125 to battery and ground. Relay 1125 becomes energized in this circuit and locks through its front contact and inner right-hand armature to ground on conductor 1112, thus opening the circuit of relay 1400 which thereupon becomes deenergized.

Upon the energization of relay 1410 ground is extended over conductor 1419, conductor 1219, and thence in series through the inner right-hand armature and back contacts of relays 1200 to 1203, inclusive, conductor 1205, conductor 1005, winding of relay 1003, to battery and ground. The ground on conductor 1419 is also extended over conductor 1219, conductor 1019, winding of relay 1004 to battery and ground, and relays 1003 and 1004 now become energized. Thereupon ground on conductor 1012 is extended through the front contact and right-hand armature of relay 1000, the left-hand armature and front contact of relay 1003, conductor 1006, front contact and corresponding left-hand armature of relay 1004, conductor 1020, conductor 1220, conductor 1420, corresponding contacts of the multicontact device controlled by magnet 1408, conductor 1440, conductor 1340, conductor 1140, winding of relay 1141 to battery and ground.

The energization of relay 1125 which is known as the marker release relay signifies the fact that the marker has performed all of its functions and is now being released from further use in the present connection. The deenergization of relay 1410 removes ground from conductor 1412 which means the removal of ground from conductor 1046, thereby causing trunk bar magnet 704 to become deenergized so that the trunk bar 710 returns to normal leaving only the contacts associated with line bar 714 in operative position. The current flowing through the right-hand winding of relay 703 is now cut off, but this relay remains energized in a circuit including battery, the left-hand winding of relay 703, front contact and

inner left-hand armature of relay 703 to ground on conductor 730. The deenergization of magnet 704 results in the removal of ground from conductor 745 whereupon magnet 1001 becomes deenergized and this is followed by the deenergization of relay 1000. Relays 1002 and 1003 become deenergized upon the deenergization of relay 1410 so that all apparatus in the district translator, the office code translator and the marker in Figs. 10, 12 and 14, respectively, are returned to normal.

It will be noted that both relays 1125 and 1141 which depend for their energization upon the circuit movement in the district translator now remain energized through virtue of locking circuits including their front contacts and inner right-hand armatures to the ground on conductor 1112. The energization of these two relays establishes a circuit from ground on conductor 1112, the outer right-hand armature and front contact of relay 1124, the outer right-hand armature and front contact of relay 1125, the outer right-hand armature and front contact of relay 1141, winding of relay 1108 to battery and ground, whereupon relay 1108 becomes energized and locks up in a circuit from battery, its winding, its front contact and inner right-hand armature, conductor 930, front contact and inner left-hand armature of relay 918, conductor 932, wiper 1106 and thence to ground.

Relay 1108 is known as the sender release relay and its function is to cause the release of all of the common apparatus now associated with the calling subscriber's line. Through the actuation of its left-hand armatures relay 1108 removes the relay 1110 from control by the calling subscriber's line, whereupon this line relay 1110 becomes deenergized and allows the holding relay 1111 to retract its armatures. However, relay 1111 is slow to release, and, therefore, the ground on conductor 1112 is maintained for a short period of time after relay 1108 has become energized. During this period a ground connection is established from the outer right-hand armature and front contact of relay 1108, front contact and left-hand armature of relay 1125, conductor 1174, conductor 974, corresponding contacts of trunk bar 923 and line bar 922, conductor 935, conductor 735, outer left-hand armature and front contact of relay 703 and thence in parallel through the windings of relays 702 and 705 to battery. Relays 702 and 705 become energized in this circuit and relay 702 extends the talking conductors of the calling subscriber's line to the armatures of relay 706.

At the same time a circuit is established from ground on conductor 1112, the left-hand armature and front contact of relay 1141, conductor 1165, conductor 965, corresponding contacts of trunk bar 923 and line bar 922, conductor 963, conductor 763, outer right-hand armature and front contact of relay 705, winding of relay 706 to battery and ground. Relay 706 becomes energized and locks up through its front contact and inner lower armature to the ground on conductor 731. This relay switches the talking conductors of the calling subscriber's line past the repeating coil 707 and through the back contacts of relay 709 to the talking conductors leading to the operator's trunk. The energization of relay 706 prevents the energization of relay 709 so that relay 706 acts as a means to remove the repeating coil entirely from the circuit when this class of connection is established.

When after a short interval relay 1111 becomes deenergized and removes ground from conductor 1112 the ground on conductor 933 for holding line bar magnet 901 actuated is disconnected and this magnet returns to normal, thereby releasing the sender selector. At the same time this removes the ground from the left-hand winding of the holding relay 700 and this relay becomes deenergized to remove ground from conductor 731. However, since this connection has by this time been extended in a manner to be described hereinafter from the non-numerical switch of Fig. 8 to an operator's position, a ground will be returned over the third conductor from that point to substitute for the ground just removed from conductor 731.

It might be appropriate at this point to mention the fact that two different supervisory circuits are provided in the district selector of Fig. 7. It will be noticed that normally the polarized relay 715 is in circuit with the called end of the line. This polarized relay functions as a supervisory relay when supervision is accomplished through the method of reversing the line.

Under other conditions relay 717 is energized to substitute an ordinary supervisory relay 718 for the polarized relay 715. Such relay 718 is marginal, not responding to very weak currents, but attracting its armature when energized by a strong current. Relay 717 may be energized through an appropriate class indication made in the district translator and communicated to the sender where a relay similar in function to relay 1141 will be energized to ground conductor 750 at the outer left-hand armature of relay 1108. Since the invention in the present case does not consist of this particular feature, it will not be more fully described at the present time.

Going back for a moment to describe a little more fully the release of the marker, we find that when relay 1410 becomes deenergized due to the energization of relay 1409 as hereinbefore described, a circuit is

established from ground, right-hand armature and back contact of relay 1410, the front contact and outer left-hand armature of relay 1409, winding of relay 1406 to battery and ground. Relay 1406 becomes energized and opens the circuit of relays 1401, 1405 and magnet 1411. Upon the deenergization of magnet 1411 the wipers 1402, 1403 and 1404 are stepped forward to their second positions. The energization of relay 1406 also causes the energization of relay 1407 and this relay becoming energized removes ground from the inner right-hand armature of relay 1406 so that upon the deenergization of relay 1409, relay 1406 will become deenergized and its locking circuit will be maintained open for a sufficient time to prevent it becoming energized again. Thus the relays of the marker go through a complete cycle of operations and the marker magnet 1408 becomes deenergized after having attracted its armatures for a definite period of time which is sufficient to insure the proper operation of the circuits controlled thereby.

Upon the energization of relay 1108 described hereinbefore, the calling subscriber's line is removed from the control of relay 1110 in the sender control circuit. When this relay becomes deenergized it results in the deenergization of the holding relay 1111. Relay 1111 becoming deenergized removes the ground from conductor 1112 thereby depriving magnet 901 of its energizing circuit whereupon it becomes deenergized and disconnects the sender from the calling line.

When relay 1410 becomes deenergized as hereinbefore described relays 1002, 1003 and 1004 become deenergized and thereby remove ground from conductor 1011. The deenergization of relay 1410 also removes ground from conductor 1046 so that the locking circuit of magnet 704 is now opened and this magnet retracts its armatures and returns trunk bar 710 to its normal position leaving only the contacts corresponding to the line bar in an actuated position. The deenergization of magnet 704 also removes ground from conductor 745 which results in the deenergization of magnet 1001 and this in turn results in the deenergization of relay 1000 so that now all of the apparatus in the figures below Figs. 7 and 8 is returned to normal.

The ground on conductor 731 being extended through the corresponding contacts of trunk bar 710 and line bar 714 is now connected through the two windings of line bar magnet 801 in series. This magnet controls a set of armatures here shown to the left which become attracted on a slight energization of the magnet and another set of armatures shown here on the right which move with the line bar 822 and require a much greater energization. Thus the ground extending through the two windings of magnet 801 in series causes only sufficient current to flow to attract the left-hand armatures of this magnet so that now a circuit is established from battery, the right-hand low resistance winding of magnet 801, the inner right-hand armature and back contact of magnet 801, the front contact and outer left-hand armature of magnet 801, the back contact and outer left-hand armature of magnet 851, left-hand armature and back contact of relay 806, winding of relay 807 to ground. Relay 807 becomes energized in this circuit but does not cause sufficient current to flow in the right-hand winding of magnet 801 to cause the energization of this latter magnet. The energization of relay 807, however, results in the energization of relay 806 in a circuit extending from battery, the left-hand winding of relay 806, the front contact and armature of relay 807, the back contact and left-hand armature of relay 808, back contact and left-hand armature of relay 809, conductor 811, winding of relay 812 to ground, relay 812 becomes energized in this circuit and extends ground to conductor 813 which leads, as in cases heretofore explained, to an alarm circuit. Relay 806 is energized in this circuit and thereby opens the energizing circuit of relay 807, which in turn becomes deenergized and opens the circuit just traced, but before this circuit can be effectively disturbed, relay 806 becomes locked in a new circuit from battery, the right-hand winding of relay 806, the front contact and right-hand armature of relay 806, winding of relay 808, back contact and left-hand armature of relay 809, to the ground on conductor 811. Relay 808 becomes energized in the locking circuit for relay 806 and thereupon extends a ground from conductor 811 over the back contact and left-hand armature of relay 809, left-hand armature and front contact of relay 808, the left-hand armature and back contact of relay 810, preference switch wiper 817, left-hand armature and back contact of relay 818, winding of trunk bar magnet 819 to battery and ground. Trunk bar magnet 819 becomes energized and actuates the trunk bar 823. This magnet also extends the ground which was instrumental in its energization through its inner left-hand armature and front contact to conductor 820 and thence to the winding of relay 810, but this relay having ground to its other terminal at this time does not become energized. Magnet 819 also extends a ground from its outer left-hand armature and front contact to the winding of relay 818 which thereupon becomes energized and removes the ground connection from the winding of magnet 819, but magnet 819 remains energized in series with relay 810 which now becomes ener-

gized. Thereupon a circuit is established from ground, winding of relay 812, conductor 811, front contact and right-hand armature of relay 810, right-hand armature and back contact of relay 809, winding of relay 824, front contact and left-hand armature of relay 806, outer left-hand armature and back contact of magnet 851, outer left-hand armature and front contact of magnet 801, back contact and inner right-hand armature of magnet 801, right-hand low resistance of magnet 801 to battery and ground. Resistance of relays 812 and 824 is low enough to permit sufficient current to flow in this circuit to cause the energization of magnet 801 which thereupon actuates line bar 822 and extends the talking conductors through the corresponding contacts of line bar 822 and trunk bar 823. Relay 824 becomes energized in this circuit and locks up through its right-hand armature and front contact to the ground on conductor 811. It also extends the ground on conductor 811 to the winding of relay 809 which now becomes energized and opens the original energizing circuit of relay 824. Upon the energization of relay 810 a circuit is established from ground, left-hand armature and back contact of relay 809, left-hand armature and front contact of relay 808, left-hand armature and front contact of relay 810, winding of magnet 814 to battery and ground. Magnet 814 prepares to move preference switch wiper 817 forward. Now upon the energization of line bar magnet 801 the energizing circuit of relay 824 is opened and this relay becomes deenergized and relay 809 being held in a locking circuit ground would be removed from the left-hand armature of relay 808 were it not for the operation of the timing relay 816. It will be noted that in a manner similar to that heretofore described relay 816 is energized at the same time that ground is extended over preference switch wiper 817. This ground connection is extended through the armature and back contact of magnet 814, the right-hand armature and back contact of relay 815, winding of relay 816 to battery and ground. Relay 816 becomes energized in this circuit and establishes a connection from ground on conductor 811, through its front contacts and two armatures to the left-hand winding of relay 815 which now becomes energized. Relay 815 opens the original energizing circuit of relay 816 and at the same time locks up through its right-hand winding, its front contact and right-hand armature to the ground which caused the energization of relay 816. In an appropriate interval during which the circuit movement heretofore described takes place, relay 816 becomes deenergized and at this time ground is removed from the front contact and left-hand armature of relay 808, whereupon relay 808 and relay 806 become deenergized. The deenergization of relay 808 caused by the removal of ground from the conductor 829 allows relay 810 and magnet 819 in series therewith to become deenergized. Magnet 819 returns the trunk bar 823 to normal position leaving only the contacts corresponding to line bar 822 in operative position. The deenergization of relay 810 also opens the circuit of magnet 814 which now moves the preference switch wiper 817 forward.

Under abnormal conditions the timing relays 815 and 816 will operate in a similar manner to the corresponding relays heretofore described.

The calling subscriber's line is now extended to the conductors connected to trunk bar 823 which extend to a special operator's position (not shown), but well known in the art. The operator will be called in the usual manner and will investigate the reason for the extension of this call to her position.

If the trouble is merely caused by the failure of the calling subscriber to manipulate his dial the operator will advise the calling subscriber to hang up his receiver and initiate a new call. If the trouble is caused by a short circuit of the calling line an attendant will be summoned who will open the calling line by actually opening the conductors 502 and 503 as they pass through what is known as the main distributing frame. This is done in order to restore the primary and secondary line switches appropriated by a calling line until the trouble can be remedied. Upon the hanging up of the receiver of the calling station or the opening of the line as described the supervisory relay in the operator's cord circuit becomes deenergized and the operator disconnects and thereby removes the holding ground from conductor 731, whereupon all relays and magnets depending upon this ground for their energization become deenergized and the entire connection is restored to normal.

Special conditions.

We are now come to a consideration of certain special conditions resulting from the use of the substation sender. Some of these conditions result from the proper use and some from the improper use of this piece of apparatus and, so, for a clear understanding of these conditions, the following notes are made in regard to the dial.

The dial used in connection with the present system is illustrated in Fig. 3, section 3 of volume 2, Machine switching equipment notes, copyrighted 1921 by the Western Electric Company. This dial is used to send a variable number of impulses consisting of short interruptions of the calling subscriber's loop circuit. These trains of impulses

vary from 1 to 10 according to the following code:

Dial code.

Impulses.	Digit.	Code letters.
1	1	——
2	2	ABC
3	3	DEF
4	4	GHI
5	5	JKL
6	6	MNO
7	7	PRS
8	8	TUV
9	9	WXY
10	0	Operator.

The special condition created when the calling subscriber fails to dial has just been described under the heading "Permanent signal." The second special condition results from the sending of a single impulse which may be done by the substation sender, or through the improper manipulation of the receiver hook and is known in the telephone art as the

Preliminary impulse.

After the sender is attached to the calling subscriber's line, the receipt of a single impulse will result in the momentary establishment of a circuit from ground, the armature and back contact of relay 1110, the front contact and left-hand armature of relay 1111, winding of relay 1128, wiper 1133 and its first position contact, right-hand armature and back contact of relay 1144, conductor 1145, conductor 1345, conductor 1545, conductor 1645, winding of magnet 1600 to battery and ground, resulting in the energization of this magnet. Upon the energization of relay 1110 the circuit of magnet 1600 is broken and this magnet becoming deenergized, retracts its armatures and moves wipers 1601 to 1606, inclusive, forward on to their first active contacts. The current for energizing magnet 1600 being connected through the winding of relay 1128 causes the energization of this relay, which thereupon closes a circuit from ground, alternate contact and right-hand armature of relay 1128, winding of magnet 1147, winding of relay 1148 to battery and ground. Magnet 1147 and relay 1148 become energized in this circuit and since relay 1128 is slow to release, they remain energized for a short period of time, after relay 1128 and magnet 1600 have become deenergized. During the energization of relay 1148 a circuit is closed from ground, front contact and right-hand armature of relay 1148, third contact and wiper 1105, front contact and left-hand armature of relay 1100, back contact, armature and winding of magnet 1101 to battery and ground, whereby magnet 1101 becoming energized, automatically opens its own circuit, and becomes deenergized to move wipers 1102 to 1106, inclusive, forward on to their fourth contacts.

Upon the retraction of its armature by relay 1128, the original energizing circuit of magnet 1147 and relay 1148 is opened, but due to the fact that only a single impulse has been sent, a substitute circuit is now established from battery and ground, winding of relay 1148, winding of magnet 1147, conductor 1154, conductor 1354, conductor 1554, conductor 1654, first active contact and wiper 1603, conductor 1655, conductor 1555, conductor 1355, conductor 1155, first position contact and wiper 1129, conductor 1149, back contact and outer right-hand armature of relay 1122, conductor 1112, right-hand armature and alternate contact of relay 1111 to ground. Thus, relay 1148 and magnet 1147 are maintained energized and brushes 1129 to 1134, inclusive, and 1135 are prevented from moving off from their first contacts. At the same time a circuit is established from ground, the normal contacts of the right-hand armature of relay 1128, wiper 1130 and its first position contact, conductor 1136, conductor 1336, conductor 1536, conductor 1636, first active contact and wiper 1604, conductor 1656, conductor 1556, conductor 1356, conductor 1156, left-hand winding of relay 1144, back contact and left-hand armature of relay 1128 to battery and ground. Thus, relay 1144 is included in an energizing circuit and attracts its armatures at this time.

If now, the calling subscriber should dial any other number, say, for instance, 5, the first impulse of this new series will be absorbed and the wipers controlled by magnet 1600 will be moved forward four additional steps so that they will come to rest on their fifth active contacts corresponding to the digit 5. The manner in which this first impulse is absorbed is as follows: Upon the retraction of its armature by relay 1110, a circuit is established from ground, the left-hand armature and back contact of relay 1110, the front contact and left-hand armature of relay 1111, winding of relay 1128, wiper 1133 and its first contact, right-hand armature, front contact and right-hand winding of relay 1144, conductor 1157, conductor 1357, conductor 1557, conductor 1657 to battery and ground. Relay 1128 is energized in this circuit and maintains the energization of magnet 1147 and relay 1148, but does not cause the operation of magnet 1600 as heretofore, and because it is connected in series with relay 1144 it maintains this relay energized until the end of this impulse. During the time that current continues to flow through the relay 1128 and the right-hand winding of relay 1144 the energizing circuit including the left-hand winding of relay 1144 is opened and upon the

end of this impulse relays 1128 and 1144 become deenergized. But before relay 1128 can retract its armatures, the second impulse of this series is sent and the connection is transferred by the right-hand armature of relay 1144 to its back contact and thence over conductors 1145, 1345, 1545, 1645, winding of magnet 1600, to battery and ground, causing the further stepping of wipers 1601 to 1606, inclusive.

Should the preliminary impulse described be not followed by another impulse then the time measure switch consisting of magnet 1113 and the wipers 1114 to 1117, inclusive, will be brought into play in the manner heretofore described. Wiper 1117 will be moved forward step by step until it rests on its last contact. At this point the circuit for the magnet 1113 is opened as the wiper 1115 comes to rest on its last contact which is not multipled to the others. However, a substitute circuit is furnished by the connection of ground over wiper 1117 and its last contact, wiper 1103 and its fourth contact, winding of relay 1158 to battery and ground. This relay becomes energized and extends ground from its right-hand armature to the winding of magnet 1101 which now becomes energized. Relay 1158 also extends ground from its left-hand armature to the last position contact on which wiper 1115 now rests. This results in the stepping of brushes 1114 to 1117, inclusive, to their normal positions. The circuit of relay 1158 is therefore, opened and this relay retracts its armatures, thereby opening the circuit of magnet 1101 which steps the brushes 1102 to 1106, inclusive, to their fifth active contacts. The time measure switch controlled by magnet 1113 now goes through another complete cycle of operations resulting in the stepping of brushes 1102 to 1106, inclusive, to their sixth active contacts and these brushes are in this manner stepped forward slowly until they rest on their last contacts, whereupon a circuit is permanently established from ground, the inner left-hand armature and back contact of relay 1107, inner right-hand armature and front contact of relay 1118, wiper 1117 and its last position contact, wiper 1103 and its last active contact, outer left-hand armature and back contact of relay 1107, signal lamp 1160, to battery and ground. This lamp is caused to glow in this circuit and thereby notify the attendant of the fact that trouble has developed,

If the trouble is removed before the time measure switch has resulted in the lighting of lamp 1160 and relay 1110 is permanently deenergized, then relay 1111 will become deenergized and remove ground from conductor 1112, whereupon relay 1118 will become deenergized and cause the time measure switch to quickly assume its normal position. Relay 1111 in retracting its armatures places a ground on conductor 1151 which is extended through conductor 1351, conductor 1551, conductor 1651, wiper 1606, and thence over the multiple contacts with which it is associated through the back contact and armature of magnet 1600, winding of magnet 1600, to battery and ground, thus including magnet 1600 in a self-interrupting circuit, whereby it moves wipers 1601 to 1606, inclusive, forward until they have assumed their normal position.

Thereupon the ground on conductor 1651 is extended through wiper 1607 and its normal contact, wiper 1608 and its normal contact, conductor 1618, conductor 1518, conductor 1318, first position contact and wiper 1302, wiper 1303 and its normal contact, conductor 1304, conductor 1504 and thence through wipers 1505 to 1511, inclusive, and their normal contacts, conductor 1561, conductor 1361, conductor 1161, wiper 1131 and its first position contact, conductor 1162, the multipled contacts associated with wiper 1104, front contact and left-hand armature of relay 1100, back contact, armature and winding of magnet 1101 to battery and ground. Thus magnet 1101 is included in a self-interrupting circuit and thereby automatically returns wipers 1102 to 1106, inclusive, to normal position.

Wiper 1106 having assumed normal position, ground is removed from conductor 932 and relay 918 becomes deenergized. The removal of ground from conductor 1112 results in the removal of ground from conductor 933 which maintained the sender selector line bar magnet 901 energized and this magnet now becomes deenergized and returns the sender selector to normal. The removal of ground from the winding of magnet 901 removes ground from conductor 730 and allows relay 700 to become deenergized, whereupon ground is removed from conductor 731 resulting in the return to normal of the rest of the apparatus held in this connection.

Returning for a moment to a consideration of the dial code, it will be noted that only digits 2 to 9, inclusive, have code letters associated with them. In this system only these digits, therefore, are used in setting up the office codes and the digits 1 and 0 have no place in such designations, except in special instances as will be described hereinafter. Consequently, if the digit 1 or the digit 0 is used in any one of the first three places of a telephone designation, it will result in a special condition. It has just been shown that the digit 1, if dialed in the first place will result in a special condition known as the "preliminary impulse", and that this impulse will be absorbed in the next train of impulses sent, or if not followed up by another series of impulses will cause the light-

ing of signal lamp 1160. As an additional precaution, and assuming what under ordinary conditions is an impossibility, we will assume that the A register controlled by magnet 1600 has been set on its first active contact and that the B and C registers have been set in a proper manner. As will be shown hereafter, at the end of the fourth series of impulses, which is used as the thousands designation, magnet 1400 will become energized. This will result, in the manner hereinbefore described, in the energization of relay 1410 and magnet 1408. Relay 1410 becoming energized extends a ground from its left-hand armature and front contact over conductor 1419 to conductor 1219. In Fig. 12 there are three sets of four relays, one set corresponding to the A register of Fig. 16, another set corresponding to the B register and a third set corresponding to the C register. Each set contains an A, B, C and D relay and the A relay of the A set is designated as AA, the A relay of the B set is designated BA, and the A relay of the C set is designated CA. These relays are energized in the following combinations in response to the setting of the A, B and C registers:

Code.

Digit.	Relay energized.
1	A
2	B
3	A, B
4	C
5	D
6	A, D
7	B, D
8	A, B, D
9	C, D
0	None.

Thus, the A register being set on its first active contact, a circuit will be closed from ground, the left-hand armature and front contact of relay 1410, conductor 1419, corresponding contacts of the device controlled by magnet 1408, conductor 1425, conductor 1625, first active contact and wiper 1601, conductor 1624, conductor 1424, corresponding contacts of the device controlled by magnet 1408, conductor 1425, conductor 1225, winding of relay 1203 to battery and ground, and relay 1203 becomes energized in this circuit. Thus in accordance with the code just given, the A register being set in accordance with the digit 1 causes the energization of the corresponding A relay in the A set of translating relays shown in Fig. 12. The ground on conductor 1219 is now extended through the inner right-hand armatures and back contacts of relays 1200, 1201 and 1202, the inner right-hand armature and front contact of relay 1203, conductor 1214, conductor 1014, winding of relay 1002 to battery and ground, thus energizing the trouble relay. The energization of this relay will result in the extension of the calling subscriber's line to a trouble operator in the same manner as hereinbefore described in connection with the "permanent signal."

The next special condition to be noted is the direct result of the proper operation of the substation sender. In case the calling subscriber is in doubt as to how to reach a particular party, or wants to make some inquiry of what is known as the "information operator," he will dial the digit 0 and his line will be extended to the

Zero operator.

For certain purposes now well known to the telephone companies, it is desirable to have an operator who may answer inquiries even in a full automatic telephone system and for this purpose, provision has been made here to extend a connection to an operator by dialing zero. This means the sending of ten impulses in quick succession and each of short duration. Each impulse of this series results in the momentary deenergization of relay 1110 whereupon a circuit is established from ground, the armature and back contact of relay 1110, the front contact and left-hand armature of relay 1111, winding of relay 1128, wiper 1133 and its first position contact, right-hand armature and back contact of relay 1144, conductor 1145, conductor 1345, conductor 1545, conductor 1645, winding of magnet 1600 to battery and ground. This ground is also extended through the armature and back contact of magnet 1600, thence over conductors 1652, 1552, 1352, first position contact and wiper 1134, winding of relay 1153, left-hand armature and back contact of relay 1144 to battery and ground and results in the energization of relay 1153 which thereupon places ground through its right-hand armature on the winding of relay 1111, and through its left-hand armature on the circuit for operating magnet 1600 to insure the proper operation of magnet 1600. Magnet 1600 becomes energized in this circuit and moves the brushes 1601 to 1606, inclusive, forward one step at the end of each impulse. When magnet 1600 has moved its armatures forward where their proper operation is insured, it opens the circuit of relay 1153 and this relay becomes deenergized. Hereafter only the energizing circuit for the switch stepping magnet will be described as it is thought unnecessary to describe the action of relay 1153 during each impulse.

Relay 1128, in series with this impulse

circuit, becomes energized but being slow to release maintains its armatures attracted throughout the sending of this set of impulses. Through its right-hand armature, relay 1128 connects ground to magnet 1147 and thence through the winding of relay 1148 to battery and ground. Magnet 1147 and relay 1148 are energized in this circuit. Relay 1148 establishes a connection from ground, the front contact and right-hand armature of relay 1148, the second position contact and wiper 1105, front contact and left-hand armature of relay 1100, back contact, armature and winding of magnet 1101 to battery and ground. Magnet 1101 becomes energized and breaking its own circuit automatically deenergizes itself and moves brushes 1102 and 1106, inclusive, to the third positions whereupon the dial tone is disconnected from the calling line by the movement of wiper 1102. The calling subscriber is thereby apprised of the fact that the dial impulses have been received by the sender.

At the end of this series of impulses, relay 1128 retracts its armatures, whereupon magnet 1147 and relay 1148 become deenergized. The deenergization of magnet 1147 results in the movement of wipers 1129 to 1134, inclusive, on to their second position contacts.

At this time a circuit is completed from the ground on conductor 1112 through the outer right-hand armature and back contact of relay 1122, conductor 1149, wiper 1129 and its second position contact, back contact and left-hand armature of relay 1124, conductor 1150, conductor 1350, conductor 1550, conductor 1650, wiper 1605 and its tenth contact, conductor 1646, conductor 1546, conductor 1346, conductor 1146, outer right-hand armature and back contact of relay 1125, conductor 1126, conductor 1326, conductor 1426, winding of relay 1400 to battery and ground. Relay 1400 performs the same function as that heretofore described, causing the energization of magnet 1408 and relay 1410. A circuit is now established from ground, the left-hand armature and front contact of relay 1410, conductor 1419, conductor 1219, and thence over the back contacts and inner right-hand armatures of relays 1200 to 1203, inclusive, conductor 1205, conductor 1005 to the winding of relay 1003 and in multiple therewith from conductor 1219, conductor 1019, winding of relay 1004 to cause the operation of these two relays in the same manner as heretofore described. In this case, however, one difference exists and that is that relay 1002 does not become energized as heretofore described. A ground is now closed from the back contact and left-hand armature of relay 1002, the right-hand armature and front contact of relay 1003 and thence through the corresponding contacts of the multi-contact relay device controlled by magnet 1001 to a conductor similar to conductor 726 but leading to a different group than that grounded by the permanent signal relay 1002. Under certain conditions, these two conductors may be connected together so that the same operator will be called in upon either a permanent signal or the dialing of the zero operator as in the present case.

The operation now is very similar to the operation heretofore described in connection with the permanent signal, that is, the ground connection established by relay 1410 causes the operation of magnet 704 and later on, relays 1141 and 1125 are both energized, resulting in the energization of the sender release relay 1108 and the consequent disconnection of the sender from the calling line.

At this stage, another function is performed which consists in connection of ground to conductor 1151 upon the retraction of its armatures by the holding relay 1111. This ground is extended over conductors 1151, 1351, 1551, wiper 1606, back contact and armature of magnet 1600 to battery and ground. Magnet 1600 is thus included in a self-interrupting circuit and moves the wipers which it controls to their normal position, whereupon this self-interrupting circuit is broken and the connection is thereby entirely returned to normal position.

Another special condition will be encountered when the calling subscriber dials a wrong office code which contains the digit 1 in the second or third place. In case the digit 1 is in the second place, then the BA relay of Fig. 12 will be energized and ground on conductor 1219 will be extended through the inner right-hand armatures and back contacts of relays 1206, 1207 and 1208, and the inner right-hand armature and front contact of relay 1209, through the winding of relay 1210 to battery and ground. Relay 1210 will become energized in this circuit and will extend ground which will be found on conductor 1011 to conductor 1211, right-hand armature and front contact of relay 1210, inner left-hand armature and back contact of relay 1215, conductor 1205, conductor 1005, winding of relay 1003 to battery and ground and thus the call will be routed in the manner hereinbefore described to the zero operator.

Should the digit 1 be found in the third position, that is, registered on the C register, the CA relay will be energized and ground will be extended from conductor 1211 over the inner right-hand armatures and back contacts of relays 1221, 1222, 1223, and the inner right-hand armature and front con-

tact of relay 1224 to the winding of relay 1215, so that this relay becomes operated. Ground is now extended from conductor 1211, the right-hand armature and back contact of relay 1210, the outer left-hand armature and front contact of relay 1215, conductor 1205, conductor 1005, winding of relay 1003 to battery and ground, so that in this case the call is routed to the zero operator.

If the digit 0 is found in the first, second, or third position, or in any combination of these positions, the call will be routed to the zero operator since either one or more of the three sets of translating relays of Fig. 12 will be wholly deenergized and a connection will be made either from conductor 1219 to conductor 1205, or from conductor 1211 to conductor 1205, thus energizing the operator's relay 1003.

Official codes.

One other special condition should be noted at this point. This is the provision for routing calls to the official telephones provided for the use of the employees of the telephone company. Here a special code consisting of any one of the digits 2 to 9, inclusive, in the first place, is used in combination with the digit 1 repeated in the second and third positions. Let us assume for the time being that the code 911 is set up on the A, B and C registers. The A register will have its wipers set on their ninth active contacts and will result according to the translating relay code in the energization of relays C and D of the A set, so that a circuit is closed from ground on conductor 1219 through the back contact and outer left-hand armature of relay 1203, the left-hand armature and front contact of relay 1200, the left-hand armature and front contact of relay 1201, winding of magnet 1216 to battery and ground, causing the energization of magnet 1216. The setting of the B register and C register in accordance with digit 1 will cause the energization of relays 1210 and 1215 as heretofore described, so that a circuit will now be established from the ground on conductor 1211 through the left-hand armature and front contact of relay 1210, the right-hand armature and front contact of relay 1215, conductor 1217, corresponding contacts controlled by magnet 1216, conductor 1218, conductor 1018, and thence into the multi-contact relay device associated with the set of conductors of which conductor 1018 is one. At the same time a circuit is established from the ground on conductor 1211 through the right-hand armature and front contact of relay 1210, the inner left-hand armature and front contact of relay 1215, conductor 1227, conductor 1027, magnet 1028 to battery and ground, whereby the ground extended over conductor 1018 is now connected through the agency of magnet 1028 to a particular set of points in this multi-contact device to cause the extension of the calling line to the official telephone called by this particular code. The manner in which this is done will be fully explained hereinafter in connection with the routing of another call.

Three-digit operator.

This system provides for the routing of still another class of calls to an operator and this condition arises when the calling party attempts to establish a connection to a telephone in a zone for which he would have to pay a greater amount than for ordinary calls. Let us assume that this telephone system is located in New York city and that the calling subscriber attempts to establish a call to the town of Wantagh, Long Island, and that this is outside the metropolitan area. The telephone directory would give the telephone address of the wanted subscriber as, say WANtagh 1234, which would indicate to the calling subscriber that he must dial the three code letters WAN before he dials the number of the particular telephone. According to the dial code given heretofore, he would dial the digits 9, 2, 6 which would result in setting the A register on its ninth active contact, the B register on its second active contact and the C register on its sixth active contact and this would result in routing the call to the three digit operator.

The A register being set on its ninth active contact would result in the energization of the AC and AD relays; the B register being set on its second active contact would result in the energization of the BB relay and the C register being set on its sixth active contact would result in the energization of the CA and CD relays. A circuit will now be established as follows: from ground, on conductor 1219, through the back contact and outer left-hand armature of relay 1203, the left-hand armature and front contact of relay 1200, the left-hand armature and front contact of relay 1201, winding of magnet 1216 to battery and ground. Ground will also be extended over conductor 1219, the inner right-hand armature and back contacts of relays 1206 and 1207, the inner right-hand armature and front contact of relay 1208, the inner left-hand armature and back contact of relay 1209, conductor 1228. Ground will also be extended from conductor 1211, the outer right-hand armature and front contact of relay 1224, the outer right-hand armature and front contact of relay 1221, the outer right-hand armatures and back contacts of relays 1222 and 1223, conductor 1229, conductor 1029,

to the right-hand multi-contact relay device shown in Fig. 10. The energization of magnet 1216 and the grounding of conductor 1228 results in the grounding of conductor 1230. Ground is thereupon extended over conductor 1030 to the winding of magnet 1031 so that this magnet becomes energized and extends the ground connection from conductor 1029 through the same contact controlled by magnet 1001 which was grounded by the relay 1003 heretofore described. The ground on conductor 1029 is also extended through the cross connection indicated to conductor 1033 which is a branch of conductor 1006, and therefore performs the same function that the ground on conductor 1006 performed as heretofore described. Thus the dialing of a code designating an office outside of the metropolitan area will result in the functioning of the apparatus in the same manner as caused by the operator's relay 1003 and the call will be routed to the operator.

Class indications.

Having now described certain special conditions which will occur during the first stages of the connection, it is appropriate to mention certain other conditions which occur at a later stage. It will be noticed that there are ten registers provided for receiving and recording designations sent by the calling station. Three of these registers designated A, B and C, are shown in Fig. 16 and the other seven are shown in Fig. 15. Reading from the right in Fig. 15, these registers are first, the thousands register, second, the hundreds register, third, the tens register, fourth, the units register, and lastly, the three stations registers. In case of a simple party line having four digits and a stations designation, only the first of these stations registers will be used. In case of other party lines, three stations registers will be used. In the regular order, these registers will be set beginning with the A register from Fig. 16 and taking each one in turn toward the left.

The first three registers will record what is known as the office code and, as we have seen heretofore, will respond to the code letters dialed by the calling subscriber in accordance with the name of the office in which the called number is located. The office code will be translated and will cause the setting of the district selector of Fig. 7 to direct the calling line in a particular one of a large plurality of directions. At the same time, a class indication will be sent from the translator in Fig. 10, back to the sender control circuits in Figs. 11 and 13. Here certain relays are operated to perform the following functions.

We have seen in the previous description how the operator's relay 1141 was operated in response to the operator's relay 1003 so that this relay will not at present be described.

In Fig. 13, there are three relays 1305, 1306 and 1307 known as the compensating resistance relays. As will be seen hereinafter, the sender, after causing the district selector of Fig. 7 to extend the connection in a certain direction, will send out a code of impulses over the trunk selected to operate apparatus further on. These impulses are of the type known as relay call indicator impulses and consist in pulses of plus and minus currents of varying strength. Since all trunk lines are not of the same length and therefore not of the same resistance, the marginal relay which must not respond to the weak impulses and must respond to the strong impulses, is adjusted to a line of maximum resistance. Therefore, when a trunk line of less than the maximum resistance is encountered, certain artificial resistances must be introduced into the impulse circuit so that the marginal relay will be properly actuated. These artificial resistances are controlled by the relays 1305, 1306 and 1307. If, for instance, a trunk line is picked which has a minimum resistance, then none of the relays 1305, 1306 and 1307 will be actuated, thus leaving all of the resistance coils shown above these relays in circuit. If a trunk line, which has a definite amount of resistance less than the maximum, is selected then a particular one of these three relays will be actuated and thus short circuit the corresponding resistance coils.

The selection and operation of one or more of these compensating resistance relays is controlled by the cross connection from the translator in Fig. 10 to the class indicator controlled by relay 1004.

After the calling subscriber has sent in the designation of the called line and thereby set the registers shown in Figs. 15 and 16, apparatus shown in Fig. 13 becomes active to send impulses out over the selected trunk. Under certain conditions, no impulses are sent from this point until after all of the registers in Fig. 15 have been set and under other conditions, the sending of impulses will take place after the thousands register has been set. For instance, if the class indicated by the particular code set up on the A, B and C registers points to an office where there are party lines, then it is obviously not possible to begin the sending of the impulses until the stations designation has been received because it is the usual practice to reverse the order of sending, so that where the calling subscriber has registered, the three office code digits, the thousands, hundreds, tens, units and stations digits in order, these designations must be repeated in the order of first, the stations digit, second, the thousands digit, third, the

hundreds digit, fourth, the tens and lastly, the units digit. Therefore, a relay known as the relay call indicator relay and here designated 1159, is provided and may be operated in direct response to the registration of a particular office code. This relay 1159 has its active terminal in one of the armatures of relay 1004, and when it becomes energized, it prevents the starting of the impulse sender at the usual time and does not allow the impulses to go out until after the stations digit has been recorded.

If the office code indicates that the call is local or intra-office then it is obvious that the office code need not be retransmitted and for this purpose a numerical relay, here designated 1313, is provided. This relay causes the impulses sent from the apparatus of Fig. 13 to start directly with the stations digit and follow this with the thousands digit and so on.

In case the office code indicates an interoffice call so that the connection will be routed through a mechanical switching center, sometimes known as a tandem office, then in this system the designations sent in by the calling subscriber will be repeated into apparatus in the mechanical switching center, and later a part of the designation will be again repeated into apparatus at the office containing the called line. Since the stations digit must be received first at the terminating office, it is obvious that if a reversal took place between the calling office and the mechanical switching center and another reversal took place between the mechanical switching center and the terminating office, trouble might develop. To obviate this, a relay, here designated 1310, is provided which may be actuated whenever a call is routed through a mechanical switching center to preserve the original order of recording during the first repetition.

Another class of calls is directed to offices containing more than 10,000 lines, that is offices where a five digit code in certain instances must be used. In this case, a relay 1314 is provided which is responsive to the setting of the thousands register on its first active contact which indicates that a call to the ten thousands group in some office is being registered. In this case, the thousands register becomes the ten thousands register, the hundreds register becomes the thousands register, the tens register becomes the hundreds register, the units register becomes the tens register and the first stations register becomes the units register. In order not to confuse the four-digit numbers beginning with the digit 1 with calls of this particular class, a relay 1311 is provided to render the relay 1314 effective only in certain cases, as indicated by the office code. Thus, relay 1314 is under the direct control of the thousands register but the stations relay 1311 is under the control of the class indicator controlled by relay 1004.

The above class distinctions may be somewhat more apparent from the following list of classes of service which may be provided in this system. The district selector of Fig. 7 is a switching device of large capacity and may direct a call in a large number of different directions. Two directions have been previously noted, that is, the trunks leading to the trouble operator and the trunks leading to the zero and three digit operator. In addition there may be trunks leading to a mechanical switching center where the apparatus will respond to the impulses sent out from the sender in Fig. 13 and where the call will be further extended by means of mechanical switching apparatus. There may be trunks leading to apparatus in the same office so that we have full mechanical operation and the impulses sent out from the sender in Fig. 13 will control apparatus in the same office to automatically extend a connection to the called subscriber's line. There may be trunks leading to a mechanical switching center equipped to take care of four digit numbers only and there may be trunks leading to a mechanical switching center equipped to take care of five digit numerical designations. Other trunks may lead to what is known as a relay call indicator tandem office where the impulses sent out from the sender in Fig. 13 will cause indicating apparatus to indicate the further direction of the call to an operator in the tandem office who will thereupon cooperate in extending the connection to the called party in the terminating office. This particular class of service may be again divided into two classes, one taking care of only four digit numbers and another taking care of five digit numbers. There may be still other trunks leading directly to a relay call indicator office where the impulses sent from the sender in Fig. 13 will cause the indicating apparatus to point out the further direction of the call to an operator who is in the terminating office who will thereupon complete the connection, and again this particular class of service may be provided for either four or five digit offices.

With this brief statement of functions and possibilities, we will not go on to the tracing of a call to a particular called subscriber.

Interoffice connection.

For the purpose of illustration we will assume that a call is to be established to telephone Wadsworth 1102. This will be shown in the directory as WADsworth 1102

and, according to the dial code heretofore given, this means that the calling subscriber will dial the following seven digits 9, 2, 3, 1, 1, 0, 2. Further, for the sake of illustration, we will assume that the Wadsworth office has no party lines and that it is a distant office and will have to be reached through a mechanical switching center. The code 923 will, therefore, have to indicate these facts. This is done by causing relay 1310 to be energized as class indication for the purpose hereinbefore described.

When the calling subscriber dials the first digit 9, it will cause the line relay 1110 to retract its armature nine times in quick succession, thus setting the A register in Fig. 16 in the manner hereinbefore described. At the end of this series of impulses, relay 1128 becoming deenergized opens the circuit of magnet 1147 and relay 1148. Upon the deenergization of magnet 1147, wipers 1129 to 1134, inclusive, are moved to their second position contacts. The next series of impulses may be traced through relay 1128, wiper 1133 and its second position contact, conductor 1163, conductor 1363, conductor 1563, conductor 1663, winding of magnet 1610 to battery and ground and thus the B register is set. At the end of this series of impulses wipers 1129 to 1134, inclusive, are moved to their third position contacts, and in a similar manner each of the other registers is set in accordance with the designations assumed. In the manner described, at the end of the third series of impulses, wiper 1129 is moved to its fourth contact, whereupon a circuit is established from ground, the normal contacts of the right-hand armature of relay 1111, conductor 1112, outer right-hand armature and back contact of relay 1122, conductor 1149, wiper 1129 and its fourth position contact, back contact and left-hand armature of relay 1159, winding of relay 1124 to battery and ground. Relay 1124 becomes energized in this circuit and locks up through its front contact and inner right-hand armature, the outer right-hand armature and back contact of relay 1159 to the ground on conductor 1149.

A circuit is now established from ground on conductor 1112, through the outer right-hand armature and front contact of relay 1124, conductor 1146, the outer right-hand armature and back contact of relay 1125, conductor 1126, conductor 1326, conductor 1426, winding of relay 1400 to battery and ground. Relay 1400 becomes energized and in the manner hereinbefore described causes the energization of magnet 1408 and relay 1410. A circuit is now extended from ground, right-hand armature and front contact of relay 1410, conductor 1412, conductor 1212, conductor 1012, normal contacts of the left-hand armature of relay 1000, conductor 1013, conductor 1213, conductor 1413, corresponding contacts controlled by magnet 1408, conductor 1427, conductor 1327, conductor 1127, back contact and left-hand armature of relay 1125, conductor 1174, conductor 974, corresponding contacts of trunk bar 923 and line bar 922, conductor 935, conductor 735, outer left-hand armature and back contact of relay 703, winding of magnet 704 to battery and ground. Magnet 704 is energized in this circuit and attracts its armatures and moves the trunk bar 710 into operative position. The energization of magnet 704 results in the connection of ground from the outer right-hand armature and front contact of magnet 704 to conductor 745, whence it is extended over conductor 845 and conductor 1045 to the winding of magnet 1001. Magnet 1001 becomes energized and extends a ground connection from its lower armature and front contact to the winding of relay 1000 which now becomes energized and transfers the ground connection from conductor 1013 to conductor 1007 whence it is extended through the corresponding contacts controlled by magnet 1001 to conductor 1046 and thence over conductor 846, conductor 746, right-hand winding of relay 703, the inner right-hand armature, front contact and winding of magnet 704 to battery and ground to maintain this latter magnet energized for the time being. The energization of relay 1000 also extends the ground on conductor 1012 to conductor 1011. Thereupon and in accordance with the code heretofore given the translating relays in Fig. 12 will be energized in such a manner that magnet 1216 is energized and conductor 1228 is grounded resulting in the grounding of conductor 1230 and the consequent energization of magnet 1031. In the same manner relays 1223 and 1224 are energized and ground is extended from conductor 1211, over the inner right-hand armature and back contacts of relays 1221 and 1222, the inner right-hand armature and front contact of relay 1223, the inner left-hand armature and front contact of relay 1224, conductor 1232, conductor 1032 and thence into the translating device of Fig. 10. The contacts corresponding to conductors 1032 and magnet 1031 are now rendered effective. These are cross connected in the manner indicated so that upon the energization of magnet 1001, conductor 726 becomes grounded and the front contact and armature of relay 1004 leading to the relay 1310 is grounded. This latter circuit may be traced from ground, right-hand armature and front contact of relay 1410, conductor 1412, conductor 1212, conductor 1012, front contact and right-hand armature of relay

1000, conductor 1011, inner right-hand armatures and back contacts of relays 1221 and 1222, inner right-hand armature and front contact of relay 1223, inner left-hand armature and front contact of relay 1224, conductor 1232, conductor 1032, cross connecting connector 1034, front contact and outer right-hand armature of relay 1004, conductor 1035, conductor 1235, conductor 1435, corresponding contacts controlled by magget 1408, conductor 1428, conductor 1328, relay 1310 to battery and ground. Relay 1310 becomes energized in this circuit and locks up through its outer left-hand armature and front contact to the ground on conductor 1312 (which is an extension of conductor 1112).

Let it be assumed that the trunk leading to the mechanical switching center is of less than the maximum resistance and that certain additional resistance is required in the impulse circuit to take care of the proper operation of the marginal relay at the mechanical switching center. Therefore, an additional cross connection will be made from the translator to the class indicator whereby ground will be extended over cross connecting conductor 1036, through the front contact and innermost right-hand armature of relay 1004, conductor 1043, conductor 1243, conductor 1443, corresponding contacts controlled by magnet 1408, conductor 1444, conductor 1344, winding of relay 1305 to battery and ground. Relay 1305 becomes energized and locked through its front contact and lower armature to the ground on conductor 1312 and through the actuation of its two upper armatures it short-circuits the resistances 1319 and 1320 thereby adjusting the resistance of the impulse path to the particular trunk line selected.

Ground is also extended over cross connecting conductor 1008 and thence through the corresponding contacts controlled by magnet 1001 to conductor 1026, conductor 826, conductor 726, the armature and back contact of relay 712, winding of magnet 713 to battery and ground. Magnet 713 becomes energized in this circuit and operates line bar 714 whereupon connection is made between the corresponding contacts of trunk bar 710 and line bar 714, thus extending the called end of the trunk line in Fig. 7 to the non-numerical switch of Fig. 8. Ground on conductor 731 now being extended to the apparatus of Fig. 8 causes the operation of the non-numerical switch at that point, whereupon the connection is extended into the office selector circuit in the mechanical switching center here shown in Fig. 17.

In a predetermined length of time as marked off by the operation of the timing relays in Fig. 14, relay 1125 will become operated in the manner described. This is an indication that the marker has performed its functions and is being released. The operation of relay 1125 results in the establishment of a connection from ground on conductor 1112, the outer right-hand armature and front contact of relay 1124, conductor 1146, outer right-hand armature and front contact of relay 1125, outer right-hand armature and back contact of relay 1141, conductor 1164, conductor 1364, winding of relay 1308 to battery and ground. Relay 1308 now becomes energized and locks up through its front contact and inner lower armature to the ground on conductor 1312. A circuit is now established from ground, the outer left-hand armature and back contact of magnet 1901, conductor 1965, conductor 1765, back contact and upper armature of relay 1702, conductor 1763, conductor 863, corresponding contacts of trunk bar 823 and line bar 822, conductor 865, conductor 765, corresponding contacts of the line bar 714 and trunk bar 710, conductor 763, back contact and outer right-hand armature of relay 705, conductor 963, corresponding contacts of line bar 922 and trunk bar 923, conductor 965, conductor 1165, conductor 1365, front contact and uppermost armature of relay 1308, resistance coil 1321, resistance coil 1322, front contact and uppermost armature of relay 1305, back contact and inner left-hand armature of relay 1323, winding of relay 1327, outer left-hand armature and back contact of relay 1323, inner upper armature and front contact of relay 1305, resistance 1324, resistance 1325, inner upper armature and front contact of relay 1308, conductor 1366, conductor 1166, conductor 966, corresponding contacts of trunk bar 923 and line bar 922, conductor 964, conductor 764, corresponding contacts of trunk bar 710 and line bar 714, conductor 766, conductor 866, corresponding contacts of line bar 822 and trunk bar 823, conductor 864, conductor 1764, inner lower armature and back contact of relay 1702, conductor 1766, conductor 1966, back contact and inner left-hand armature of line bar magnet 1901, left-hand winding of line relay 1905 to battery and ground. Line relay 1905 and impulse relay 1327 both become energized in this circuit.

The energization of relay 1327 results in the connection of ground from conductor 1312 through the front contact and armature of relay 1327, winding of relay 1329 to battery and ground. Relay 1329 becomes energized in this circuit and extends the ground which caused its energization to the winding of relay 1300, but this relay having its other terminal connected to conductor 1312 does not become energized at this time.

Line relay 1905 is energized and thereby completes a circuit from battery through the

right-hand low resistance winding of line bar magnet 1901, right-hand low resistance winding of line relay 1905, front contact and right-hand armature of line relay 1905, left-hand armature and back contact of group relay 1906, winding of group relay 1907 to ground. Relay 1907 becomes energized in this circuit, but its resistance is such that it prevents the energization of line bar magnet 1901 at this instant.

Relay 1907, upon energizing, establishes a circuit from battery, left-hand winding of group relay 1906, front contact and armature of relay 1907, back contact and left-hand armature of starter relay 1908, back contact and left-hand armature of relay 1909, conductor 1911, winding of alarm relay 1912, to ground. Alarm relay 1912 becomes energized in this circuit and extends a ground over conductor 1913 to an alarm circuit in the same manner as relay 512 in the primary master switch. Group relay 1906 also becomes energized in this circuit and opens the original energizing circuit of relay 1907, but before this latter relay can become deenergized and open the circuit for relay 1912, a substitute circuit is closed from battery through the right-hand winding of relay 1906, front contact and right-hand armature of relay 1906, winding of starter relay 1908 and thence over the circuit described to the ground on conductor 1911. Relay 1908 becomes energized in this circuit and extends ground through the winding of relay 1912, conductor 1911, back contact and left-hand armature of relay 1909, left-hand armature and front contact of relay 1908, conductor 1929, left-hand armature and back contact of relay 1910, preference switch wiper 1917 and its second contact, outer left-hand armature and back contact of relay 1918, winding of trunk bar magnet 1919 to battery and ground. The trunk bar 1923 is thereby actuated. At the same time trunk bar magnet 1919 extends the ground which caused its energization over its inner left-hand armature and front contact to conductor 1920, whence it is extended through the winding of relay 1910 to the ground on conductor 1929. Thus relay 1910 having ground on each of the terminals of its windings is short circuited at this time and does not become energized.

Trunk bar magnet 1919 in operating extends ground through its outer left-hand armature and front contact to conductor 1930 and thence through the winding of relay 1918 which now becomes energized. Relay 1918, upon energizing extends ground from its front contact and right-hand armature to conductor 1931. Ground on conductor 1930 is extended through the back contact and armature of magnet 2101, left-hand armature and back contact of relay 2106, wiper 2104 and its normal contact, winding of magnet 2101 to battery and ground. Magnet 2101 is energized in this circuit and upon attracting its armatures breaks its own circuit and moves the wipers 2102 to 2105 forward onto their first active contacts. The ground on conductor 1930 is now extended over the back contact and armature of magnet 2101, left-hand armature and back contact of relay 2106, wiper 2104 and its first active contact, right-hand armature and back contact of relay 2107, winding of relay 2109 to battery and ground.

Relays 2107, 2108 and 2109 are timing relays and are all of the slow-releasing type. Their function is to cause the advance of the wipers 2102 to 2105, inclusive, forward after a certain time interval has passed. The energization of relay 2109 results in the extension of ground over its armature and front contact to the winding of relay 2108 which thereupon becomes energized and causes the energization of relay 2107. Relay 2107 opens the energizing circuit of relay 2109 and this after a time opens the energizing circuit of relay 2108 which thereupon extends ground from the armature and back contact of relay 2108, front contact and left-hand armature of relay 2107, winding of magnet 2101 to battery and ground. Thus magnet 2101 is energized and in attracting its armatures opens the circuit whereby ground is supplied from conductor 2130 to wiper 2104 to maintain the timing relays operated. Thus, magnet 2101 in effect opens its own circuit and becoming deenergized it moves wipers 2102 to 2105 forward on to their second active contacts. After another time interval, these brushes will again be moved forward in the same manner.

The ground extended to conductor 1931 is, after the wipers 2102 to 2105 have been moved to their first active contacts, extended over the inner right-hand armature and back contact of the sender release relay 2100, wiper 2102, winding of relay 2110 to battery and ground. Relay 2110 is energized in this circuit with results which will be described hereinafter.

Upon the movement of wiper 2105 on to its active contacts, relay 1918 is locked into a circuit including battery and ground, its front contact and inner left-hand armature, conductor 1932, conductor 2132, wiper 2105 to ground.

Upon the energization of relay 1918 the original energizing circuit of trunk bar magnet 1919 is opened. This removes the ground from one terminal of relay 1910 and, consequently, relay 1910 now becomes energized in a circuit from battery through the

winding of trunk bar magnet 1919, inner left-hand armature and front contact of magnet 1919, conductor 1920, winding of relay 1910, conductor 1929, front contact and left-hand armature of relay 1908, left-hand armature and back contact of relay 1909, conductor 1911, winding of relay 1912 to ground. Relay 1910, therefore, becomes energized and establishes a circuit from battery, through the right-hand low resistance winding of line bar magnet 1901, right-hand low resistance winding of line relay 1905, front contact and right-hand armature of relay 1905, left-hand armature and front contact of group relay 1906, back contact and right-hand armature of relay 1909, front contact and right-hand armature of relay 1910, conductor 1911, winding of relay 1912 to ground. Line bar magnet 1901 thereby becomes energized and connection is made between the corresponding contacts of line bar 1922 and trunk bar 1923. Upon the engagement of the corresponding contacts of line bar 1922 and trunk bar 1923, ground is extended from the front contact and right-hand armature of relay 1918, conductor 1931, conductor 2131, the inner right-hand armature and back contact of relay 2106, conductor 2133, conductor 1933, corresponding contacts of trunk bar 1923 and line bar 1922, conductor 1935 to maintain trunk bar magnet 1901 energized by extending this ground through its two windings in series. This ground is also extended over conductor 1735 and thence through the right-hand winding of relay 1700 to battery and ground, causing the energization of relay 1700. Relay 1700 attracts its armature and connects ground through its armature and contact to conductor 1731 for purposes which will be mentioned hereinafter.

Upon the energization of relay 1910, a circuit is established from ground, winding of relay 1912, conductor 1911, left-hand armature and back contact of relay 1909, left-hand armature and front contact of relay 1908, conductor 1929, left-hand armature and front contact of relay 1910, winding of stepping magnet 1914 to battery and ground. Stepping magnet 1914 is energized and prepares to move wiper 1917 one step. The energization of trunk bar magnet 1901 now closes a circuit from ground, the outer left-hand armature and front contact of trunk bar magnet 1901, front contact and left-hand armature of line relay 1905, winding of relay 1909 to battery and ground. Relay 1909 becomes energized in this circuit and locks up through its right-hand armature and front contact and the right-hand armature and front contact of relay 1910 to ground on conductor 1911. By attracting its armature relay 1909 thus opens the original energizing circuit of relays 1908 and 1906, but these relays are maintained energized until timing relay 1916 retracts its armatures.

When this occurs, the deenergization of relay 1908 opens the holding circuit of trunk bar magnet 1919 which now becomes deenergized and thereby restores trunk bar 1923 to normal position leaving only the contacts corresponding to line bar 1922 operated. The energization of the line bar magnet also opens the circuit of line relay 1905 so that this relay now becomes deenergized. The deenergization of relay 1908 also opens the holding circuit of relay 1910 and the master switch for the sender selector switch is now returned to normal.

Under abnormal conditions relays 1915 and 1916 operate in a similar manner to relays 515 and 516 hereinbefore described.

The impulse circuit traced from the back contact and outer left-hand armature of trunk bar magnet 1901, through the winding of relay 1327, back to the back contact and inner left-hand armature of relay 1901 is now extended through the corresponding contacts of line bar 1922 and trunk bar 1923 to conductors 1963 and 1964. Conductor 1963 extends over conductor 2163, outer right-hand armature and back contact of relay 2111, winding of relay 2114, winding of relay 2113, winding of relay 2112, back contact and outer left-hand armature of relay 2111, conductor 2164, conductor 1964.

Relay 2112 is the marginal relay heretofore mentioned and responds to strong current impulses only. Relays 2113 and 2114 are polarized relays which respond to plus and minus impulses, respectively. These three relays are included in series with the impulse circuit now extending back to the apparatus of Fig. 13.

Returning now to the operation of the apparatus in Fig. 13, it will be noted that when line bar magnet 1901 became energized that the circuit for relay 1327 was opened. Relay 1327 thereupon becomes deenergized and in retracting its armature opens the original energizing circuit of relay 1329, but this relay remains energized in series with relay 1300, which now becomes energized due to the removal of ground and the substitution of battery on one of its terminals. The energization of relay 1300 transfers the ground connection from conductor 1312 from the winding of relay 1301, over the back contact of relay 1300 to the winding of relay 1323 over the front contact of relay 1300. Thus relay 1323 becomes energized at this time and through the attraction of its armatures disconnects relay 1327 from the impulse circuit. Relay

1301 being a slow-to-release relay, in a certain interval, retracts its armature whereupon a circuit is established from ground on conductor 1312, through the lowermost armature and front contact of relay 1308, armature and back contact of relay 1301, armature and back contact of relay 1309, wiper 1330 and its normal contact, winding of relay 1331 to battery and ground. Relay 1331 becomes energized in this circuit and by the movement of its armatures connects ground through its right-hand armature and front contact, the back contact and armature of magnet 1332, winding of magnet 1332 to battery and ground. Magnet 1332 becomes energized in this circuit but since the ground extended to the winding of relay 1331 is also extended to the winding of this magnet it does not become deenergized at this time.

The energization of relay 1331 extends a connection from ground over the front contact and left-hand armature of relay 1331, conductor 1335, lowermost armature and back contact of relay 1341, left-hand armature and back contact of relay 1348, winding of relay 1349 to battery and ground. Relay 1349 becomes energized in this circuit. At the same time a circuit is completed from ground, front contact and left-hand armature of relay 1331, conductor 1335, back contact and armature of magnet 1343, brush 1353 and its normal contact, winding of magnet 1343 to battery and ground. Therefore, magnet 1343 becomes energized at the same time as relay 1349 and by attracting its armature removes ground from the armature of relay 1349. Magnet 1343 also opens its own circuit and it thereby becomes deenergized and moves the associated wipers on to their first active contacts. It is here noted that magnet 1343 controls wipers 1302, 1315, 1316, 1330, 1353 and 1358.

Upon the movement of brush 1330 onto its first position contact, the circuit of relay 1331 is opened and this relay retracts its armatures thereby allowing magnet 1332 to become deenergized. Magnet 1332 controls wipers 1303, 1317, 1333 and 1334 and these wipers are now moved to their first active contacts.

Magnet 1343 and its associated wipers comprise the impulse sending switch and magnet 1332 and its associated wipers comprise the impulse control switch. It is here noted that as the impulse sending switch moves on to its first active contacts that the impulse control switch is advanced. One special result of this will be noted hereafter in connection with the operation of the stations register.

Upon the movement of wiper 1353 to its first active contact a circuit is completed from ground, wiper 1353, armature and front contact of relay 1349, winding of relay 1348 to battery and ground. Relay 1348 becomes energized and locks up through a circuit from battery, winding of relay 1348, front contact and left-hand armature of relay 1348, back contact and outer lower armature of relay 1341, conductor 1335, armature and back contact of magnet 1343 which has now returned to normal position, wiper 1353 and its first active contact to ground. This condition now is maintained for an instant until relay 1349 which is slow to release, finally retracts its armatures and during this interval an impulse is sent out over the impulse circuit as will be described a little later. When relay 1349 retracts its armature it establishes a circuit from ground, wiper 1353, armature and back contact of relay 1349, front contact and right-hand armature of relay 1348, outer right-hand armature and back contact of relay 1347, winding of relay 1341 to battery and ground, whereupon relay 1341 attracts its armatures and disconnects the impulse circuit from wipers 1315 and 1316. Upon the energization of relay 1341 the circuit of relay 1348 is opened at the back contact and lowermost armature of relay 1341 and relay 1348 thereupon becomes deenergized. Relay 1347 is now included in a series circuit with relay 1341 which circuit may be traced from ground, wiper 1353, armature and back contact of magnet 1343, conductor 1335, winding of relay 1347, front contact and inner lower armature of relay 1341, winding of relay 1341 to battery and ground, whereupon relay 1347 becomes energized. This provides a new circuit for relay 1349 which may be traced from ground on conductor 1335, inner right-hand armature and front contact of relay 1347, left-hand armature and back contact of relay 1348, winding of relay 1349 to battery and ground. Upon the energization of relay 1349 a circuit is established from ground, wiper 1353, armature and front contact of relay 1349, winding of relay 1348 to battery and ground, so that relay 1348 now becomes energized and locked through its front contact and left-hand armature and at the same time opens the circuit of relay 1349. In a short interval relay 1349 becomes deenergized whereupon a circuit is established from ground, wiper 1353, armature and back contact of relay 1349, front contact and right-hand armature of relay 1348, outer right-hand armature and front contact of relay 1347, winding of magnet 1343 to battery and ground. Magnet 1343 becomes energized and removes ground from conductor 1335 whereupon the circuit of relays

1341, 1347 and 1348 is opened these relays retract their armatures and in so doing open the circuit of magnet 1343 which now returns to normal and moves the associated wipers on to their second active contacts. The impulse circuit is now again connected to wipers 1315 and 1316 so that the second impulse of a series may be transmitted. At this time a circuit is established from ground, wiper 1353, armature and back contact of magnet 1343, conductor 1335, outer lower armature and back contact of relay 1341, left-hand armature and back contact of relay 1348, winding of relay 1349 to battery and ground, whereupon relay 1349 becomes energized. This results in the establishment of an energizing circuit for relay 1348 which attracts its armatures and opens the circuit of relay 1349. A definite interval now is consumed before relay 1349 becomes deenergized and during this interval the second impulse of the series is transmitted over the impulse circuit. When relay 1349 becomes deenergized it results in the energization of relay 1341 and the same cycle of operations just described takes place. Briefly, this consists of first the energization of relay 1341, second, the deenergization of relay 1348, third the energization of relay 1347, fourth the energization of relay 1349, fifth the energization of relay 1348, the deenergization of relay 1349, sixth the energization of magnet 1343 and seventh the deenergization of relays 1341, 1347, 1348 and magnet 1343. Thereupon the associated wipers are moved on to their third active contacts and the third impulse is transmitted. This third impulse is maintained during the energization of relay 1349 and the energization of relay 1348 and until relay 1349 again becomes deenergized whereupon this cycle of operations again takes place. When at last the wipers controlled by magnet 1343 move to their normal position, ground being no longer connected to wiper 1353, this impulse switch comes to halt and further movement depends upon the next energization of relay 1331. If neither relay 1301 nor relay 1309 is energized at this time relay 1331 will become energized and the wipers controlled by magnet 1332 will be moved onto their second active contacts and the wipers controlled by magnet 1343 will be started on a second revolution.

Each step of the wipers controlled by magnet 1332 corresponds to one digit and each complete revolution of the wipers controlled by magnet 1343 also corresponds to one digit. An examination of wipers 1315 and 1316 will show that during the sending of impulses corresponding to each digit there may be as many as four separate impulses transmitted. For purposes of further understanding this circuit the following impulse code is given at this point:

Relay call indicator code.

Digit.	Impulses.				Relay energized.
	1	2	3	4	
1	+	–		–	A
2		H–		–	B
3	+	H–		–	A B
4		–	+	–	C
5		–		H–	D
6	+	–		H–	A D
7		H–		H–	B D
8	+	H–		H–	A B D
9		–	+	H–	C D
0		–		–	None

The first column represents the digits which may be registered on the office code registers in Fig. 16 and the numerical registers in Fig. 15. The second, third, fourth and fifth columns represent the impulses propagated and transmitted over the impulse circuit through the wipers 1315 and 1316. The column headed "1" represents the impulses which may be sent while wipers 1315 and 1316 are resting on their first active contacts. The column 2 represents the impulses which may be sent while these wipers are resting on their second active contacts and so on. The sixth column headed "Relay energized" represents the code relays which respond to the impulses at any one of the offices to which connection may be extended. For the sake of clearness these code relays shown in one instance in Figs. 25, 26 and 36 are marked A, B, C and D and for the purpose of particular identification are given numerical designations in addition. It will be noted that this code is the same as the code used in the operation of the office code translator relays in Fig. 12.

Attention is further called to the fact that while wipers 1315 and 1316 are resting on their first and third active contacts that only plus impulses of small current value are transmitted and that while wipers 1315 and 1316 are resting on their second and fourth active contacts that minus impulses of both small and comparatively great current value are transmitted. The light impulses are represented by the symbol "—" and the heavy impulses are represented by the symbol "H—." The light impulses are propagated by including resistance 1359 in series with the impulse circuit and the heavy impulses are propagated by including a low resistance 1360 in series with the impulse circuit.

It will be noted that wiper 1358 being connected to the grounded conductor 1312 energizes relay 1370 on its first active contact, relay 1371 on its second active contact,

relay 1372 on its third active contact, and relay 1373 on its fourth active contact. It will be further noticed that wiper 1316 is connected to ground when resting on its first and third active contact and that wiper 1315 is connected to ground when resting on its second and fourth active contacts. Thus, a connection from ground to wiper 1316, thence over the impulse circuit and back to wiper 1315 and thence through circuits which will be hereinafter traced to battery through resistance 1359 will create a plus impulse of small current value. For the sake of illustration suppose that the A register in Fig. 16 is set for the digit 6. Then, when wipers 1315 and 1316 are set on their first active contacts a circuit will be established from ground, wiper 1316, over the impulse circuit described, wiper 1315, its first active contact, inner left-hand armature and lower front contact of relay 1370, conductor 1362, conductor 1562, conductor 1662, wiper 1605, conductor 1650, conductor 1550, conductor 1350, conductor 1150, left-hand armature and front contact of relay 1124, conductor 1167, conductor 1367, first active contact and wiper 1317, conductor 1368, resistance 1359 to battery and ground. Thus a plus impulse is transmitted to the three relays 2112, 2113 and 2114 which results in the energization of only relay 2113. Shortly after this, as described, wipers 1315 and 1316 are moved to their second active contacts whereupon a circuit is established from ground, wiper 1315 and its second active contact, over the impulse circuit, back to wiper 1316 and its second active contact, conductor 1368, resistance 1359, to battery and ground, whereupon a minus impulse of small value is transmitted resulting in the operation of relay 2114. Upon the movement of wipers 1315 and 1316 to their third active contacts, no circuit is found for wiper 1315. Wiper 1315 is now connected to the armature of relay 1372 and this is in contact with conductors leading to the third and tenth active contacts associated with wiper 1605 and since wiper 1605 is now supposedly resting on its sixth contact, an open circuit will be found so that no impulse will be sent while wipers 1315 and 1316 are on their third active contacts. When these two wipers, however, are moved to their fourth active contacts, a circuit will be found leading from ground, wiper 1315, over the impulse circuit, back to wiper 1316, conductor 1368, wiper 1317 and its first active contact, conductor 1367, conductor 1167, front contact and left-hand armature of relay 1124, conductor 1150, conductor 1350, conductor 1550, conductor 1650, wiper 1605 and its sixth active contact, conductor 1662, conductor 1562, conductor 1362, lower front contact and innermost right-hand armature of relay 1373, low resistance 1360 to battery and ground. Thus, a minus impulse of comparatively great current value is transmitted over the impulse circuit and this results in the energization of both relays 2112 and 2114.

In the same manner that the digit 6 may be transmitted as just described, the other digits will be transmitted to effect the three relays 2112 to 2114, inclusive. We have assumed in this particular case that the call is being directed to WADsworth 1102 in which case, the digits and impulses sent, with the corresponding results in the code relays, are given in the following table:

Designation.	Digit.	Pos. of wipers 1315-1316.	Impulses.	Relays affected by impulses.	Local relays affected.	Resulting in energization of relays	Here designated
W	9	1					
		2	−	2114	2115		
		3	+	2113	2115, 2116	C	3506
		4	H−	2114, 2112	2116	D	3507
		Normal.					
A	2	1					
		2	H−	2114, 2112	2115	B	3508
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
D	3	1	+	2113		A	3509
		2	H−	2114, 2112	2115	B	3510
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
1	1	1	+	2113		A	2606
		2	−	2114	2115		
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
1	1	1	+	2113		A	2607
		2	−	2114	2115		
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
0	0	1					
		2	−	2114	2115		
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
2	2	1					
		2	H−	2114, 2112	2115	B	2504
		3			2115, 2116		
		4	−	2114	2116		
		Normal.					
		1					
		2	−	2114	2115	2502	
		3			2115, 2116		
		4	−	2114	2116		

We have assumed in this case that the Wadsworth office contains no party lines and that, therefore, the sending of impulses is started before all of the digits of the called number have been recorded. Let us suppose that by the time the calling subscriber has just finished sending the tens digit that the sending of impulses has progressed to this same point. During the sending of the tens digit wiper 1133 will be on its sixth contact which is connected to conductor 1169 which leads through conductor 1369 and

conductor 1569 to the winding of magnet 1568 which controls the tens register. In the same manner wiper 1132 will be on its sixth contact which is connected to conductor 1175 and through this conductor to conductor 1375 to the sixth active contact associated with wiper 1334. If the hundreds designation has been sent out over the impulse circuit wiper 1334 will have moved to its sixth active contact and a circuit will be completed from ground on conductor 1112, through wiper 1132, conductor 1175, conductor 1375, wiper 1334, winding of relay 1309 to battery and ground. This opens the circuit leading to wiper 1330 and thence to relay 1331 so that until relay 1309 is deenergized and retracts its armature, another series of code impulses cannot be sent since the relay 1331 must become energized to start the operation of the switch controlled by magnet 1343. Thus, means are provided to delay the sending of impulses should this operation overtake the receipt of the digit designations from the calling subscriber's substation.

One other point to be noted here is the effect of the operation of relay 1310. Since this call is being routed through a mechanical switching center, relay 1310 was energized. When, therefore, wiper 1317 arrives at its fourth active contact, where under other conditions it would connect conductor 1368 to the back contact of the inner left-hand armature of relay 1310 and thence to the first stations register, it finds this circuit open due to the energization of relay 1310. Therefore, another circuit is provided from ground, wiper 1333, and its fourth active contact, front contact and middle left-hand armature of relay 1310, back contact and armature and winding of magnet 1332 to battery and ground, whereby magnet 1332 is caused to step its associated wipers past their fourth active contacts and directly on to their fifth active contacts so that as soon as the designation registered on the C register is transmitted, the thousand register will be made effective.

It has heretofore been pointed out that as the impulse switch moves on to its first active contact that the impulse control switch is caused to move forward, therefore, after the units register has been set, the impulse switch is started forward again notwithstanding the fact that a stations designation has not been set up on the first stations register. As wipers of the impulse switch are moved on to their first active contacts the magnet 1332 will become deenergized and move its associate wipers on to their ninth active contacts, in which position a circuit for the release of the sender will be established. However, before the sender can be disconnected, the impulse switch will make a complete revolution and send out two negative impulses while on its second and fourth active contacts. As will be noted hereinafter, the release of the sender is not completed until the slow release relay 1111 retracts its armatures and since this is comparatively much slower than the slow relay 1349 in the impulse sending switch, this switch has time to send out the designation zero which results from leaving the stations register in its normal position. The function of this action will appear hereinafter.

It will now be noted that when the sending of impulses as registered on the A, B, C, thousands, hundreds, tens and units registers has been completed and wiper 1333 has moved to its ninth active contact corresponding to the first stations register, a circuit will be completed from ground, wiper 1333, conductor 1374, conductor 1574, normal contact and wiper 1573, conductor 1576, conductor 1376, conductor 1176, winding of relay 1108 to battery and ground. This is known as the sender release relay. Upon its operation it disconnects the calling line from the control of relay 1110 whereupon relay 1111 is deenergized and after a short time ground is removed from conductor 1112 which causes the release of all relays in the sender and marker which are at this time operated.

In the meantime and before relay 1111 retracts its armatures a circuit is established from ground, wiper 1106, conductor 932, inner left-hand armature and front contact of relay 918, conductor 930, outer right-hand armature and front contact of relay 1108, front contact and left-hand armature of relay 1125, conductor 1174, conductor 974, corresponding contacts of trunk bar 923 and line bar 922, conductor 935, conductor 735, outer left-hand armature and front contact of relay 703 and thence in parallel through the windings of relays 702 and 705. Relays 702 and 705 are energized in this connection and both attract their armatures and lock up to the ground on conductor 731. This circuit may be traced from ground, front contact and left-hand armature of relay 700, conductor 731, inner lower armature and front contact of relay 702, and thence in parallel through the windings of relays 702 and 705. Relay 702 extends the talking conductors from the calling subscriber's line through the armatures and back contacts of relay 706 to the primary windings of repeating coil 707. Relay 708 is now included in series with the calling subscriber's line and through the attraction of its armature grounds the right-hand winding of relay 700 so that this relay is maintained energized after the sender selector switch of Fig. 9 is released.

It will be noted that in this connection relay 706 is not operated and that relay 709 is operated so that now the called subscriber's line will be connected to the sec-

ondary windings of repeating coil 707 and polarized relay 715 will be connected through the back contacts and armatures of relay 717 in series with the secondary windings of this repeating coil. Upon the removal of ground from conductor 1112 all relays depending on this ground for their continued energization are released and ground being removed from conductor 935 through the corresponding contacts of line bar 922 and trunk bar 923, line bar magnet 901 is released thus returning the sender selector switch to normal position.

The operation of relays 2115 and 2116 should be noted at this point. These two relays are connected in a circuit in such a manner that they periodically operate through a cycle in which they are energized in all possible combinations. From the table heretofore given, it will be noted that each set of impulses for a digit comprises two negative impulses. This means that during the sending of one digit relay 2114 is energized twice. Upon the first energization of this relay a connection is made from ground, back contact and outer right-hand armature of relay 2106, conductor 2150, armature and front contact of relay 2114, upper armature and back contact of relay 2116, upper winding of relay 2115, upper winding of relay 2116 to battery and ground. Relay 2116 is marginal and does not become energized in this connection. Relay 2115, however does become energized so that during the first negative impulse relay 2115 only becomes energized. At the end of this impulse when relay 2114 becomes deenergized, relay 2116 becomes energized in a circuit from ground on conductor 2150, the inner lower armature and front contact of relay 2115, the lower winding of relay 2116, the upper winding of relay 2115, the upper winding of relay 2116 to battery and ground. Now when relay 2114 again becomes energized ground is extended from conductor 2150, through the armature and front contact of relay 2114, the upper armature and front contact of relay 2116, the winding of relay 2116 to battery and ground. At this time relay 2115 is short-circuited because one terminal of its upper winding is connected through the front contact and upper armature of relay 2116 to ground and the other terminal of its upper winding is connected through the lower winding of relay 2116, the front contact and inner lower armature of relay 2115 to ground on conductor 2150. Thus, during this second negative impulse relay 2116 is maintained energized and relay 2115 is deenergized and it retracts its armature. At the end of this second impulse when ground is removed from the upper armature of relay 2116, this relay becomes deenergized. These two relays are therefore energized in the following order: first, relay 2115, second, both relays 2115 and 2116, third, relay 2116 and lastly, neither relay 2115 nor relay 2116.

Keeping in mind this combination, we will now assume that the digit 6 is being received over the impulse circuit. Referring back for a moment to the code of impulses hereinbefore given, it will be noted that the first is a positive impulse which will result in the energization of relay 2113. Bearing in mind that at this time neither relay 2115 nor relay 2116 is energized, it will be seen that a circuit is established from ground on conductor 2150, through the armature and front contact of relay 2113, the lowermost armature and back contact of relay 2115, conductor 2122, conductor 2322, conductor 2522, conductor 2622, conductor 3522, through the outer right-hand armature and back contact of relay 3500, right-hand winding of the A relay, here numbered 3511, to battery and ground. Relay 3511 attracts its armatures and when the ground has been removed from conductor 3522, relay 3511 is maintained energized in a circuit from battery, its two windings in series, its front contact and left-hand armature, conductor 3550, conductor 2650, conductor 2550, conductor 2350, conductor 2150, the outer right-hand armature and back contact of relay 2106 to ground. Thus, on a positive impulse preceding either of the two negative impulses, the A relay here numbered 3511 will be energized.

Following the receipt of this impulse, a weak negative impulse will be received. This results as hereinbefore described in the energization of relay 2115, but does not energize any one of the code relays shown in Fig. 35. A circuit is now established from ground on conductor 2150, through the upper armature and front contact of relay 2115, conductor 2123, conductor 2323, conductor 2523, conductor 2623, conductor 3523, middle right-hand armature and back contact of relay 3501, winding of relay 3500 to battery and ground. Relay 3500 becomes energized in this circuit and connects the ground on conductor 3550 to the winding of relay 3501, but this relay having ground connected to its other winding at this time does not become energized. Upon the end of this negative impulse, relay 2116 becomes energized. This is followed in a short interval by a strong negative impulse which will energize both relays 2112 and 2114. The energization of relay 2114 maintains relay 2116 energized and causes the deenergization of relay 2115. Thereupon, a circuit is established from ground on conductor 2150, through the armature and front contact of the marginal relay 2112, the low-

ermost armature and front contact of relay 2116, conductor 2124, conductor 2324, conductor 2524, conductor 2624, conductor 3524, innermost right-hand armature and back contact of relay 3501, right-hand winding of relay 3507 to battery and ground. This relay becomes energized and locks up to the ground on conductor 3550 in the same manner as did relay 3511.

Upon the end of this impulse, both relays 2115 and 2116 become deenergized and ground being removed from conductor 2123 results in the removal of the short-circuit from around the winding of relay 3501 so that now relays 3500 and 3501 are included in a series circuit from ground on conductor 3550, the left-hand armature and front contact of relay 3500, winding of relay 3501, winding of relay 3500 to battery and ground. Thus, relays 3500 and 3501 become energized and transfer the conductors 3521 to 3525, inclusive, to the next set of code relays so that the following impulses being received over the impulse circuit will selectively energize the four code relays corresponding to the second place in the office code designation.

With this explanation it is believed that the energization of the code relays for the digits as set forth in the table hereinbefore will be readily understood and no further detailed explanation will be necessary.

Upon the receipt of the first negative impulse in the third office code designation when relay 3504 is energized, a circuit is established from ground on conductor 3550, outermost right-hand armature and front contact of relay 3504, conductor 3526, conductor 2626, conductor 2526, conductor 2326, conductor 2126, left-hand armature and back contact of relay 2117, outer right-hand armature and back contact of relay 2118, conductor 2127, conductor 2327, conductor 2427, winding of relay 2400 to battery and ground. Relay 2400 becomes energized in this circuit. A circuit is now completed from battery, left-hand winding of relay 2401, front contact and armature of relay 2400, first contact and wiper 2403, back contact and armature of relay 2405, back contact and inner left-hand armature of relay 2406, armature and back contact of relay 2407 to ground. Relay 2401 is energized in this circuit and thereupon locks up in a circuit from battery, right-hand winding of relay 2401, front contact and inner right-hand armature of relay 2401, first contact and wiper 2402, winding of relay 2405, back contact and inner left-hand armature of relay 2406, armature and back contact of relay 2407 to ground. Relay 2405 now becomes energized in this circuit. At this stage, a ground is projected from the inner right-hand armature and front contact of relay 2405, outer right-hand armature and front contact of relay 2401, winding of magnet 2408 to battery and ground. Magnet 2408 becomes energized in this circuit and actuates the multiple contacts shown diagrammatically above it. The ground is also extended from the outer right-hand armature and front contact of relay 2405, the inner left-hand armature and back contact of relay 2409, winding of relay 2410 to battery and ground. Relay 2410 becomes energized in this circuit. Relay 2405 also closes a circuit from ground, armature and back contact of relay 2407, inner left-hand armature and back contact of relay 2406, left-hand armature and front contact of relay 2405, winding of magnet 2411 to battery and ground. Magnet 2411 controls the wipers 2402, 2403 and 2404 and upon its energization prepares to move them one step forward.

The energization of relay 2410 closes a circuit from ground, right-hand armature and front contact of relay 2410, conductor 2412, conductor 2212, conductor 2012, the normal contacts of the left-hand armature of relay 2000, conductor 2013, conductor 2213, conductor 2413, corresponding contacts of the multicontact device controlled by magnet 2408, conductor 2428, conductor 2328, conductor 2128, back contact and outer right-hand armature of relay 2100, conductor 2134, conductor 1934, corresponding contacts of trunk bar 1923 and line bar 1922, conductor 1936, conductor 1736, left-hand armature and back contact of relay 1703, winding of trunk bar magnet 1704 to battery and ground. Magnet 1704 becomes energized in this circuit and moves the trunk bar 1710 into operative position. At the same time magnet 1704 attracts its armatures and establishes a circuit from ground, outer right-hand armature and front contact of magnet 1704, conductor 1745, conductor 1845, conductor 2045, magnet 2001 to battery and ground. Magnet 2001 becomes energized in this circuit and through the attraction of its armatures and the multicontact device shown diagrammatically above it, establishes circuits as follows: first, ground, lower armature and front contact of magnet 2001, winding of relay 2000 to battery and ground. Relay 2000 becomes energized in this circuit and transfers the ground from conductor 2013 to conductor 2007 and this ground is further extended through the corresponding contacts of the multicontact device controlled by magnet 2001 to conductor 2046, conductor 1846, conductor 1746, left-hand winding of relay 1703, inner right-hand armature and winding of magnet 1704 to battery and ground. Thus, as the original energizing circuit of magnet 1704 is opened by the removal

of ground from conductor 2013, it is maintained energized through the application of ground to conductor 2007. Relay 1703 becomes actuated in this circuit and locks up to the ground on conductor 1735, through its right-hand armature, front contact and right-hand winding.

Upon the energization of magnet 2408 and relay 2410, connection is established from ground through the left-hand armature and front contact of relay 2410, conductor 2419 through the corresponding contacts of the multicontact device controlled by magnet 2408, conductor 2420, conductor 2620, conductor 3520 and thence in multiple to the outer right-hand armatures of the 12 code relays shown on Fig. 35. Those code relays which are energized will now extend this ground to the corresponding code relays in the office code translator in Fig. 22. Thus, the ground on conductor 3520 will be extended through the outer right-hand armatures and front contacts of relays 3506 to 3510 inclusive. For sake of illustration, we will trace one of these circuits from outer right-hand armature and front contact of relay 3506, conductor 3530, conductor 2630, conductor 2430, corresponding contacts of the multicontact device controlled by magnet 2408, conductor 2414, conductor 2214, winding of relay 2201 to battery and ground, whereupon relay 2201 becomes energized. Thus, in response to the energization of the C relay in the A register, the AC relay in the office code translator is energized. In a similar manner and in response to the energization of the relays 3507, 3508, 3509, 3510 respectively, relays 2200, 2208, 2224, 2223, respectively, will be energized.

In response to the operation of relays 2200 and 2201, a circuit is established from ground, left-hand armature and front contact of relay 2410, conductor 2419, conductor 2219, back contact and outer left-hand armature of relay 2203, left-hand armature and front contact of relay 2200, left-hand armature and front contact of relay 2201, winding of magnet 2216 to battery and ground. Magnet 2216 is energized in this circuit. In response to the operation of relay 2208, a circuit is established from ground on conductor 2219 through the inner right-hand armatures and back contacts of relays 2206 and 2207, the inner right-hand armature and front contact of relay 2208, the inner left-hand armature and back contact of relay 2209, conductor 2228, corresponding contacts controlled by magnet 2216, conductor 2230, conductor 2030, winding of magnet 2031 to battery and ground, whereupon this magnet becomes energized. In response to the operation of relays 2223 and 2224 a circuit is established from ground, right-hand armature and front contact of relay 2410, conductor 2412, conductor 2212, conductor 2012, front contact and right-hand armature of relay 2000, conductor 2011, conductor 2211, the inner right-hand armatures and back contacts of relays 2221 and 2222, the inner right-hand armature and front contact of relay 2223, inner left-hand armature and front contact of relay 2224, conductor 2232, conductor 2032 and thence through the corresponding contacts controlled by magnet 2031 to cross connecting conductors 2008, 2034 and 2036. Cross connecting conductor 2008 leads to the office selector switch and functions to cause the selection of an idle one of a particular group of trunks. Cross connecting conductor 2034 functions to operate the numerical relay in the sender impulse circuit. This connection may be traced from the ground on conductor 2032, cross connection conductor 2034, corresponding front contact and armature of relay 2004, which is energized through its connection to conductor 2019, conductor 2035, conductor 2235, conductor 2435, corresponding contacts controlled by magnet 2408, conductor 2444, conductor 2344, winding of numerical relay 2313 to battery and ground. Relay 2313 becomes energized in this circuit and locks in a circuit from ground, wiper 2301 and its normal contact, right-hand armature and front contact of relay 2313, winding of relay 2313 to battery and ground.

Cross connecting conductor 2036 extends ground over the front contact and innermost right-hand armature of relay 2004, conductor 2037, conductor 2237, conductor 2437, corresponding contacts controlled by magnet 2408, conductor 2443, conductor 2343, winding of compensating resistance relay 2335 to battery and ground. Relay 2335 becomes energized and locks up through its front contact and lower armature to the ground on conductor 2350. This adjusts the resistance of the impulse circuit to the trunk selected to the WADsworth office.

The ground extended over cross connecting conductor 2008 leads through corresponding contacts of the device controlled by magnet 2001 to conductor 2026, thence over conductor 1826, conductor 1726, left-hand armature and back contact of relay 1712, winding of line bar magnet 1713 to battery and ground. Magnet 1713 becomes energized in this circuit and moves the line bar 1714 into operative position whereupon connection is made between the corresponding contacts of trunk bar 1710 and line bar 1714 so that the trunk is now extended to the non-numerical switch in Fig. 18. Ground on conductor 1731 is now extended to the right-hand winding of relay 1712 and as soon as the ground is removed from conductor 1726, relay 1712 becomes energized

in series with magnet 1713 and this relay and magnet are maintained energized thereafter until the ground on conductor 1731 is removed. The grounded conductor 1731 is now extended through the two windings of magnet 1801 and this magnet being similar to the magnet 801 hereinbefore described causes the operation of its left-hand armatures, but does not cause the operation of its right-hand armatures or the line bar 1822, this results in the establishment of a connection from battery, the right-hand low resistance winding of magnet 1801, the inner right-hand armature and back contact of magnet 1801, outer left-hand armature and front contact of magnet 1801, the back contact and outer left-hand armature of magnet 1851, left-hand armature and back contact of relay 1806, winding of group relay 1807 to ground. Relay 1807 is energized in this circuit. A new circuit is now established from battery, the left-hand winding of relay 1806, the front contact and armature of relay 1807, back contact and left-hand armature of relay 1808, back contact and left-hand armature of relay 1809, conductor 1811, winding of alarm relay 1812 to ground. Alarm relay 1812 is energized in this circuit and connects ground to conductor 1813 which leads to an alarm circuit in the same manner as hereinbefore described. Relay 1806 also becomes energized in this circuit and opens the circuit of group relay 1807, which becomes deenergized and opens the original energizing circuit of relay 1806, but before this can be accomplished, a new circuit for the energization of relay 1806 is established from battery, the right-hand winding of relay 1806, front contact and right-hand armature of relay 1806, winding of relay 1808 and thence to ground over the circuit hereinbefore traced. Relay 1808 now becomes energized and this results in the establishment of a circuit from ground, the winding of relay 1812, conductor 1811, left-hand armature and back contact of relay 1809, left-hand armature and front contact of relay 1808, conductor 1829, left-hand armature and back contact of relay 1810, preference switch wiper 1817, left-hand armature and back contact of relay 1818, winding of magnet 1819 to battery and ground. Magnet 1819 becomes energized in this circuit and actuates trunk bar 1823. Magnet 1819 also attracts its armatures and extends the ground which causes its energization to conductor 1820, whence it is extended to the winding of relay 1810, but this relay having its other terminal grounded does not become energized at this time. Ground is also extended from the outer left-hand armature and front contact of magnet 1819 to the winding of relay 1818 which now becomes energized and by opening the original energizing circuit of magnet 1819 causes relay 1810 to become energized in series with magnet 1819. The energization of relay 1810 results in the connection of ground on conductor 1811 through the back contact and left-hand armature of relay 1809; front contact and left-hand armature to relay 1808, conductor 1829, left-hand armature and front contact of relay 1810, winding of magnet 1814 to battery and ground. Magnet 1814 becomes energized in this circuit and prepares to move wiper 1817 to its next contact.

The energization of relay 1810 also results in the establishment of a circuit from ground on conductor 1811, front contact and right-hand armature of relay 1810, right-hand armature and back contact of relay 1809, winding of relay 1824, front contact of left-hand armature of relay 1806, outer left-hand armature and back contact of magnet 1851, outer left-hand armature and front contact of magnet 1801, back contact and inner right-hand armature of magnet 1801, right-hand low resistance winding of magnet 1801 to battery and ground. The current flowing through this circuit causes the energization of relay 1824, which becomes energized and locked up through its front contact and right-hand armature to the ground on conductor 1811. The current flowing through the windings of relays 1824 and magnet 1801 also causes the energization of magnet 1801 so that this magnet now actuates line bar 1822 and its two right-hand armatures. The actuation of line bar 1822 extends the trunk through the corresponding contacts of trunk bar 1823 to the incoming selector in the distant office, here shown in Fig. 27.

The energization of relay 1824 results in the establishment of a circuit from ground on conductor 1811 through the inner left-hand armature and front contact of relay 1824, winding of relay 1809 to battery and ground. Relay 1809 becomes locked in a circuit including its front contact and right-hand armature, the right-hand armature and front contact of relay 1810 to ground on conductor 1811. The circuit controlled by the left-hand armature and back contact of relay 1809 is now controlled by the front contact and outer left-hand armature of relay 1824. Upon the movement of the right-hand armatures of relay 1801, the circuit of relay 1824 is broken and this relay becomes deenergized but the relay 1809 remains energized. Therefore, the ground extended from conductor 1811 to the left-hand armature of relay 1808 for the energization of relay 1810 is now open, but relay 1810 is maintained energized through the operation of relay 1816.

It should be noted that upon the first energization of relay 1808, a circuit is established from ground, winding of relay 1812, conductor 1811, left-hand armature and back

contact of relay 1809, left-hand armature and front contact of relay 1808, conductor 1829, left-hand armature and back contact of relay 1810, armature and back contact of magnet 1814, right-hand armature and back contact of relay 1815, winding of slow-to-release relay 1816 to battery and ground. Relay 1816 is energized in this circuit and through the movement of its left-hand armature connects ground on conductor 1829 to the left-hand winding of relay 1815. Relay 1815 now becomes energized and through the movement of its right-hand armature opens the circuit of relay 1816 and at the same time locks up through its right-hand winding, its front contact and right-hand armature to the ground instrumental in the energization of relay 1816. Relay 1816 being slow to release does not immediately retract its armatures. When relay 1816 does retract its armatures, the circuit movement hereinbefore described has been completed so that now ground will be entirely removed from conductor 1829, and relay 1810 in series with magnet 1819 will be deprived of current. Relay 1810 becomes deenergized and opens the connection through the winding of magnet 1814 so that this magnet retracts its armatures and moves the preference switch wiper 1817 to its next position. Magnet 1819 also becomes deenergized and returns trunk bar 1823 to normal position leaving only the contacts corresponding to line bar 1822 in their operating position. This completes the operation of the outgoing trunk secondary line switch.

During the operation of the translator and the outgoing trunk secondary line switch, the timing relays in the marker have been operated. Thus, upon the energization of relay 2410, a circuit is completed through the right-hand armature and back contact of relay 2415, winding of relay 2416 to battery and ground. Relay 2416 attracts its armature and extends ground through its front contact and armature to the winding of relay 2417 which now becomes energized. Relay 2417 extends ground through its armature and front contact to the winding of relay 2415 which locks up through its front contact and right-hand armature to the ground on conductor 2419. Both relays 2416 and 2417 are slow to release so that after the energization of relay 2415 a certain time elapses before relay 2416 will retract its armatures. When this occurs, the circuit of relay 2417 is opened and after a short interval this relay retracts its armatures. A circuit is now completed from ground, the armature and back contact of relay 2417, the front contact and left-hand armature of relay 2415, winding of relay 2409 to battery and ground. Relay 2409 becomes energized and functions to signal the release of the marker. The release of the marker is accomplished through the energization of relay 2409 which opens the circuit of relay 2410. When the armatures of relay 2410 resume their normal position, a circuit is established from ground, right-hand armature and back contact of relay 2410, front contact and outer left-hand armature of relay 2409, winding of relay 2406 to battery and ground. Relay 2406 locks up through ground on the back contact and armature of relay 2407. Relay 2406 causes the energization of relay 2407 and this relay attracts its armature.

Upon the energization of relay 2406, ground is removed from the winding of relay 2405 and this relay becomes deenergized. The deenergization of relay 2405 in turn opens the circuit of magnet 2411 whereupon wipers 2402 to 2404, inclusive, are moved onto their next contacts. The removal of ground from the winding of relay 2405 also opens the circuit of magnet 2408 so that this magnet becomes deenergized.

The deenergization of relay 2410 is followed by the deenergization of relay 2415, whereupon the energizing circuit of relay 2409 is open. Relay 2409 retracts its armatures in a short interval and opens the original energization circuit of relay 2406.

Upon the opening of the circuit of relay 2406, this relay resumes its normal position and thus the marker is restored entirely to normal.

Upon the energization of relay 2409 and before magnet 2408 is deenergized, a connection is extended from ground, right-hand armature and front contact of relay 2409, conductor 2418, corresponding contacts of the multi-contact device controlled by magnet 2408, conductor 2439, conductor 2339, conductor 2139, winding of marker release relay 2118 to battery and ground. Relay 2118 becomes energized in this circuit and locks up through its front contact and left-hand armature to the ground on conductor 2150.

The operation of relay 2118 results in the establishment of a circuit from ground on conductor 3550 through the outer right-hand armature and front contact of relay 3504, conductor 3526, conductor 2626, conductor 2526, conductor 2326, conductor 2126, left-hand armature and back contact of relay 2117, outer right-hand armature and front contact of relay 2118, back contact and left-hand armature of relay 2119, conductor 2129, conductor 2329, armature and back contact of relay 2309, winding of relay 2307, to battery and ground. Relay 2307 becomes energized in this circuit and attracts its armatures. Through the movement of its right-hand armature, relay 2307 connects the impulse relay 2308 across the impulse

circuit leading to the incoming selector in the distant office.

A circuit is now established from battery, the left-hand high resistance winding of relay 2905, inner left-hand armature and back contact of magnet 2901, conductor 2976, conductor 2776, back contact and inner lower armature of relay 2702, conductor 2774, conductor 1874, corresponding contacts of trunk bar 1823 and line bar 1822, conductor 1876, conductor 1776, corresponding contacts of line bar 1714 and trunk bar 1710, conductor 1774, conductor 1974, corresponding contacts of line bar 1922 and trunk bar 1923, conductor 1976, conductor 2176, outer left-hand armature and back contact of relay 2100, conductor 2174, conductor 2374, resistance 2330, resistance 2331, front contact and outer upper armature of relay 2335, conductor 2376, front contact and right-hand armature of relay 2307, winding of relay 2308, upper inner armature and front contact of relay 2335, resistance 2332, resistance 2333, conductor 2373, conductor 2173, back contact and inner left-hand armature of relay 2100, conductor 2175, conductor 1975, corresponding contacts of trunk bar 1923 and line bar 1922, conductor 1973, conductor 1773, corresponding contacts of trunk bar 1710 and line bar 1714, conductor 1775, conductor 1875, corresponding contacts of line bar 1822 and trunk bar 1823, conductor 1873, conductor 2773, inner upper armature and back contact of relay 2702, conductor 2775, conductor 2975, and back contact and outer left-hand armature of magnet 2901 to ground. Line relay 2905 and impulse relay 2308 becomes energized in this circuit.

The energization of line relay 2905 results in the establishment of a circuit from battery, the right-hand low resistance winding of magnet 2901, right-hand low resistance winding of line relay 2905, front contact and right-hand armature of relay 2905, left-hand, armature and back contact of group relay 2906, winding of group relay 2907 to ground. Relay 2907 becomes energized in this circuit and attracts its armature whereupon another circuit is established from battery, left-hand winding of relay 2906, front contact and armature of relay 2907, back contact and left-hand armature of relay 2908, back contact and left-hand armatures of relay 2909, conductor 2911, winding of relay 2912 to ground. Relay 2912 becomes energized in this circuit and through the movement of its armature extends ground to conductor 2913, which leads to an alarm circuit and operates a device thereat in a manner similar to that hereinbefore described. Relay 2906 also becomes energized in this circuit and opens the energizing circuit of relay 2907, which in turn becomes deenergized and opens the original energizing circuit of relay 2906, but before relay 2906 can become deenergized, it is locked in a circuit from battery, right-hand winding of relay 2906, front contact and right-hand armature of relay 2906, winding of relay 2908, back contact and left-hand armature of relay 2909 to the ground on conductor 2911. Relay 2908 now becomes energized and extends a connection from ground on conductor 2911 through the left-hand armature and back contact of relay 2909, left-hand armature and front contact of relay 2908, left-hand armature and back contact of relay 2910, preference switch wiper 2917 and its second contact, outer left-hand armature and back contact of relay 2918, winding of magnet 2919 to battery and ground. Magnet 2919 becomes energized in this circuit and through the movement of its armatures extends the ground through which it was energized to conductor 2920. The ground on conductor 2920 is extended to one terminal of relay 2910 but this relay having ground on its other terminal does not become energized at this time. Magnet 2919 also attracts its outer left-hand armature and connects ground to the winding of relay 2918. Relay 2918 in turn becomes energized and cuts off the original energizing circuit of magnet 2919 so that this magnet is now maintained energized in series with the relay 2910 which becomes energized. The energization of relay 2910 extends a circuit from ground, winding of relay 2912, conductor 2911, left-hand armature and back contact of relay 2909, left-hand armature and front contact of relay 2908, conductor 2929, left-hand armature and front contact of relay 2910, winding of magnet 2914 to battery and ground. Magnet 2914 becomes energized and prepares to move preference switch wiper 2917 ahead.

The energization of relay 2910 also provides a circuit from the ground on conductor 2911 through the right-hand armature and front contact of relay 2910, the right-hand armature and back contact of relay 2909, the front contact and left-hand armature of relay 2906, the right-hand armature and front contact of relay 2905, the right-hand low resistance winding of relay 2905, the right-hand low resistance winding of magnet relay 2901 to battery and ground. Magnet 2901 is energized in this circuit and by attracting its armatures, cuts off the original circuit of relay 2905, but this relay is maintained energized in a locking circuit through its right-hand low resistance winding. A circuit is now established from the outer left-hand armature and front contact of magnet 2901, front contact and left-hand armature of relay 2905, the winding of relay 2909, to battery and ground. Relay 2909 attracts its armatures and locks through its

front contact and right-hand armature to the ground which was extended to magnet 2901.

The energization of magnet 2901 also actuates line bar 2922 so that connection is made between the corresponding contacts of line bar 2922 and trunk bar 2923, whereupon ground is extended from conductor 2933 in a manner which will be shortly explained through the corresponding contacts of trunk bar 2923 and line bar 2922 to conductor 2935, which is now extended through the two windings of magnet 2901 in series to maintain this magnet energized.

The energization of relay 2909 opens the original circuit of relay 2908, but this is maintained in another circuit controlled by the right-hand armature of relay 2916. It should be noted here that upon the first energization of relay 2908, circuit is established from ground, winding of relay 2912, conductor 2911, back contact and left-hand armature of relay 2909, left-hand armature and front contact of relay 2908, left-hand armature and back contact of relay 2910, armature and back contact of magnet 2914, right-hand armature and back contact of relay 2915, winding of relay 2916 to battery and ground. Relay 2916 becomes energized in this circuit and extends the ground on conductor 2911 through the left-hand armature and front contact of relay 2916 to the left-hand winding of relay 2915. Relay 2915 now becomes energized and opens the energizing circuit of relay 2916, at the same time locking up through its right-hand winding, its front contact and right-hand armature to the ground originally extended to the winding of relay 2916. After an interval, during which the circuit movement hereinbefore described has taken place, relay 2916 becomes deenergized thereupon opening the circuit of relay 2908 and relay 2906, and these relays become deenergized. Ground being now removed from conductor 2929, relay 2910 in series with the winding of magnet 2919 becomes deenergized and this relay and magnet retract their armatures. Magnet 2919 restores trunk bar 2923 to normal leaving only the contacts associated with line bar 2922 in operated position. The deenergization of relay 2910 also opens the circuit of magnet 2914 which thereupon becomes deenergized and moves the wiper 2917 to its next position. This completes the circuit movement in the sender selector switch.

Upon energization of relay 2918, a circuit is established from ground, front contact and right-hand armature of relay 2918, conductor 2931, conductor 3131, armature and back contact of magnet 3101, left-hand armature and back contact of relay 3106, wiper 3104 and its normal contact, winding of magnet 3101 to battery and ground. Magnet 3101 becomes energized in this circuit and by opening its own circuit automatically becomes deenergized and moves the wipers 3102 to 3105 inclusive, forward onto their first active contacts. The grounded conductor 3131 is also extended through the right-hand armature and back contact of relay 3107, the right-hand armature and back contact of relay 3108, winding of relay 3109 to battery and ground so that this relay becomes energized.

Upon the energization of magnet 2919, ground is placed on conductor 2930 and extended through conductor 3130, the right-hand armature and back contact of relay 3106, conductor 3133, conductor 2933, corresponding contacts of trunk bar 2923 and line bar 2922, conductor 2935 and thence to the windings of magnet 2901 in series. This ground is also extended over conductor 2935 to conductor 2735 through the normal contacts of the left-hand armature of relay 2703 to conductor 2731 where it functions as a holding circuit.

As the wiper 3102 is moved onto its first active contact, a circuit is established from the ground on conductor 3131, wiper 3102, armature and front contact of relay 3109, winding of relay 3100 to battery and ground, whereby relay 3100 attracts its armatures for a purpose which will be explained hereinafter. Upon the movement of wiper 3103 onto its second active contact, a potential circuit is established from the ground on conductor 3131 through wiper 3103, the contact and armature of relay 3100 to the winding of release relay 3106 and in multiple therewith relay 3118, but neither of these relays is energized at this time due to the energization of relay 3100, just explained. Upon the movement of wiper 3105 onto its second contact, a circuit is established from ground, wiper 3105, conductor 3132, conductor 2932, inner left-hand armature and front contact of relay 2918 to battery and ground whereby relay 2918 is maintained energized to mark trunk bar 2923 as busy until wiper 3105 is returned to normal.

Upon the movement of wipers 3102 to 3105, inclusive, onto their first active contacts, the timing relays 3110 and 3111 come into play. Circuit may be traced from ground on conductor 3131 through the armature and back contact of magnet 3101, left-hand armature and back contact of relay 3106, wiper 3104, left-hand armature and back contact of relay 3111, winding of relay 3110 to battery and ground. Relay 3110 attracts its armatures and extends the ground on conductor 3131 through its armature and front contact to the winding

of relay 3111. Relay 3111 is energized in this circuit and locks up through its front contact and left-hand armature to the ground supplied for the energization of relay 3110. This opens the circuit of relay 3110 and after a short interval this relay retracts its armatures whereupon the circuit is established from ground on conductor 3131 through the armature and back contact of relay 3110, the front contact and right-hand armature of relay 3111, winding of magnet 3101 to battery and ground. Magnet 3101 becomes energized in this circuit and attracting its armature, opens up the circuit of relay 3111 which after an interval retracts its armatures, thereby opening the circuit just traced for the energization of magnet 3101. Upon its deenergization, magnet 3101 steps the brushes 3102 to 3105, inclusive, forward on to their second active contacts.

In the manner described, relays 3110 and 3111 go through their cycle of operation and cause the wipers 3102 to 3105, inclusive, to travel forward. These relays are so adjusted and timed that the operations following will be completed under normal conditions before wipers 3102 to 3105, inclusive, have reached their last contacts.

In the meantime and upon the engagement of the corresponding contacts of line bar 2922 and trunk bar 2923, the impulse circuit including conductors 2975 and 2976 is extended to conductors 2973 and 2974, respectively. Conductor 2973 may be traced over conductor 3173, the outer right-hand armature and back contact of relay 3112, conductor 3176, conductor 3376, windings of the minus impulse responsive relay 3314, winding of the plus impulse responsive relay 3313, winding of the marginal impulse responsive relay 3312, conductor 3375, conductor 3175, back contact and outer left-hand armature of relay 3112, conductor 3174 to conductor 2974. Thus the impulse circuit is extended from the impulse sender in Fig. 23 to the impulse responsive means in the distant office, here shown in Fig. 33.

Return now to the operations in the impulse sender in Fig. 23. It is noted that relay 2308 was energized in series with the winding of line relay 2905. The energization of relay 2308 extends ground from conductor 2329 over the front contact and armature of relay 2308, winding of relay 2310, to battery and ground. Relay 2310 extends this ground to the winding of relay 2309 but since the other terminal of relay 2309 is connected also to conductor 2329, relay 2309 does not become energized this time. Upon the energization of magnet 2901, relay 2308 becomes deenergized and in retracting its armatures opens the circuit of relay 2310 but this relay is now maintained energized in series with relay 2309. Relay 2309 becomes energized and opens the circuit of relay 2307.

Upon the energization of relay 2307 hereinbefore described, a circuit is extended from ground, wiper 2302 and its normal contact, the front contact and left-hand armature of relay 2307, the contact and armature of magnet 2311 to battery and ground and in parallel therewith through the normal contact of wiper 2319, winding of relay 2312 to battery and ground. Relay 2312 and magnet 2311 become energized from this circuit. Magnet 2311 upon attracting its armature, opens its own circuit and immediately becomes deenergized thus moving wipers 2302 and 2306 onto their first active contacts. Relay 2312 is maintained energized through the movement of wiper 2302 onto its first active contact and the extension of ground therefrom over the front contact and inner left-hand armature of the numerical relay 2313, the normal contact and wiper 2319, winding of relay 2312 to battery and ground. This also causes the energization of magnet 2311 and since the first, second and third active contacts associated with wiper 2302 are multipled together, this circuit is maintained until the magnet 2311 has, through its automatic operation, moved the wipers 2302 to 2306 inclusive, onto their fourth active contacts where magnet 2311 and relay 2312 become deenergized.

The operations described up to this point have taken place immediately after the receipt of the impulses representing the third office code designation resulting in the energization of relay 3504, and during this interval, the rest of the impulses representing the thousands, hundreds, tens and units designation have been operating the relays 2115 and 2116. It was hereinbefore noted that the connection now being described is being extended to a mechanical office wherein there are no party lines and therefore no stations designation is being transmitted. However, it was pointed out that in spite of the fact that no stations designation was recorded by the calling subscriber, the designation "zero" was to be sent from the originating office to the mechanical switching center. The function of this is to cause the energization of relay 2502. Upon the energization of this relay, which acts as a signal that the complete train of impulses has been sent and received, a circuit is established from ground on conductor 2550, the outer right-hand armature and front contact of relay 2502, winding of relay 2505 to battery and ground. Relay 2505 attracts its armatures and establishes a circuit from ground, the inner right-hand armature and front contact of relay 2505, conductor 2534, conductor 2334, back contact and inner

right-hand armature of relay 2336, fourth active contact and wiper 2305, armature of the back contact of relay 2312, conductor 2337, back contact and armature of magnet 2338, wiper 2318 and its normal contact, winding of magnet 2338 to battery and ground. Magnet 2338 becomes energized in this circuit. At the same time, ground on conductor 2337 is extended through the outer lower armature and back contact of relay 2341, left-hand armature and back contact of relay 2348, winding of relay 2349 to battery and ground. Relay 2349 becomes energized in this circuit. Upon the energization of magnet 2338, this magnet opens its own circuit and becoming deenergized moves the wipers 2315 to 2319, inclusive, which it controls, onto their first active contacts.

Wiper 2319 moving onto its first active contact, extends ground to the winding of relay 2312 which becomes energized and removes the original ground from conductor 2337 and switches it onto the winding of magnet 2311. This magnet now becomes energized and will remain energized until relay 2312 becomes again deenergized.

Upon the movement of the impulse sending switch onto its first active contacts, the impulse circuit hereinbefore described is connected through the upper armatures and back contacts of relay 2341 to wipers 2315 and 2316. The result of this action will be described hereinafter.

The movement of wiper 2318 to its first active contacts connects ground through the armature and back contact of magnet 2338 to conductor 2337 to maintain relay 2349 energized. The energization of this relay connects ground from wiper 2318 through the armature and front contact of relay 2349 to the winding of relay 2348 so that this relay now becomes energized. In attracting its armatures, relay 2348 locks up through its front contact and left-hand armature to the ground on conductor 2337. The energizing circuit of relay 2349 is now opened and after a short interval, this relay retracts its armature whereupon the ground is extended from wiper 2318 over armature and back contact of relay 2349, contact and right-hand armature of relay 2348, the outer right-hand armature and back contact of relay 2347, winding of relay 2341 to battery and ground. Relay 2341 becomes energized and in attracting its armatures cuts off the impulse circuit from wipers 2315 and 2316 and at the same time opens the locking circuit of relay 2348. Relay 2348 now becomes deenergized, and by retracting its armatures, opens the original energizing circuit of relay 2341, but this relay is maintained energized through its inner lower armature and front contact, winding of relay 2347, conductor 2337, back contact and armature of magnet 2338, wiper 2318 to ground. The energization of relay 2347 now provides a new energizing circuit for relay 2349 which may be traced from ground, wiper 2318, armature and back contact of magnet 2338, conductor 2337, inner right-hand armature and front contact of relay 2347, left-hand armature and back contact of relay 2348, winding of relay 2349, to battery and ground. Relay 2349 becomes energized and in attracting its armature establishes a circuit from ground, wiper 2318, armature and front contact of relay 2349, winding of relay 2348 to battery and ground. Relay 2348 attracts its armatures and locks up through its front contact and left-hand armature to the ground which was extended to the winding of relay 2349. Relay 2349 now becomes deenergized and in retracting its armature establishes a circuit from ground, wiper 2318, armature and back contact of relay 2349, front contact and right-hand armature of relay 2348, outer right-hand armature and front contact of relay 2347, winding of magnet 2338 to battery and ground. Magnet 2338 becomes energized in this circuit and by attracting its armature removes ground from conductor 2337, whereupon relays 2341 and 2347 and 2348 and magnet 2338 return to normal. The deenergization of magnet 2338 causes the wipers 2315 to 2319 inclusive, to move forward onto their second active contacts. This cycle of operations is now repeated so that wipers 2315 to 2319, inclusive, move forward, step by step, until they are returned to their normal position. At this time, ground being removed from wiper 2319 as it passes from its fourth active contact to its normal contact relay 2312 becomes deenergized.

The deenergization of relay 2312 is followed by the deenergization of magnet 2311, whereupon wipers 2301 to 2306 inclusive, are moved onto their fifth active contacts corresponding to the thousands register. In this position, ground is extended from conductor 2650 over the outer right-hand armature and front contact of relay 2600, conductor 2658, conductor 2558, conductor 2358, fifth active contact and wiper 2305, armature and back contact of relay 2312 to conductor 2337, thus starting the impulse switch again. With this explanation, it is believed that the action of the impulse sending switch controlled by magnet 2338 and the impulse control switch controlled by magnet 2311 will be readily understood without further description.

In a manner similar to that hereinbefore described as wipers 2315 and 2316 travel from their normal contacts over their active contacts, and thence back again to their normal contacts, impulses are propagated and transmitted over the impulse circuit to oper-

ate the impulse responsive relays at the terminating office. The first set of impulses sent will correspond to the digit "0" registered on the stations register, here represented by the second set of code relays at the right of Fig. 25. Since none of these code relays are energized, this will result in the sending of two weak negative impulses. The manner in which this is accomplished is as follows.

Upon the movement of wipers 2315 and 2316 on to their first active contacts, no circuit will be established. Wiper 2315 will be connected to ground and wiper 2316 will be connected to conductor 2340, which extends to conductor 2540, next to the outer right-hand armature of relay 2544, and thence to the front contact and right-hand armature of the A relay, but since the A relay is not energized, this circuit is open. Relay 2544 is energized at this time through a connection from ground on wiper 2304, fourth active contact, middle right-hand armature and back contact of relay 2336, conductor 2345, conductor 2545, winding of relay 2544.

As wipers 2315 and 2316 move to their second active contacts, a circuit is established from ground, wiper 2316, over the impulse circuit and thence back to wiper 2315, high resistance 2342, to battery and ground. This establishes a flow of current in the direction to energize relay 3314. With wipers 2315 and 2316 on their third active contacts, no impulse is sent, and when they have moved to their fourth active contacts, another weak negative impulse is sent.

For further illustration, the sending of the digit 1 will be here noted. When the wipers 2315 and 2316 return to normal, magnet 2311 is deenergized in the manner hereinbefore described and moves the impulse control switch to its fifth active contact. Thereupon a circuit is established from ground, wiper 2304 and its fifth active contact, conductor 2353, conductor 2553, conductor 2653, winding of relay 2608 to battery and ground. Now, as wipers 2315 and 2316 move on to their first active contacts, a circuit is established from ground, wiper 2315, over the impulse circuit and back to wiper 2316, conductor 2340, conductor 2540, conductor 2640, next to the outer right-hand armature and front contact of relay 2608, front contact and inner right-hand armature of relay 2606, conductor 2661, conductor 2561, conductor 2361, fifth active contact and wiper 2303 outer left-hand armature and back contact of numerical relay 2313, resistance 2342, to battery and ground. Thus current is caused to flow in the impulse circuit in such a direction as to energize relay 3313. The complete set of impulses will not be further described. In place thereof the following table is presented:

Designation.	Digit.	Position of impulse control switch.	Position of impulse sending switch.	Impulses.	Relays directly affected by impulses. 3312.	3313.	Local relays affected. 3314.	3315.	3316.	Counting relays energized.	Code relays energized.	Code relays here designated.
Stations.	---	4	1	---								
	---	4	2	−			V	V		3300		
	---	4	3	---				V	V			
	---	4	4	−			V		V			
	---	5	N.	---						3301		
Thousands.	1	5	1	+		V					A	3404
	---	5	2	−			V	V		3400		
	---	5	3	---				V	V			
	---	5	4	−			V		V			
	---	6	N.	---						3401		
Hundreds.	1	6	1	+		V					A	3405
	---	6	2	−			V	V		3402		
	---	6	3	---				V	V			
	---	6	4	−			V		V			
	---	7	N.	---						3403		
Tens.	0	7	1	---								
	---	7	2	−			V	V		4200		
	---	7	3	---				V	V			
	---	7	4	−			V		V			
	---	8	N.	---						4201		
Units.	2	8	1	---								
	---	8	2	H−	V		V	V		4202	A	4204
	---	8	3	---				V	V			
	---	8	4	−			V		V			
	---	9	N.	---						4203		

The table herein presented is divided into a number of columns. The first column, headed "Designation" shows the order in which the digits are sent and received. This order is stations, thousands, hundreds, tens and units. It should be noted at this point that a call is now being described as extending to a terminating office where there are no stations designations, that is, there are no party lines. Since the majority of offices in any district will be equipped for party lines, it is necessary to equip the mechanical switching center with apparatus to send stations designations. In the drawings here used to illustrate this invention, a stations register is shown in Fig. 33, but as has been described, this stations register will not be set since the digit 0 will in all cases like the present be sent. In actual practice, the code relays A, B, C and D would not be installed in a terminating office where there are no party lines, but only the counting relays 3300 and 3301 would be provided. These counting relays will absorb the first set of impulses corresponding to the stations digit 0 so that when the thousands designation is transmitted, the code relays A, B, C and D to the left in Fig. 34 will be energized in their proper order.

Another method which may be pursued would be to leave out the stations register consisting of the four code relays A, B, C and D to the right in Fig. 33 and the two counting relays 3300 and 3301 and to cause the class indicator in the mechanical switch center to energize relay 2336. This relay is known as the "stations last" relay and

causes the normal order of the sending of impulses to be reversed so that the thousands designation is sent first and the stations designation last.

The circuits are shown in the form here given for the reason that several classes of calls must be described, and there would be a mere useless duplication of drawings to show the different classes of registers. Thus the block of sixteen drawings representing the terminating office includes a stations register and means for operating party lines, but in the present description this party line apparatus will be ignored and treated as if it were absent.

The second column of the table just given represents the digit sent. It will be noted that only the digits 1102 representing the line number of the called line at the terminating office are sent. The three office code designations hereinbefore used in setting the district selector and the office selector are not repeated into the terminating office because their function has been fully performed.

The third column represents the position in which the impulse control switch is placed during the sending of the impulses representing the digits noted in the second column. This impulse control switch comprises magnet 2311 and wipers 2301 to 2306 inclusive.

The fourth column of this table represents the position of the impulse sending switch comprising magnet 2338, controlling relays 2341, 2347, 2348 and 2349, and wipers 2315 to 2319 inclusive. For each step of the impulse control switch the impulse sending switch makes a complete cycle.

The fifth column of this table represents the impulses sent. The characters here used are the same as those used in a previous table.

The sixth, seventh and eighth columns tabulate the action of the relays which are directly affected by the impulses. Looking down these three columns it will be noted that relay 3312 is affected only by a strong negative impulse, as for instance when the digit "2" is being sent and while the impulse sending switch is on its second active contact. It will be noted also that relay 3313 responds only to the plus impulses, as for instance when the digit "1" is being sent and the impulse sending switch is resting on its first active contact. Relay 3314 is responsive to negative impulses, both weak and strong.

The ninth and tenth columns of this table represent the action of the pair of relays which is responsive to the operation of the three relays included in the impulse circuit. These two relays are included in a circuit arrangement including a contact point (front contact of relay 3314) in such a manner that the successive openings and closings of this contact point cause these two relays to be energized in all possible combinations.

The eleventh column of this table presents the counting relays which are operated and indicates the point at which they become energized. It should be noted that relays 3312 to 3316 inclusive are energized only in the positions in which they are checked, while the counting relays become energized and remain energized thereafter until the sender is released.

The twelfth and thirteenth columns of this table represent the code relays and indicate the point at which they are energized. These code relays, like the counting relays, after becoming energized remain in that condition until the sender is released. Thus the sending of called number 1102 results in the energization of the A relay in the thousands register, the A relay in the hundreds register, none of the relays in the tens register, and the B relay in the units register. This is in accordance with the code hereinbefore given.

As the last impulse of this train of impulses is sent, the impulse sending switch passes on to its normal contact, and the impulse control switch is moved on to its ninth active contact. In this position a circuit is established from ground, wiper 2301 and its ninth active contact, conductor 2357, conductor 2557, front contact and left-hand armature of relay 2505, back contact and left-hand armature of relay 2506, back contact and left-hand armature of relay 2507, conductor 2568, conductor 2368, conductor 2168, back contact and right-hand armature of relay 2138, winding of sender release relay 2100. Sender release relay 2100 becomes energized in this circuit, and through its front contact and inner right-hand armature locks up to the ground on conductor 2131. At the same time this relay releases relay 2110 so that relay 2110 becomes deenergized and extends a connection from ground on conductor 2131, wiper 2103, armature and back contact of relay 2110, conductor 2159, conductor 2359, wiper 2306, and its ninth active contact, back contact and armature of magnet 2311, winding of magnet 2311 to battery and ground. Magnet 2311 is thus included in a self-interrupting circuit, and it therefore vibrates its armatures and moves the wipers 2302 and 2306 on to their normal positions.

Sender release relay 2100 closes a circuit from ground, front contact and outer right-hand armature of relay 2100, conductor 2134, conductor 1934, corresponding contacts of trunk bar 1923 and line bar 1922, conductor 1936, conductor 1736, left-hand armature and front contact of relay 1703, winding of relay 1702, to battery and ground. Relay 1702 becomes energized in this condition and

locks up through its front contact and outer lower armature to the ground on conductor 1731.

It will be shown hereinafter that almost simultaneously with this action that relay 2702 in the incoming selector at the distant office is energized, thus connecting ground and battery to the talking conductors. This provides a current path through the windings of relay 1701, which now becomes energized, and through the movement of its armatures energizes the left-hand winding of relay 1700. This relay, which was previously energized through its right-hand winding will shortly lose its energizing circuit through the release of the sender selector in Fig. 19 so that this substitute energizing circuit through its left-hand winding is closed at this time. Relay 1700 maintains its ground on conductor 1731.

The movement of the left-hand armatures of the sender release relay 2100 also disconnects the impulse circuit from the impulse sending switch of Fig. 23 so that this circuit is ineffective for the sending of more impulses.

As the impulse control switch moves its wipers to their normal position, a circuit is established from ground on conductor 2131, wiper 2103, armature and back contact of relay 2110, conductor 2159, conductor 2359, wiper 2306, conductor 2351, conductor 2151, winding of relay 2106, to battery and ground. Relay 2106 becomes energized, and by removing ground from conductor 2150 causes the release of all of the code relays in Figs. 25, 26 and 36, and the other relays shown in Figs. 21 and 23, which are depending on this ground for their continued energization at this time. Relay 2106 locks up through its front contact and inner right-hand armature to the ground of conductor 2131. A circuit is now closed from ground, wiper 2105, conductor 2132, conductor 1932, inner left-hand armature and front contact of relay 1918, conductors 1930 and 2130, back contact and armature of magnet 2101, left-hand armature and front contact of relay 2106, winding of magnet 2101 to battery and ground. Magnet 2101 is thus included in a self-interrupting circuit and thereby causes the wipers 2102 to 2105 inclusive to move on to their normal contacts. In this position, relay 1918 is deenergized, and by removing ground from conductor 1930 and 1931, causes the release of relays 2100 and 2106. At the same time, ground is removed from conductor 2133, thus allowing line bar magnet 1901 to become deenergized, whereby the sender selector switch is returned to normal position. The circuit is now established from the calling line, through the various switches in the originating office and the office selector with its secondary line switch, shown in Fig. 18, to the incoming selector of the terminating office here shown in Fig. 27.

We will now consider the operations taking place at the distant office. Upon the completion of the receipt of impulses representing the hundreds digit, relay 3402 becomes energized. This relay establishes a circuit from ground, its innermost left-hand armature and front contact, conductor 3417, conductor 3317, conductor 3117, winding of relay 3113, to battery and ground. Relay 3113 is energized in this circuit and is instrumental in completing other circuits as follows: from battery, left-hand armature and front contact of relay 3113, conductor 3116, conductor 3216, conductor 3416, outer left-hand armature and back contact of relay 3407, left-hand armature and back contact of relay 3408, the outer right-hand armature and front contact of relay 3404, conductor 3409, conductor 3209, winding of relay 3200, conductor 3210, conductor 3410, back contact and inner right-hand armature of relay 3407, conductor 3450, conductor 3350, conductor 3150, back contact and armature of relay 3118, to battery and ground. Relay 3200 becomes energized in this circuit. The energization of relay 3113 also establishes another circuit which may be traced from ground on conductor 3150, the inner right-hand armature and back contact of relay 3114, the outer right-hand armature and front contact of relay 3113, conductor 3115, conductor 3215, conductor 3015, winding of relay 3000, to battery and ground. Relay 3000 now becomes energized. This results in the establishment of a circuit from battery, the upper winding of magnet 3001, front contact and armature of relay 3000, back contact and inner right-hand armature of relay 3002, back contact and left-hand armature of relay 3003, back contact and armature of relay 3004, to ground. Magnet 3001 now becomes energized and attracts its armature, and actuates the multicontact device shown diagrammatically above it. Magnet 3001 now locks up in a circuit from battery, its lower winding, its front contact and lower armature, winding of relay 3002, and thence over the circuit previously described to ground connected to the armature of relay 3004. Relay 3002 now becomes energized in this circuit and opens the original energizing circuit of magnet 3001. A new circuit is now established from ground, front contact and outer right-hand armature of relay 3002, inner left-hand armature and back contact of relay 3005, winding of relay 3006, to battery and ground. Relay 3006 becoming energized, establishes a circuit from ground, its left-hand armature and front contact, conductor 3012, through the corresponding contacts controlled by magnet 3001, conductor 3019, conductor 3219, conductor 3119, back

contact and outer left-hand armature of relay 3114, back contact and armature of relay 3120, conductor 3121, conductor 2921, corresponding contacts of trunk bar 2923, line bar 2922, conductor 2924, conductor 2724, outer right-hand armature and back contact of relay 2703, winding of magnet 2704, to battery and ground. Magnet 2704 becomes energized in this circuit, and attracting its armatures extends a circuit from ground, outer right-hand armature and front contact of magnet 2704, conductor 2745, conductor 2845, conductor 3045, winding of magnet 3013, to battery and ground. Magnet 3013 becomes energized and actuates the multi-contact device shown diagrammatically above it.

The energization of relay 3006 results also in the energization of relay 3007, through the right-hand armature of relay 3006. Relay 3007 closes a circuit from ground, its armature and front contact, conductor 3010, corresponding contacts controlled by magnet 3001, conductor 3022, conductor 3222, conductor 3122, the outer right-hand armature and back contact of relay 3123, conductor 3124, conductor 3224, right-hand armature and front contact of relay 3200, conductor 3214, conductor 3014, corresponding contacts controlled by magnet 3001, conductor 3016, corresponding contacts controlled by magnet 3013, conductor 3026, conductor 2826, conductor 2726, armature and back contact of relay 2712, winding of magnet 2713, to battery and ground. Magnet 2713 becomes energized in this circuit and actuates the trunk bar 2714 so that connection is made between the corresponding contacts of line bar 2714 and trunk bar 2710.

The energization of relay 3007 results also in the establishment of a circuit from ground, armature and front contact of relay 3007, inner left-hand armature and back contact of relay 3008, winding of relay 3009, to battery and ground. Relay 3009 becomes energized, and through the attraction of its armatures causes the energization of relay 3008. Relay 3008 now locks up through its front contact and inner left-hand armature, to the ground which causes the energization of relay 3009. After a short interval, relay 3009 retracts its armature, whereupon a circuit is established from ground, armature and back contact of relay 3009, front contact and outer left-hand armature of relay 3008, winding of relay 3005, to battery and ground, so that this relay now becomes energized and locked up through its front contact and inner left-hand armature to the ground supplied by the outer right-hand armature of relay 3002. Relay 3005 establishes a circuit from ground, outer left-hand armature and front contact of relay 3005, conductor 3017, corresponding contacts controlled by magnet 3001, conductor 3025, conductor 3225, conductor 3125, outer left-hand armature and back contact of relay 3123, winding of relay 3114, to battery and ground. Relay 3114 becomes energized and locks up through its front contact and inner right-hand armature to the ground on conductor 3150. The energization of relay 3114 removes ground from conductor 3115, hereinbefore described as extending to the winding of relay 3000. Relay 3000 therefore becomes deenergized.

At the same time the energization of relay 3005, just described, opens the circuit of relay 3006 so that this relay after a short interval retracts its armatures. This results in the deenergization of the relay 3007, which, being a slow to release relay retracts its armatures after an interval. Relay 3007 in turn opens the circuit of relay 3008, whereupon this relay becomes deenergized. When the armature of relay 3007 returns to its normal position, a circuit is completed from ground, armature and back contact of relay 3007, front contact and right-hand armature of relay 3005, winding of relay 3003, to battery and ground. Relay 3003 becomes energized and causes the energization of relay 3004. Ground now being removed from the winding of relay 3002, this relay in series with the lower winding of magnet 3001 becomes deenergized, and both relay 3002 and magnet 3001 retract their armatures.

The deenergization of relay 3006 just described opens the energizing circuit of magnet 2704, whereupon this magnet retracts its armatures and returns trunk bar 2710 to normal position, leaving only the contacts corresponding to line bar 2714 in an operated position. The deenergization of magnet 2704 extends the ground on conductor 2731 through the inner right-hand armature and back contact of magnet 2704, corresponding contacts of trunk bar 2710 and line bar 2714, winding of relay 2712, winding of magnet 2713, to battery and ground. As soon as the ground is removed from conductor 2726, which happens as soon as magnet 3001 retracts its armatures, relay 2712 becomes operated in series with magnet 2713.

The retraction of its armatures by magnet 2704 removes ground from conductor 2745, resulting in the deenergization of magnet 3013. Upon the deenergization of relay 3002, hereinbefore described, the holding circuit of relay 3005 is opened, thereby returning all of the apparatus shown in Fig. 30 to its normal position.

The energization of relay 3114 hereinbefore described also establishes a circuit from ground on conductor 3150, front contact and inner left-hand armature of relay 3114, conductor 3127, conductor 3327, conductor 3427, conductor 4227, right-hand armature and front contact of relay 4201, conductor 4211,

conductor 3411, conductor 3211, left-hand armature and front contact of relay 3200, conductor 3201, conductor 4001, winding of relay 4000, to battery and ground. Relay 4000 becomes energized in this circuit, and in attracting its armature establishes a circuit for magnet 4002, extending from battery, the upper winding of magnet 4002, front contact and armature of relay 4000, conductor 4003, conductor 3803, back contact and right-hand armature of relay 3802, armature and back contact of relay 3801, winding of relay 3800, to ground. Relay 3800 is energized in this circuit as well as magnet 4002. The energization of magnet 4002 results in the establishment of a locking circuit for this magnet from battery, lower winding, front contact and armature of magnet 4002, conductor 4004, conductor 3804, winding of relay 3802, armature and back contact of relay 3801, winding of relay 3800, to ground. Relay 3802 now becomes energized and opens the original energizing circuit of magnet 4002. By the movement of its right-hand armature, relay 3802 also closes a circuit from ground, winding of relay 3800, back contact and armature of relay 3801, right-hand armature and front contact of relay 3802, left-hand armature and back contact of relay 3809, outer left-hand armature and back contact of relay 3810, winding of slow to release relay 3811 to battery and ground. Relay 3811 becomes energized. Relay 3802 also closes another circuit from ground, left-hand armature and front contact of relay 3802, right-hand armature and back contact of relay 3805, winding of relay 3806, to battery and ground. Relay 3806 attracts its armatures and extends a connection from ground, left-hand armature and front contact of relay 3806, conductor 3819, conductor 4019, conductor 4119, to conductor 4319. The grounded conductor 4319 plays the same part in the three sets of code relays, shown in Fig. 43, as conductor 1219 plays in the corresponding relays, shown in Fig. 12.

It may be assumed by this time that all of the impulses have been received and that the units register is set. The energization of the code relays, shown in Figs. 34 and 42, will cause the energization of the corresponding code relays, shown in Fig. 43. Thus the energization of relay 3405, in Fig. 34, causes the establishment of a circuit from ground on conductor 4019, corresponding contacts controlled by magnet 4002, conductor 4018, conductor 4218, conductor 3418, left-hand armature and front contact of relay 3405, conductor 3412, conductor 4212, conductor 4012, corresponding contacts controlled by magnet 4002, conductor 4005, conductor 4105, conductor 4305, winding of relay 4303, to battery and ground. In a similar manner, the energization of relay 4204 will cause the energization of relay 4323.

A circuit is now established from ground on conductor 4319, through the inner right-hand armatures and back contacts of relays 4300, 4301 and 4302, and the inner right-hand armature and front contact of relay 4303, conductor 4304, conductor 4104, winding of magnet 4100, to battery and ground. Magnet 4100 becomes energized in this circuit. Since none of the relays 4306 to 4309 inclusive, have been energized, a circuit is now established from ground on conductor 4319, through the inner right-hand armatures and back contacts of relays 4306 to 4309 inclusive, conductor 4310, conductor 4110, corresponding contacts controlled by magnet 4100, conductor 4101, winding of magnet 4102, to battery and ground. Magnet 4102 becomes energized in this circuit.

Attention is now particularly called to the arrangement shown in Figs. 37 and 39 which illustrate a circuit arrangement identical with that shown in Fig. 5 with the addition of a cross connecting frame introduced between the conductors leading from the line bars of the primary line switch and the subscribers' lines. The working parts of the primary line switch are shown in Fig. 37 and the controlling circuits known as the master switch are shown in Fig. 39. At the right in Fig. 37 and at the right in Fig. 39, a number of terminal blocks are shown which comprise the cross connecting frame just mentioned. Terminal blocks 3713 to 3717 are those individual to the line bars of the primary line switch and are all wired in a uniform manner to the line switch. Terminal blocks 3745 to 3749 inclusive, are individual to the subscribers' lines and are wired uniformly to the lines in the same manner. In order to supply different classes of service to the subscribers' lines here numbered 3705 to 3709 inclusive, different cross connections are made between the terminal blocks of the two groups.

Line 3708, for instance, is shown as an individual line and the cross connection between the subscriber's terminal block 3748 and the line switch terminal block 3714 is made in the manner shown.

Subscriber's line 3706 illustrates a party line and it will be noted that the cross connection between the subscriber's line block 3746 and the line switch terminal block 3716 is different than in the case of the individual line.

Again the three lines 3705, 3707 and 3709 illustrate three lines leading to a single private branch exchange. For this type of service, additional terminal blocks 3943 to 3945 inclusive, are employed. Each of these terminal blocks has a relay whose terminals and contacts are uniformly wired to the

said terminal block. One of these devices is employed in connection with each private branch exchange line. In the example here given, the line 3705 is the first line in this particular group of private branch exchange lines. Associated with line 3705 is relay 3901 reached through cross connections to the terminal block 3945. The second line of this group of PBX trunks is line 3707 which has associated with it relay 3902 reached through cross connections to terminal block 3944. The last line of this group 3709 has associated with it the relay 3904 reached through cross connections to the terminal block 3943.

In the arrangement shown, line 3705 and line 3707 have line numbers and line 3709 has no line number but is reached through calling either line 3705 or 3707. We have here shown two of the group of PBX trunks as having line numbers for the purpose of illustrating what is known as "night service." In such a case, several line numbers are listed in the telephone directory as leading to different points in the private branch exchange installation and therefore, these particular points can only be reached when night service conditions are set up by calling such particular numbers. For the ordinary service in the daytime, only a single number is listed in the directory so that all lines may be reached through calling this one number.

The arrangement here shown in which an actual line leading from the exchange to a subscriber is employed having no line number forms one of the features of this invention. This feature makes it possible to have a number of lines radiating from the exchange greatly in excess of the capacity of the exchange as measured by the possible line numbers which may be listed. The number of lines such as 3709 which may be associated in a group with one line having a line number is unlimited.

In the present instance, if line 3705 is called and is busy, it will be, through the action of relay 3901, automatically switched on to line 3707 and if this line is busy the call will be automatically switched on to line 3709. In cases such as the present where two line numbers are provided for one group of PBX trunks, if the line 3707 is called and is found to be busy then the call will be automatically switched on to line 3709.

With this short explanation, we will now continue to trace the circuits which are employed in extending a call to line 3705 which has the line number WADsworth 1102. Upon the energization of relay 3806 hereinbefore described, a circuit is established from ground, right-hand armature and front contact of relay 3806 to the master switch conductor 3813 and thence extended over conductor 4013, conductor 4113, conductor 4313, left-hand armature and front contact of relay 4311, conductor 4315, conductor 4115, corresponding contacts controlled by magnet 4102, conductor 4131, conductor 3931, conductor 3731, cross connecting conductor 3733, cross connecting conductor 3933, left-hand armature and back contact of relay 3901, cross connecting conductor 3925, cross connecting conductor 3725, master switch wire 3724, conductor 3924, outer right-hand armature and back contact of relay 3908, relay 3923, relay 3909 to battery and ground. Both relays 3923 and 3909 become energized in this circuit. A circuit is now established from ground, winding of relay 3912, conductor 3911, front contact and outer left-hand armature of relay 3909, conductor 3929, right-hand armature and back contact of relay 3910, preference switch wiper 3917, left-hand armature and back contact of relay 3918, winding of magnet 3919, to battery and ground. Magnet 3919 becomes energized in this circuit and extends the ground instrumental in its energization through its inner left-hand armature and front contact over conductor 3920, winding of relay 3921 to battery and ground. Relay 3921 becomes energized and further extends this ground connection to one terminal of relay 3910 but this relay having ground connected to its other terminal through conductor 3929 does not become energized at this time. A circuit is now established from ground, winding of relay 3912, conductor 3911, front contact and inner left-hand armature of relay 3909, conductor 3949, front contact and outer left-hand armature of magnet 3919, conductor 3930, conductor 3730, conductor 3630, winding of relay 3628 to battery and ground. Relay 3628 becomes energized and extends the ground instrumental in its energization through its inner right-hand armature and front contact over conductor 3602, outer right-hand armature and back contact of relay 3608, back contact and inner left-hand armature of relay 3621, winding of relay 3609 to battery and ground. Relay 3609 now becomes energized and further extends this ground connection through its inner left-hand armature and front contact over conductor 3631, conductor 3831, winding of relay 3807, to battery and ground so that relay 3807 now becomes energized.

The energization of relay 3807 also results in the establishment of a circuit from ground, left-hand armature and front contact of relay 3807, winding of relay 3808, to battery and ground, and this relay becoming energized locks up through its inner right-hand armature and front contact and the armature and back contact of relay 3801, winding of relay 3800, to ground. Relay 3808 becoming energized, extends a connec-

tion from ground, outer right-hand armature and front contact of relay 3808, conductor 3816, conductor 4016, corresponding contacts controlled by magnet 4002, conductor 4035, conductor 3235, conductor 3135, outer right-hand armature and front contact of relay 3114, conductor 3146, winding of relay 3112, to battery and ground. Relay 3112 becomes energized and establishes a circuit from ground, front contact and inner right-hand armature of relay 3112, conductor 3126, conductor 2926, corresponding contacts of trunk bar 2933, line bar 2922, conductor 2925, conductor 2725, and thence in parallel through the windings of relays 2702 and 2703 to battery and ground. Relay 2702 in attracting its armatures, establishes a circuit from ground, the left-hand winding of relay 2705, the normal contacts of the left-hand armature of relay 2706, upper winding 2707 of the repeating coil, front contact and inner upper armature of relay 2702, conductor 2773, conductor 1873, corresponding contacts of trunk bar 1823 and line bar 1822, conductor 1875, conductor 1775, corresponding contacts of line bar 1714 and trunk bar 1710, conductor 1773, left-hand winding of relay 1701, front contact and upper armature of relay 1702, conductor 1763, conductor 863, corresponding contacts of trunk bar 823 and line bar 822, conductor 865, conductor 765, corresponding contacts of line bar 714 and trunk bar 710, conductor 763, upper armature and front contact of relay 709, upper secondary winding of repeating coil 707, outer right-hand armature and back contact of relay 717, windings of relay 715, back contact and inner right-hand armature of relay 717, lower secondary winding of repeating coil 707, front contact and lower armature of relay 709, conductor 764, corresponding contacts of trunk bar 710 and line bar 714, conductor 766, conductor 866, corresponding contacts of line bar 822 and trunk bar 823, conductor 864, conductor 1764, inner lower armature and front contact of relay 1702, right-hand winding of relay 1701, conductor 1774, corresponding contacts of trunk bar 1710 and line bar 1714, conductor 1776, conductor 1876, corresponding contacts of line bar 1822 and trunk bar 1823, conductor 1874, conductor 2774, inner lower armature and front contact of relay 2702, winding 2709 of the repeating coil, normal contacts of the right-hand armature of relay 2706, right-hand winding of relay 2705, to battery and ground. Relay 2705 becomes energized in this circuit and through its armature places ground on conductor 2731 to replace the ground supplied to this conductor through the normal contacts of the left-hand armature of relay 2703. Relay 715 is energized in this circuit, but the current now flows in such a direction that its armature is not attracted at this time. Relay 1701 is also energized in this circuit. Upon the energization of relay 2703, the ground supplied to conductor 2731 through the contacts of the sender selector switch in Fig. 29 is cut off, but a substitute ground is supplied in the manner just described. Relay 2703 locks up in a circuit from ground, armature and front contact of relay 2705, conductor 2731, alternate contacts of the left-hand armature of relay 2703, winding of such relay to battery and ground. Relay 2702 is also held energized in a circuit from ground, armature and front contact of relay 2705, conductor 2731, alternate contacts of the left-hand armature of relay 2703, conductor 2725, winding of relay 2702, to battery and ground.

Movement of the armatures of relay 2702 cuts off the impulse sending circuit from the relays 3312 to 3314, inclusive.

Upon the energization of relay 3909, a circuit is established from ground, winding of relay 3912, conductor 3911, back contact and inner left-hand armature of relay 3910, right-hand armature and front contact of relay 3909, conductor 3932, conductor 3832, winding of relay 3809 to battery and ground. The energization of relay 3809 is a signal indicating the fact that the master switch wire controlled by relay 3806 has properly entered the master switch and performed its functions at that point. The energization of relay 3807 is an indication that the master switch of the secondary line switch has been started and when this relay 3807 becomes deenergized, it will be a signal that the secondary line switch has been properly set and it will then be time for the primary line switch to be finally actuated. The energization of relay 3809 opens the original circuit of relay 3811 and this relay after an interval retracts its armatures. In the meantime, however, a circuit is established from ground, winding of relay 3800, back contact and right-hand armature of relay 3801, right-hand armature and front contact of relay 3802, left-hand armature and front contact of relay 3809, winding of relay 3810 to battery and ground. Relay 3810 becomes energized and locks up through its inner left-hand armature and front contact to the ground supplied by the winding of relay 3800. During the interval between the energization of relay 3809 and the deenergization of relay 3811, the busy test relay 3812 is connected through the conductor 3839, front contact and right-hand armature of relay 3811, the front contact and right-hand armature of relay 3809 to conductor 3814 which is known as the "line bar" wire and leads, as will be hereinafter seen, over conductor 3703 to the winding of line bar magnet 3701. In the case of a PBX line however, this test connection has no function, but instead should

all the trunks prove to be busy, then a substitute connection is established, leading from ground supplied at the right-hand armature and front contact of relay 3806 over the master switch wire connection as hereinbefore described, to the left-hand armature of relay 3901, thence over the associated front contact of relay 3901, the left-hand armature and front contact of relay 3902, left-hand armature and front contact of relay 3904, conductor 3950, conductor 3750, all trunks busy conductor 3739, conductor 3939, conductor 3839, normal contacts of the inner left-hand armature of relay 3812, winding of relay 3812 to battery and ground. In such a case, relay 3812 becomes energized. Upon the energization of relay 3812, the circuit just traced is broken, but relay 3812 immediately establishes a new connection through the alternate contacts of its inner left-hand armature, the front contact and right-hand armature of relay 3802, the armature and back contact of relay 3801, winding of relay 3800 to ground. Relay 3812 thereupon transmits a busy indication back to the calling line which will be more fully described hereinafter.

Let us assume, however, that line 3705 is idle and that the connection can be properly established. After an interval relay 3811 becomes deenergized and establishes a condition which will be effective upon the releasing of relay 3807.

The energization of relay 3609 now results in the establishment of a connection from ground, winding of relay 3612, conductor 3611, outer left-hand armature and front contact of relay 3609, conductor 3629, left-hand armature and back contact of relay 3610, outer right-hand armature and front contact of relay 3609, preference switch wiper 3632 and its first contact, left-hand armature and back contact of relay 3618, winding of magnet 3619 to battery and ground. Magnet 3619 becomes energized and extends the ground instrumental in its energization through its inner left-hand armature and front contact to conductor 3620 and thence to one winding of relay 3610, but this relay having its other terminal grounded at this time does not become energized. Magnet 3619 also establishes a circuit from ground, its outer left-hand armature and front contact, conductor 3633, conductor 2833, winding of magnet 2800, winding of relay 2801 to battery and ground. Magnet 2800 becomes energized and actuates trunk bar 2810. Relay 2801 becomes energized and establishes a circuit from battery, outer left-hand armature and front contact of relay 2801, left-hand winding of magnet 2802, conductor 2803, back contact and outer right-hand armature of magnet 2804, conductor 2806, through the back contacts and outer right-hand armatures of other magnets similar to 2804 which are individual to the trunk connected to line bar 2714, conductor 2807, back contact and outer right-hand armature of magnet 2802, conductor 2805, conductor 2705, corresponding contacts of line bar 2714, and trunk bar 2710, conductor 2701, inner right-hand armature and back contact of relay 2700, front contact and inner right-hand armature of relay 2703 to ground. Magnet 2802 becomes energized in this circuit and immediately locks up in a circuit from ground, conductor 2731, inner right-hand armature and back contact of magnet 2704, corresponding contacts of trunk bar 2710 and line bar 2714, conductor 2708, conductor 2808, left-hand armature and front contact of magnet 2802, front contact and inner right-hand armature of magnet 2802, right-hand winding of magnet 2802 to battery and ground. Magnet 2802 in attracting its armatures actuates the line bar 2814 and causes connection to be established between the corresponding contacts of line bar 2814 and trunk bar 2810. The energization of magnet 2802 now opens the series circuit including conductors 2806 and 2807, so that no other magnet such as 2802 or 2804 individual to the trunk line connected to line bar 2714 can be actuated.

The ground on conductor 2808 is now extended through the corresponding contacts of line bar 2814 and trunk bar 2810 to conductor 2824, conductor 3624 and thence through the winding of relay 3618 to battery and ground. Relay 3618 becomes energized in this circuit and cuts off the original ground connection to magnet 3619. This magnet however, is retained in an energized condition in series with the winding of relay 3610 which now becomes energized. Upon the energization of relay 3610, a circuit is established from ground, winding of relay 3612, conductor 3611, right-hand armature and front contact of relay 3610, right-hand armature and back contact of relay 3621, conductor 3603, inner right-hand armature and front contact of relay 3609, conductor 3625, front contact and left-hand armature of relay 3628, right-hand low resistance winding of relay 3604, left-hand low resistance winding of magnet 3601 to battery and ground. Relay 3604 and magnet 3601 become energized in this circuit whereupon magnet 3601 actuates the line bar 3622 and causes connection to be made between the corresponding contacts of line bar 3622 and trunk bar 3623. The energization of this relay and magnet also establishes a circuit from ground, the outer left-hand armature and front contact of magnet 3601, front contact and inner left-hand armature of relay 3604, winding of relay 3621 to battery and ground. Relay 3621 becomes energized and locks up in a circuit from ground, winding

of relay 3612, conductor 3611, right-hand armature and front contact of relay 3610, right-hand contact and armature of relay 3621, winding of relay 3621 to battery and ground. The energization of relay 3621 also opens the circuit of relay 3609 which now becomes deenergized.

The deenergization of relay 3609 opens the circuit of relay 3807 which now becomes deenergized and in so doing establishes a circuit from ground, winding of relay 3800, back contact and armature of relay 3801, right-hand armature and front contact of relay 3802, right-hand armature and back contact of relay 3807, left-hand armature and back contact of relay 3811, left-hand armature and front contact of relay 3808, front contact and right-hand armature of relay 3810, back contact and right-hand armature of relay 3811, right front contact of relay 3809, conductor 3814, conductor 4014, conductor 4114, conductor 4314, right-hand armature and front contact of relay 4311, conductor 4312, conductor 4112, corresponding contacts controlled by magnet 4102, conductor 4103, conductor 3903, conductor 3703, cross connecting conductor 3700, cross connecting conductor 3900, right-hand armature and back contact of relay 3901, cross connecting conductor 3934, cross connecting conductor 3734, winding of line bar magnet 3701, to battery and ground. Line bar magnet 3701 becomes energized and actuates line bar 3722, thus making contact between the corresponding contacts of line bar 3722 and trunk bar 3723. The ground extended to the right-hand armature of relay 3901 is now extended through the winding of relay 3901, cross connecting conductor 3935, cross connecting conductor 3735, corresponding contacts of line bar 3722 and trunk bar 3723, conductor 3736, conductor 3936, right-hand winding of relay 3918, to battery and ground. Relay 3918 becomes energized in this circuit and locks up in a circuit from ground, front contact and outer right-hand armature of relay 3628, outer left-hand armature and front contact of relay 3604, conductor 3637, conductor 3737, conductor 3937, right-hand armature and front contact and right-hand winding of 3918 to battery and ground. The energization of relay 3918 opens the original energizing circuit of magnet 3919, but this magnet is now retained energized in series with relay 3910 and this latter relay becomes energized.

The energization of relay 3910 opens the circuit of relay 3809 and this relay becoming deenergized opens the connection to the line bar wire 3814 so that ground is removed from the right-hand armature and back contact of relay 3901 and this relay therefore becomes energized in a circuit from battery, the winding of line bar magnet 3701, conductor 3734, conductor 3934, winding of relay 3901, conductor 3935, conductor 3735, corresponding contacts of line bar 3722 and trunk bar 3723, conductor 3736, conductor 3936, front contact and right-hand armature of relay 3918, conductor 3937, conductor 3737, conductor 3637, corresponding contacts of line bar 3622 and trunk bar 3623, conductor 3624, conductor 2824, corresponding contacts of trunk bar 2810 and line bar 2814, conductor 2808, conductor 2708, corresponding contacts of line bar 2714 and trunk bar 2710, back contact and inner right-hand armature of trunk bar magnet 2704 to ground on conductor 2731. The deenergization of relay 3809 also establishes a circuit from ground, winding of relay 3800, back contact and armature of relay 3801, right-hand armature and front contact of relay 3802, left-hand armature and back contact of relay 3809, outer left-hand armature and front contact of relay 3810, winding of relay 3805 to battery and ground. Relay 3805 becomes energized and locks up in a circuit from ground, left-hand armature and front contact of relay 3802, right-hand armature and front contact of relay 3805, winding of relay 3805 to battery and ground. Relay 3805 now opens the energizing circuit of relay 3806 and after an interval, this relay retracts its armatures. During this interval, however, a circuit is established from ground, outer left-hand armature and front contact of relay 3805, conductor 3815, conductor 4015, corresponding contacts controlled by magnet 4002, conductor 4034, conductor 3234, conductor 3134, winding of relay 3107 to battery and ground. Relay 3107 becomes energized in this circuit and locks up through its front contact and inner right-hand armature to the ground on conductor 3131. At the same time the connection through the right-hand armature and back contact of relay 3107 to the winding of relay 3109 is opened, and relay 3109 retracts its armature. Thereupon a circuit is established from ground on conductor 3131, wiper 3102, armature and back contact of relay 3109, front contact and outer left-hand armature of relay 3114, back contact and armature of relay 3120, conductor 3121, conductor 2921, corresponding contacts of trunk bar 2923 and line bar 2922, conductor 2924, conductor 2724, outer right-hand armature and front contact of relay 2703, winding of relay 2700, to battery and ground, and in parallel with relay 2700 through the back contact and armature of relay 2711, back contact and armature of relay 2715, winding of relay 2716, to battery and ground. Relays 2700 and 2716 become energized in this circuit and establish a ringing condition on the called line, which will be more fully described hereinafter. It will be noted at this point, however, that

relay 2715 is at the present time short-circuited by the contact and armature of relay 2711.

The energization of relay 3107 establishes a release condition in the apparatus common to the connection now being established, and this condition will now be described. During the energization of relay 3109, relay 3100 was energized, so that upon the deenergization of relay 3109, relay 3100 becomes deenergized. This results in the establishment of a circuit from ground on conductor 3131, wiper 3103, back contact and armature of relay 3100, winding of relay 3118, to battery and ground. Relay 3118 becomes energized and removes the ground connection from conductor 3150 so that all of the relays depending upon this ground for their continued energization now become deenergized. Relay 3106 is wired in parallel with the winding of relay 3118, and hence upon the energization of relay 3118, relay 3106 also becomes energized. This results in the establishment of a circuit from ground on conductor 3131, through the armature and back contact of magnet 3101, left-hand armature and front contact of relay 3106, winding of magnet 3101, to battery and ground. Thus magnet 3101 is included in a self-interrupting circuit and now becomes energized to quickly move the wipers 2312 to 2315, inclusive, back to their normal positions. When this position has been reached, the ground on conductor 3132 is removed, resulting in the deenergization of relay 2918 and the consequent removal of ground from conductor 2931. The energization of relay 3106 besides restoring the time measure switch, also removes ground from conductor 3133 so that line bar magnet 2901 becomes deenergized, thus entirely releasing the connection between the trunk line comprising conductors 2773 and 2774 and the common apparatus associated therewith.

The energization of relay 3805, hereinbefore described, causes the deenergization of relay 3806, and this relay in a short interval establishes a circuit for the energization of relay 3801 through the inner left-hand armature and front contact of relay 3805. The energization of relay 3801 removes ground from the right-hand armature of relay 3802, thus opening the holding circuit of the various relays in Fig. 38 and causing the release of magnet 4002. The deenergization of relay 3806 also removes ground from conductor 3819, which extends and forms part of conductor 4319 so that the code relays, shown in Fig. 43, now become deenergized, and this is followed by the deenergization of relays 4311 and magnets 4100 and 4102. The deenergization of relay 4311 removes the ground from the master switch wire 3724, resulting in the deenergization of relays 3923 and 3909, whereupon ground is removed from conductor 3929.

The timing relays 3915 and 3916 of the primary master switch have been operating through this interval in the following manner: Upon the first energization of relay 3909, a circuit is established from ground, winding of relay 3912, conductor 3911, front contact and outer left-hand armature of relay 3909, armature and back contact of magnet 3914, right-hand armature and back contact of relay 3915, winding of relay 3916, to battery and ground. Relay 3916 attracts its armatures and establishes a circuit for the energization of relay 3915, which may be traced from ground, winding of relay 3912, conductor 3911, front contact and outer left-hand armature of relay 3909, conductor 3929, right-hand armature and back contact of relay 3910, left-hand armature and front contact of relay 3916, left-hand winding of relay 3915, to battery and ground. Relay 3915 becomes energized in this circuit and opens the original energizing circuit of relay 3916, and at the same time locking up to the ground provided for the energization of relay 3916, through its right-hand armature and front contact and its right-hand winding. Relay 3916, however, is slow to release, and does not retract its armatures for a certain period of time. During this time the operations described have taken place so that upon the deenergization of relay 3909, relay 3910 is maintained energized in a circuit from ground, winding of relay 3912, conductor 3911, front contact and right-hand armature of relay 3916, winding of relay 3910, front contact and right-hand armature of relay 3921, conductor 3920, front contact and inner left-hand armature of magnet 3919, winding of magnet 3919, to battery and ground. When relay 3916 retracts its armatures, it opens this circuit and relays 3910 and magnet 3919 become deenergized. The deenergization of relay 3919 restores trunk bar 3723 to normal position, leaving only the contacts corresponding to line bar 3722 in an operated condition.

Also upon the first energization of relay 3910 a circuit is established from ground, winding of relay 3912, conductor 3911, front contact and outer left-hand armature of relay 3909, right-hand armature and front contact of relay 3910, winding of magnet 3914, to battery and ground. Magnet 3914 becomes energized in this circuit and prepares to move preference switch wiper 3917 forward onto its next contact. Upon the deenergization of relay 3916, just described, this circuit is opened and magnet 3914 becoming deenergized, moves the preference switch wiper 3917 forward. In this manner the master switch shown in Fig. 39 functions, and after causing the proper connec-

tion to be made between the corresponding contacts of line bar 3722 and trunk bar 3723, it becomes restored to normal.

In a very similar manner the master switch for the secondary line switch here shown in Fig. 36, performs its functions and becomes restored to normal. Thus upon the first energization of relay 3609 a circuit is established from ground, winding of relay 3612, conductor 3611, outer left-hand armature and front contact of relay 3609, conductor 3629, armature and back contact of magnet 3614, right-hand armature and back contact of relay 3615, winding of relay 3616, to battery and ground. Relay 3616 is energized in this circuit and establishes a circuit from ground, winding of relay 3612, conductor 3611, outer left-hand armature and front contact of relay 3609, conductor 3629, left-hand armature and back contact of relay 3610, left-hand armature and front contact of relay 3616, left-hand winding of relay 3615, to battery and ground. Relay 3615 becomes energized in this circuit, and attracting its right-hand armature cuts off the original energizing circuit of relay 3616 and locks up to the ground supplied over the back contact of magnet 3614. Through the right-hand armature and contact of relay 3616, a connection is maintained between conductors 3629 and 3611 so that upon the deenergization of relay 3609, relay 3610 and magnet 3619 do not immediately become deenergized. Upon the deenergization of relay 3616, however, this circuit is opened and relay 3610 retracts its armatures, and magnet 3619 becomes deenergized. The deenergization of magnet 3619 restores trunk bar 3626 to normal position, leaving only the contacts corresponding to line bar 3612 in an operated position.

The preference switch wiper magnet 3614 is operated in a manner similar to that hereinbefore described.

Upon the deenergization of magnet 3619 ground is removed from conductor 3633, which results in the deenergization of magnet 2800 and relay 2801. Magnet 2800, becoming deenergized, restores trunk bar 2810 to normal position, leaving only the contacts corresponding to line bar 2814 actuated. Thus the connection between the calling subscriber at the substation 500 and the called station on line 3705 is established, and a ringing condition now prevails.

Ringing current is now connected from a source of ringing current 2717, through the left-hand winding of relay 2711, the back contact and left-hand armature of relay 2722, back contact and outer right-hand armature of relay 2719, front contact and inner lower armature of relay 2716, front contact and outer right-hand armature of relay 2700, conductor 2751, corresponding contacts of trunk bar 2710 and line bar 2714, conductor 2720, conductor 2820, corresponding contacts of line bar 2814 and trunk bar 2810, conductor 2851, conductor 3651, corresponding contacts of trunk bar 2623 and line bar 3622, conductor 3626, conductor 3726, corresponding contacts of trunk bar 3723 and line bar 3722, conductor 3751, through the apparatus at the called substation, back over conductor 3752, corresponding contacts of line bar 3722 and trunk bar 3723, conductor 3727, conductor 3627, corresponding contacts of line bar 3622 and trunk bar 3626, conductor 3652, conductor 2852, corresponding contacts of trunk bar 2810 and line bar 2814, conductor 2805, conductor 2705, corresponding contacts of line bar 2714 and trunk bar 2710, conductor 2701, inner right-hand armature and front contact of relay 2700, inner upper armature and front contact of relay 2716, inner right-hand armature and back contact of relay 2719 to ground. The ringing current flowing through this circuit is insufficient to cause the energization of relay 2711. When, however, the called subscriber answers, a path of low resistance will be provided and relay 2711 will become energized. At this time the short circuit is removed from about the winding of relay 2715 and this relay will become energized. Relay 2715 now attracts its armature and establishes a circuit for itself from battery, front contact and armature of relay 2715, winding of relay 2715, left-hand armature and front contact of relay 2700, conductor 2731, to ground. In this circuit relay 2716 becomes short circuited and consequently deenergized, so that it retracts its armatures and cuts off the ringing current from the called subscriber and at the same time connects the called subscriber to the windings 2742 and 2743 of the repeating coil. Thus a talking connection is established.

Attention is here called to the circuit for supplying ringing tone to the calling subscriber. During the ringing period a small amount of ringing current will flow from the source of ringing current 2717 through the left-hand winding of relay 2711, back contact and left-hand armature of relay 2722, the outer upper armature and front contact of relay 2716, condenser 2727, the upper winding 2742 of the repeating coil, to ground. Through induction a tone characteristic of this ringing current is propagated in the primary winding of the repeating coil and transmitted over the calling subscriber's line so that the calling subscriber will know that the bell of the called subscriber is being rung.

When the called subscriber answers and relay 2716 is deenergized relay 2744 is included in series with the called subscriber's line, and this relay becomes energized and causes in turn the energization of relay 2706. The energization of relay 2706 results in the

reversal of the current flowing through the windings of relay 715 so that this relay now attracts its armature. Relay 715 closes a circuit from ground, armature and front contact of relay 715, winding of relay 711, to battery and ground. Relay 711 now locks up in a circuit from ground, right-hand armature and front contact of relay 700, right-hand armature and front contact and winding of relay 711, to battery and ground. The function of relay 711 is to prepare a circuit for the registering of a call on the calling subscriber's meter 525. When the calling subscriber hangs up his receiver at the end of the conversation, he thereby deenergizes relay 708 whereupon a circuit is established from ground, armature and back contact of relay 708, left-hand armature and front contact of relay 711, winding of slow to release relay 719, to battery and ground. Relay 719 through the agency of its inner left-hand armature maintains a ground on conductor 731 for a short interval to insure the operation of the meter 525. Through the agency of its outer left-hand armature relay 719 establishes a circuit from ground and battery, front contact and outer left-hand armature of relay 719, conductor 733, conductor 633, corresponding contacts of trunk bar 623 and line bar 622, conductor 634, conductor 534, corresponding contacts of trunk bar 523 and line bar 522, conductor 533, winding of meter 525 to ground. Meter 525 becomes energized and registers one call. It will be noted that the action of relays 711 and 719 depends directly on the action of relay 708, for relay 700 is maintained energized by relay 708 and relay 700 in turn maintains relay 711 energized. It is therefore not until after relay 708 retracts its armature that relay 711 becomes deenergized and it is during the interval between the deenergization of relays 708 and 700 that relay 719 operates.

During the talking period the calling subscriber has control of supervisory relay 708, and therethrough has control over relay 700 so that ground is maintained on conductor 731 at the will of the calling subscriber. Ground on conductor 731 maintains the primary line switch in Fig. 5, the secondary line switch in Fig. 6, the district selector in Fig. 7, and the district selector outgoing secondary line switch in Fig. 8. The office selector and the outgoing trunk secondary line switch, shown in Figs. 17 and 18, respectively, are maintained energized through the ground connection to conductor 1731, supplied by the armature and front contact of relay 1700. Relay 1700 is under control of relay 1701, and this relay depends for its continued energization on the maintenance of a closed circuit between the windings of relays 715 and 2705. The switches at the terminating office, that is, the incoming switch shown in Fig. 27, the in-trunk line switch shown in Fig. 28, the subscriber's secondary line switch shown in Fig. 36, and the subscriber's primary line switch shown in Fig. 37, are maintained through a ground connection to conductor 2731. This ground connection is supplied through the armature and front contact of relay 2705. Relay 2705 depends for its continued energization on the circuit including relay 715. This circuit can only be broken by the restoration of the district switch, shown in Fig. 7, or the out trunk secondary line switch, shown in Fig. 8, and since these are under the control of the calling subscriber, therefore, the switches depending on the ground on conductor 2731 are also under the control of the calling subscriber. In this manner the whole train of switches is under the control of the calling subscriber. The called subscriber has control only over relay 2744 and therethrough controls relay 715. Hence at the end of the conversation if the called subscriber hangs up his receiver first, the only result will be the deenergization of relays 2744, 2726 and the movement of the armature but not the deenergization of relay 715. However, when the calling subscriber hangs up his receiver the whole train of switches will be restored to normal, starting with the four switches shown in the originating office and following when any one of the last two of these switches have been restored with the release of the switch as shown in Figs. 17, 18, 27, 28, 36 and 37. The release of a switch is caused by the deenergization of the line bar magnet, such for instance as line bar magnet 713. Such a magnet becoming deenergized restores the line bar 714 to normal, and as this line bar moves to its normal position, the contacts of the trunk bar 710, which have been engaged, snap back into their normal positions.

Intra-office connection.

A connection between the calling subscriber in one office and a called subscriber in the same office will be very similar to the inter-office connection just described, with the exception that the switches in the mechanical switching center will be omitted. To illustrate an intra-office connection the drawings should be placed as shown in Fig. 3. Here it will be noticed that the arrangement is the same with the exception that Figs. 17 to 26, inclusive, and 35 have been omitted. These switches represent the apparatus of the mechanical switching center, and hence are not used in this connection. The one particular point of difference in this connection will be noted in the manner in which the circuits of Figs. 8 and 27 match. Here it is noted that the trunk between the outgoing trunk secondary line

switch associated with the district selector, and the incoming selector, shown in Fig. 27, is a three-conductor trunk instead of a two-conductor trunk, as hereinbefore described. Otherwise the connections are the same.

The office code which will be transmitted by the calling subscriber will now operate the register and affect the marker in such a manner that no one of the compensating resistance relays 1305 to 1307, inclusive, is energized, nor is the stations last relay 1310 energized. In the present instance the numerical relay 1313 becomes energized because the stations code is not to be repeated into the sender associated with the line marker. Thus, when the registers in Figs. 15 and 16 have been set and the office code has been translated, and the proper trunk has been selected through the district selector in Fig. 7, the sender control switch of Fig. 13 will be automatically moved to its fourth active contact so that the first series of impulses sent to the relays 3312 to 3314, inclusive, will be those registered on the first stations register comprising in part wipers 1509 and 1573. This automatic action is caused through the connection of ground on wiper 1333, through its first three active contacts, the left-hand armature and front contact of relay 1313, through the back contact and armature of magnet 1332, winding of magnet 1332, to battery and ground. The code relays shown in Figs. 33, 34 and 42 are energized in the same manner as hereinbefore described, and the circuit movements which take place thereupon will be similar to those hereinbefore described.

Further detailed description of these circuits will now be presented in the form of a series of notes dealing with isolated circuit movements and functions.

Assuming that a call is being established to a party line, it is here expedient to describe the ringing code. This is presented in the following table:

Ringing code.

Party.	Code impulses.	Code relays.	Marker relay.	Relay 2719.	Relay 2722.	Tip.	Ring.
M	6	AD	3136		√	G	—
W	9	CD	3137	√	√	—	G
J	5	D	3138			G	+
R	7	BD	3139	√		+	G

In this table the first column represents the party line designation. In accordance with the dial code hereinbefore given these party line designations correspond to trains of impulses, as listed in the second column of this table. Trains of such number of impulses will, as described in another table of the specification, cause the energization of code relays, such as those listed in the third column of this table. Referring now to Figs. 31 and 33, it will be noted that the combination of relays given will cause the energization of certain marker relays, as listed in the fourth column of this table. Thus, for instance, if the party M has been called, at the proper time, relay 3112 will become energized. At this time a circuit will be established from ground, inner left-hand armature and front contact of relay 3112, conductor 3140, conductor 3340, the left-hand armature and front contact of relay 3323, the left-hand armature and back contact of relay 3322, the left-hand armature and back contact of relay 3321, the left-hand armature and front contact of relay 3320, conductor 3341, conductor 3141, winding of relay 3136, to battery and ground. Thus, relay 3136 responds to the dialing of the code representing party M. The energization of the marker relays results in the energization under various conditions of two relays, 2719, and 2722 in the incoming selector circuit. Thus, the energization of relay 3136 results in the establishment of a circuit from ground, outer left-hand armature and back contact of relay 3108, conductor 3142, left-hand armature and front contact of relay 3136, conductor 3163, front contact and outer left-hand armature of relay 3112, conductor 3174, conductor 2974, corresponding contacts of trunk bar 2923 and line bar 2922, conductor 2975, conductor 2775, front contact and outer upper armature of relay 2702, winding of relay 2722, to battery and ground. Relay 2722 becomes energized and locks up through its front contact and right-hand armature to the ground on conductor 2731. Thus the energization of relay 3136 results in the energization of relay 2722 in the manner checked in the fifth and sixth columns of this table. The energization of relays 2719 and 2722 in the various combinations applies ringing current in different manners to the called line. Thus, when relay 2722 is energized, minus ringing current supplied from the source 2723 is connected through the right-hand winding of relay 2711, front contact and left-hand armature of relay 2722, the back contact and outer right-hand armature of relay 2719, the front contact and inner lower armature of relay 2716, to the "ring" conductor of the called line, and ground is connected to the "tip" conductor of this line through the inner upper armature and front contact of relay 2716, the inner right-hand armature and back contact of relay 2719 to ground. These combinations of ringing current connections are set forth in the seventh and eighth columns of this table. The ringing current supplied from the two sources 2717 and 2723 is of that character necessary to operate such a selective signal circuit as is described in the patent to Thompson & Robes No. 644,647, issued March 6, 1900. It is also be-

lieved to be obvious how the present circuits could be modified to employ other standard types of selective ringing circuits such for instance, as that known as harmonic ringing where a plurality of sources of ringing currents of different frequencies are employed.

Busy conditions.

It has hereinbefore been explained how the busy relay 3812 is energized when all of the trunks in a group leading to a private branch exchange installation are busy. In the case of an individual line during the interval after relay 3809 has become energized and before relay 3811 becomes deenergized, a circuit is established from battery, winding of relay 3812, the normal contacts of the inner left-hand armature of relay 3812, conductor 3839, front contact and right-hand armature of relay 3811, front contact and right-hand armature of relay 3809, line bar conductor 3814, conductor 4014, conductor 4114, conductor 4314, through the right-hand armature and front contact of one of the marker relays such as 4316, conductor 4317, conductor 4117, corresponding contacts controlled by magnet 4106, conductor 4156, conductor 3956, conductor 3756, and thence through the corresponding contacts of the primary line switch to the third conductor of the line which will be grounded in the manner hereinbefore described, if such line is busy. The ground on the third conductor in the case of an individual line is connected to the line bar magnet 3720 through cross-connecting conductor 3721. This will result in the energization of relay 3812.

In the case of a party line such as 3706, the same condition will be established with the exception that the line bar conductor, instead of leading directly to the test conductor of the line will be connected through cross-connecting conductor 3753, cross-connecting conductor 3953, winding of relay 3946, cross-connecting conductor 3954, cross-connecting conductor 3754 and thence through the corresponding contacts of the primary line switch to the test conductor which will be grounded if line 3706 is busy. Thus, in case the called line is busy relay 3812 will become energized.

The energization of relay 3812 will result in the establishment of a circuit from ground, the outer left-hand armature and front contact of relay 3812, conductor 3817, conductor 4017, corresponding contacts controlled by magnet 4002, conductor 4043, conductor 3243, conductor 3143, winding of relay 3108 to battery and ground. Relay 3108 becomes energized in this circuit and opens the circuit of relay 3109 which becomes deenergized and causes the release of the common apparatus associated with the district selector. At the same time a circuit will be completed from ground, outer left-hand armature and front contact of relay 3108, conductor 3144, conductor 2944, corresponding contacts of trunk bar 2923 and line bar 2922, conductor 2928, winding of busy tone relay 2729 to battery and ground. Busy tone relay 2729 is energized in this circuit and locks up through its right-hand armature and front contact to the ground on conductor 2731. At the same time, this relay establishes a circuit from a source of busy tone 2730, front contact and left-hand armature of relay 2729, back contact and outer lower armature of relay 2716, condenser 2727, winding 2742 of the repeating coil to ground. A busy tone is thus induced in the windings 2707 and 2709 of the repeating coil and thereupon transmitted back over the calling line to apprise the calling subscriber that the called line is busy.

It should be also noted at this point that when a connection is extended toward the winding of magnet 2713 that if the associated trunk is busy relay 2712 will be energized and that if the next trunk in the same group is also busy, relay 2732 will be energized and the ground connection for the energization of the line bar magnet will be extended over conductor 2734, conductor 2834, conductor 3034, corresponding contacts controlled by magnet 3013, conductor 3027, corresponding contacts controlled by magnet 3001, conductor 3043, conductor 3243, conductor 3143, winding of relay 3108 to battery and ground. Thus, if all the trunks of the wanted group are busy, the busy tone relay 2729 will be operated in the same manner as when the particular called line is busy. A release condition will be established through the energization of relay 3108.

This leads naturally to the discussion of the condition established when all of the trunks of a group leading from the district selector in Fig. 7 are busy.

Upon the extension of ground to conductor 726, if all of the trunks in the group served by this conductor are busy, this ground will be extended through the right-hand armature and front contact of relay 712, right-hand armature and front contact of relay 716 and in a similar manner through the right-hand armatures and front contacts of other relays belonging to the same group, to conductor 725, thence over conductor 825, conductor 1025, the corresponding contacts controlled by magnet 1001, conductor 1041, conductor 1241, conductor 1441, winding of relay 1422 to battery and ground. Relay 1422 connects ground to the winding of relay 1409 so as to cause the release of the marker immediately without waiting for the timing relays 1416 and 1417 to perform their regular functions. Before the marker can release,

however, a connection is established from ground, the outer right-hand armature and front contact of relay 1422, conductor 1423, corresponding contacts controlled by magnet 1408, conductor 1442, conductor 1342, conductor 1142, winding of relay 1122 to battery and ground. Relay 1122 becomes energized in this circuit and through its inner right-hand armature and front contact locks to the ground on conductor 1112. Relay 1122 transfers the left-hand winding of induction coil 1109 from a source of dial tone 1123 to a source of busy tone 1143 and this busy tone is substituted for dial tone and the called subscriber is thereby apprised of the fact that a connection cannot be made on account of the busy condition of the trunks over which he is now trying to establish a connection. The movement of the armatures of relay 1122 also disconnects ground from conductor 1149 so that the sender control switch shown in Fig. 13 cannot be started and hence no impulses will be sent out over the impulse circuit hereinbefore described. The called subscriber being apprised of the fact that the connection cannot be established, replaces his receiver on its hook and causes the deenergization of relay 1110 and later relay 1111 whereupon release takes place in the manner hereinbefore described.

The same condition will be met in the mechanical switching center. Relay 2422 now becomes energized and causes the immediate release of the marker shown in Fig. 24. In the meantime however, a circuit is extended from the outer right-hand armature and front contact of relay 2422, to the winding of relay 2111, so that relay 2111 becomes energized. This latter relay cuts off the impulse circuit from the call indicator relays 2112 to 2114, inclusive, and transfers said impulse circuit to the windings of relay 2137. This operation takes place shortly after the office code has been registered in the code relays, shown in Fig. 35, and hence relay 2137 will absorb the balance of the impulses being transmitted to energize the code relays shown in Figs. 25 and 26. It should be noted that relay 2137 is connected to the impulse circuit in such a way that it will become energized on the negative impulses, and will not become energized on the positive impulses. Thus relay 2137 will regularly vibrate its armatures until release takes place in the sender at the originating office, and connection is made from the windings of relay 715 to talking conductors leading over the trunk into the mechanical switching center. The operation of relay 2137 causes the energization of slow releasing relay 2140 which becomes energized and holds up its armature throughout the following succession of impulses. When relay 715 is switched into circuit it operates as a means to hold relay 2137 permanently energized. Thereupon a busy tone circuit becomes effective. Such circuit leads from ground, secondary winding of transformer 2135, supplying a busy tone, through condenser 2136, the middle winding of relay 2137, the inner right-hand armature and front contact of relay 2111, to ground. Through induction in the two outer windings of relay 2137 a busy tone is transmitted to the calling subscriber's substation.

Upon the energization of relay 2140 a circuit is established from ground, armature and front contact of relay 2140, winding of relay 2138, to battery and ground. Relay 2138 locks up to ground on conductor 2150 through its inner left-hand armature and front contact, and thereupon prepares a circuit for the release of the apparatus common to the trunk line.

The calling subscriber, recognizing the busy tone, hangs up his receiver and by deenergizing relay 708 causes the release of the switches so far employed in this connection. The release of the switches shown in Figs. 7 and 8, opens the circuit including the windings of relays 2137 and 715, whereupon relay 2137 becomes permanently deenergized. After a short interval relay 2140 retracts its armature and establishes a circuit from ground, armature and back contact of relay 2140, front contact and right-hand armature of relay 2138, winding of relay 2100, to battery and ground. Relay 2100 becomes energized and causes the release of the connection in the manner hereinbefore described.

Blank lines and restricted service.

In case that a line is not equipped with a substation or in case that the service on a line is to be restricted for some reason or other, a cross-connection such as 3718 is made. Therefore, upon the grounding of the master switch conductor, this ground will be extended over the cross-connecting conductor 3718, conductor 3738, conductor 3938, conductor 4138, conductor 4038, corresponding contacts controlled by magnet 4002, conductor 4047, conductor 3247, conductor 3147 and thence in parallel through the winding of relays 3123 and 3120 to battery and ground. Both of these relays become energized and lock up through a connection from ground on conductor 3150 through the inner right-hand armature and front contact of relay 3123. The energization of relay 3123 transfers the connection of conductor 3122 from conductor 3124 to conductor 3155 and thence over conductor 3255, conductor 3055, corresponding contacts controlled by magnet 3001, conductor 3018, corresponding contacts controlled by magnet 3013, conductor 3046, conductor 2846, conductor 2746, and thence to a line bar magnet controlling a line bar associated

with a trunk leading to a special operator's position. Thus the connection is switched from the direction in which it was intended to be established to a special operator who will inform the calling subscriber either that he has called a line which is not equipped with a substation or that he has called a line to which service may not be supplied for some reason or another.

As another instance of restricted service let us assume that the party line 3706 has connected to it only two of the four possible substations. Thus, line 3706 shows two substations marked R and W and the parties M and J are not connected. If now a calling subscriber should attempt to establish a connection to party M, a connection would be established from ground, inner left-hand armature and front contact of relay 3808, conductor 3840, conductor 3940, conductor 3740, through cross-connecting conductor 3755, cross-connecting conductor 3955, outer left-hand armature and front contact of relay 3946, conductor 3948, conductor 4148, corresponding contacts controlled by magnet 4002, conductor 4049, conductor 3249, conductor 3149, front contact and right-hand armature of relay 3136, conductor 3147, and thence in parallel through the windings of relays 3123 and 3120 which results in switching the call to a special operator's position in the same manner as hereinbefore described. Relay 3946 is energized when the line bar conductor is grounded and the line is found idle in the same manner as relay 3901 is energized. Since the inner left-hand armature of relay 3946 corresponds to the party W, and the outer right-hand armature of relay 3946 corresponds to the party R and since both of these parties are connected to the line, connection is not made between these armatures and the conductor 3955 so that a call to either party, R or W, will be established in the proper manner.

What is claimed is:

1. In a telephone system, telephone lines, a sender common to said lines, a series of selective stages each comprising a plurality of switches having sets of permanently paired primary and secondary contacts and a marker for controlling said switches, and means under control of said sender for controlling said markers in accordance with the record established in said sender.

2. In a telephone system, telephone lines, a sender common to said lines, a series of selective stages each comprising a plurality of cross bar switches and a marker for controlling said switches, and means under control of said sender for controlling said markers in accordance with the record established in said sender.

3. In a telephone system, telephone lines, a sender common to said lines, means for associating said lines with said sender and establishing therein a record designating the path desired to be established, a series of selective stages through which the path may be established, each selective stage comprising switches having sets of permanently paired primary and secondary contacts, and a marker for controlling said switches, and means under control of said sender for operating said markers.

4. In a telephone system, telephone lines, a sender common to said lines, means for associating said lines with said sender and establishing therein a record designating the path desired to be established, a series of selective stages through which the path may be established, each selective stage comprising cross bar switches and a marker for controlling said switches, and means under control of said sender for operating said markers.

5. In a telephone system, telephone lines, a sender common to said lines, said sender comprising means for recording impulses translating the record thus established and sending impulses of a different character, means for associating said lines with said sender, a series of selective stages through which the connection may be extended, each selective stage comprising switches and a marker for controlling said switches, and means responsive to the impulses sent by said sender for operating said markers.

6. In a telephone system, telephone lines, a sender common to said lines, said sender comprising means for recording impulses, translating the record thus established and sending impulses of a different character, means for associating said lines with said sender, a series of selective stages through which the connection may be extended, each selective stage comprising switches having sets of permanently paired primary and secondary contacts and a marker for controlling said switches, and means responsive to the impulses sent by said sender for operating said markers.

7. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses, translating the record thus established, and transmitting impulses characteristic of the said translated record, a selective stage for extending said telephone lines comprising a switch and a marker for controlling said switch, said marker being controlled by said sender, and a second selective stage for further extending said lines comprising a plurality of switches and a marker for controlling said switches, said marker being controlled by said sender.

8. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses, translating the record thus estab-

lished and transmitting impulses characteristic of the said translated record, a selective stage for extending said telephone lines comprising a switch having sets of permanently paired primary and secondary contacts and a marker for controlling said switch, said marker being controlled by said sender, a second selective stage for further extending said lines comprising a plurality of switches each having sets of permanently paired primary and secondary contacts and a marker for controlling said switch, said marker being controlled by said sender.

9. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses, translating the record thus established and transmitting impulses characteristic of said translated record, a selective stage for extending said telephone lines comprising a cross bar switch and a marker for controlling said switch, said marker being controlled by said sender, a second selective stage for further extending said lines comprising a plurality of cross bar switches and a marker for controlling said switches, said marker being controlled by said sender.

10. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses, translating the record thus established and transmitting impulses characteristic of said translated record, a selective stage for extending said telephone lines comprising a switch and a marker for controlling said switch, said marker being controlled by means responsive to the translated record in said sender, a second selective stage for further extending said lines comprising a plurality of switches and a marker for controlling said switches, said marker being controlled by impulses transmitted from said sender.

11. In a telephone system, telephone lines, senders common to said lines each said sender comprising means for recording impulses, translating the record thus established and transmitting impulses characteristic of the said translated record, a selective stage for extending said telephone lines, comprising a switch and a marker for controlling said switch, said marker being controlled by means responsive to the translated record established in said sender, a plurality of other selective stages for further extending said lines, each of said other selective stages comprising a plurality of switches and a marker for controlling said switches, said marker being controlled by impulses transmitted from said sender.

12. In a telephone system, telephone lines, senders common to said lines, switches for extending said lines to said common senders, each said sender comprising means for recording impulses, translating the record thus established and transmitting impulses characteristic of the said translated record, a selective stage for extending said telephone lines comprising a switch and a marker for controlling said switch, said marker being controlled by means responsive to a portion of said translated record, senders common to said lines extended from said first selective stage, switches for extending said extended lines to said last mentioned senders, each of said senders comprising means for recording impulses transmitted from said first senders, translating the record thus established and transmitting impulses characteristic of said translated record, a second selective stage for further extending said lines comprising a plurality of switches and a marker for controlling said switches, said marker being controlled by means responsive to a portion of said translated record in said last mentioned senders, registers common to said further extended lines, switches for extending said further extended lines to said registers, each said register comprising means responsive to the impulses transmitted from said last mentioned senders and translating the record thus established, a final selective stage for extending said further extended lines comprising a switch and a marker for controlling said switch, said marker being controlled by means responsive to the translated record established in said registers.

13. In a telephone system, means for extending a connection over a series of selective stages, a sender common to each of said selective stages, a marker at each of said selective stages, each of said selective stages comprising a switch controlled by said senders through the agency of said markers, means responsive to a portion of the record thus established for setting the switches of the first selective stage, means for thereupon transferring the record from the sender at the first selective stage to a sender at the next selective stage, means responsive to a portion of the record established in the sender associated with the second selective stage for setting the switch at the second selective stage, and means for thereupon transferring the record established in the sender at the second selective stage to the sender at the final selective stage, means responsive to the record established therein for setting the switch at the final selective stage.

14. In a telephone system, a sender and a marker associated with said sender, said sender comprising means for recording impulses and for transmitting impulses, means responsive to a portion of the record established in said sender for controlling the said marker, and means in said marker for controlling the transmission of impulses from said sender.

15. In a telephone system, a sender and a marker associated with said sender, said sender comprising means for recording impulses of one character and for transmitting impulses of another character, means responsive to a portion of the record established in said sender for controlling said marker, and means in said marker for controlling the transmission of impulses in said sender.

16. In a telephone system, a sender and a marker associated with said sender, a switch, said sender comprising means for recording impulses and for transmitting impulses, means responsive to a portion of the record established in said sender for controlling said marker and therethrough for controlling said switch, and means in said marker for controlling the transmission of impulses from said sender.

17. In a telephone system, a sender and a marker associated with said sender, a switch having permanently paired primary and secondary contacts, said sender comprising means for recording impulses and for transmitting impulses, means responsive to a portion of the record established in said sender for controlling said marker and therethrough for controlling said switch, and means in said marker for controlling the transmission of impulses from said sender.

18. In a telephone system, a sender and a marker associated with said sender, a crossbar switch, said sender comprising means for recording impulses and for transmitting impulses, means responsive to a portion of the record established in said sender for controlling said marker and therethrough for controlling said switch, and means in said marker for controlling the transmission of impulses from said sender.

19. In a telephone system, a sender and a marker associated with said sender, a switch, said sender comprising registers for recording a series of trains of impulses, and means for translating said impulses and transmitting impulses characteristic of said translated record, means responsive to the record established on a portion of said registers for controlling said marker and therethrough for controlling said switch, a translator in said marker, said translator being controlled by and in accordance with the record established on the said portion of said registers, and means responsive to said translator for controlling the transmission of impulses from said sender.

20. In a telephone system, telephone lines, a sender common to said lines and means for associating said lines with said sender, a marker associated with said sender, a switch, said sender comprising means for recording impulses created in said lines, and means for transmitting impulses, means responsive to a portion of the record established in said sender for controlling said marker and therethrough for controlling said switch, and means in said marker for controlling the transmission of impulses from said sender.

21. In a telephone system, telephone lines, means in each of said telephone lines for transmitting a series of trains of impulses, a sender selector associated with said lines, a sender accessible to said lines through said sender selector, and a marker associated with said sender, a switch, said sender comprising a plurality of registers each responsive to a train of impulses and means for transmitting impulses, certain of said registers being arranged to establish different class of service indications in response to their settings, means responsive to said class of service registers for controlling said switch, and means in said marker for translating the record established in the class of service registers and transmitting back to the sender an indication for controlling the transmission of impulses from said sender.

22. In a telephone system, a sender and a marker associated with said sender, a switch, means in said sender for controlling said marker and therethrough for setting said switch, and means in said marker for transmitting to said sender a class of service indication responsive to the control exercised over said marker by said sender.

23. In a telephone system, a sender and a marker associated with said sender, said sender being provided with means for receiving impulses, and means to control said marker in accordance with a portion only of said impulses, said marker being provided with means for controlling switching apparatus, and means in said marker responsive to the said portion of said impulses for controlling the means in said sender for receiving the remaining portion of said impulses.

24. In a telephone system, a calling line, a sender accessible to said line, a switch for extending said line, a plurality of groups of trunks served by said switch, means under control of said sender for setting said switch, and means in said sender responsive to the busy condition of all the trunks in a group for transmitting a busy tone to the calling line.

25. In a telephone system, a calling line, a sender accessible to said line, a crossbar switch for extending said line, a plurality of groups of trunks served by said switch, means under control of said sender for setting said switch, and means in said sender responsive to the busy condition of all the trunks in a group for transmitting a busy tone to the calling line.

26. In a telephone system, a calling line, a sender accessible to said line, a switch having permanently paired primary and

secondary contacts for extending said line, a plurality of groups of trunks served by said switch, means under control of said sender for setting said switch, and means in said sender responsive to the busy condition of all the trunks in a group for transmitting a busy tone to the calling line.

27. In a telephone system, a calling line, a sender accessible to said line, a marker associated with and under control of said sender, a switch controllable by said marker for extending said line, a plurality of groups of trunks served by said switch, means in said sender responsive to the busy condition of all the trunks in a group for transmitting a busy tone to the calling line.

28. In a telephone system, a calling line, a plurality of switches for extending said line, a plurality of groups of trunks served by each of said switches, a marker associated with each of said switches, a sender associated with the calling line, means in said sender for controlling said markers and therethrough for setting said switches, and means also in said sender responsive to the busy condition of all the trunks in a group for transmitting a busy tone to the calling line.

29. In a telephone exchange, numbered subscribers' lines, unnumbered subscribers' lines, means for promiscuously grouping said lines, and means for extending a connection to any line of a group by calling a numbered line in the said group.

30. In a telephone exchange, numbered subscribers' lines, unnumbered subscribers' lines, means for promiscuously grouping said lines, and means for extending a connection to any line of a group by calling the first line in the said group.

31. In a telephone exchange, numbered subscribers' lines, unnumbered subscribers' lines, means for associating a plurality of lines in a group, and means for extending a connection to any line of said group by calling one of the numbered lines of said group.

32. In a telephone exchange, numbered subscribers' lines, unnumbered subscribers' lines, means for associating a plurality of said lines in a group including at least one of said numbered lines, and means for extending connections to the lines of said group by calling the numbered line or lines of said group.

33. In a telephone exchange, numbered subscribers' lines, unnumbered subscribers' lines, means for associating a plurality of promiscuously scattered said lines in a group, and means for extending connections to the lines of said group by calling any one of the said numbered lines included in said group.

34. In a telephone exchange, numbered lines, unnumbered lines, said lines being promiscuously dispersed and connected to equivalent terminal sets, switching devices having a plurality of line terminals connected to equivalent terminal sets, means for associating a plurality of lines in a group, said means comprising cross connecting conductors for connecting said lines to said switching device through said terminal sets, and means for actuating said devices to extend connections to said lines of said group by calling any one of the numbered lines of said group.

35. In a telephone exchange, numbered lines, unnumbered lines, a sender, a marker controlled by said sender, individual conductors leading from said marker to said numbered lines, means for grouping said lines and extending the marker wire of a numbered line to the other lines of the group, and means for extending connections to the lines to said group by setting said sender to control said marker to electrically affect the marker wire of a numbered line of said group.

36. In a telephone system, selective switches, a variably operable recording mechanism for receiving the record of a designation, a plurality of selection controlling devices, means for connecting the recording mechanism to one of said devices and for transferring to such device a portion of the record on said mechanism, such device selectively operating one of said switches to extend the connection and means for connecting the recording mechanism to another of said devices and for then transferring to such other device another portion of said record for selectively operating another of said switches to further extend the connection.

37. In a telephone system, selective switches, a variably operable recording mechanism for receiving the record of a designation, a plurality of selection controlling devices, means for connecting the recording mechanism to one of said devices and for then transferring to such device a part of the record on such mechanism, such device seectively operating one of said switches to extend a connection, means for causing the disconnection of said recording mechanism from said last controlling device, means for connecting the recording mechanism to another of said devices and for then transferring to such other device another portion of said record, said last device selectively operating another of said switches to further extend a connection, and means for causing the disconnection of the recording mechanism from said last mentioned device.

38. In a telephone system, selective switches, a variably operable recording mechanism comprising a number of registers responsive to a calling party for recording the wanted designation, a plurality of selection controlling devices, means for

connecting the recording mechanism to one of said devices and for transferring to such device a portion of the record established on the registers, said device selectively operating one of said switches to extend a connection, and means for connecting the recording mechanism to another of said devices and for transferring to such other device another portion of the record established on said registers, said last device selectively operating another of said switches to further extend the connection.

39. In a telephone system, selective switches, a recording mechanism having a number of relay registers for receiving the record of a designation, a plurality of selection controlling devices each having a number of relay registers, means for connecting a recording mechanism to one of said devices and for transferring to the relay registers thereof a portion of a record on the relay registers of said mechanism, said device selectively operating one of said switches to extend a connection and means for connecting the recording mechanism to another of said devices and for transferring to the relay registers thereof another portion of the record estabished on the relay registers of said mechanism, said last device selectively operating another of said switches.

40. In a telephone system, selective switches, a variably operable recording mechanism for receiving the record of a designation, a plurality of selection controlling devices, each having a number of registers, means for connecting the recording mechanism to one of said devices and for transferring to the registers thereof a portion of the record on said mechanism, said device arranged to effect a group selecting operation of one of said switches according to the setting of its registers to extend a connection, and means for connecting the recording mechanism to another of said devices and for transferring to such other device another portion of said record, said last device selectively operating another of said switches to further extend the connection.

41. In a telephone system, selective switches, a plurality of recording senders for receiving the record of the wanted line, a plurality of selection controlling devices, means for connecting any one of said senders to one of said devices and for transferring to such device a portion of the record on such sender, said device selectively operating one of said switches to extend a connection, and means for connecting said sender to another of said devices and for transferring to such other device another portion of said record, said last device selectively operating another of said switches to further extend the connection.

42. In a telephone system having a number of selective stages and a plurality of switches at each stage, groups of circuits accessible to the switches at each stage, selection controlling devices, one for each stage and common to the switches thereat, a recording sender for receiving the record of a designation, means for connecting the sender to the controlling device at a given stage and for transferring a part of the record from the sender to such device, means controlled by said device for operating one of the corresponding switches to select a group of circuits, means for connecting the sender to the controlling device at a succeeding stage and for transferring another portion of the record to said last device and means controlled by the last device for operating a switch at the corresponding stage to select a group of circuits.

43. In a telephone system having a number of selective stages and a plurality of switches at each stage, groups of circuits accessible to the switches at each stage, selection controlling devices, one for each stage and common to the switches thereat, a recording sender for receiving the record of a wanted designation, means for connecting the sender to the controlling device at a given stage and for transferring a part of the record from the sender to such device, means for connecting the controlling device to one of the corresponding switches, means controlled by said device for operating the switch to which it is connected to select a group of circuits, means for connecting the sender to the controlling device at a succeeding stage and for transferring another portion of the record to said last device, and means controlled by the last device for operating a switch at the corresponding stage to select a group of circuits.

44. In a telephone system having a number of selective stages and a plurality of switches at each stage, groups of circuits accessible to the switches at each stage, controlling devices, one for each stage and common to the use of all switches thereat, a plurality of recording senders for receiving the registration of a wanted line, means for connecting any one of the senders to the controlling devices at a given stage and for reproducing in said controlling device a part of the registration in said sender, means controlled by said device for operating one of the corresponding switches to select a group of circuits, means for connecting the sender to the controlling device at a succeeding stage and for reproducing in said later device another portion of the record of said sender, and means controlled by said last mentioned device for operating the switch at the succeeding stage to select a group of circuits.

45. In a telephone system arranged to establish connections of different classes, selective switches, selection controlling de-

vices, a recording sender, means for connecting the sender to a controlling device and for transferring to said device a record on said sender, said device acting according to the record received to selectively operate a switch to extend a connection and to reproduce in the sender a record of the class of connection, means for connecting the sender with another controlling device and for transferring a record thereto, and means controlled by said second device to operate another switch to further extend the connection.

46. In a telephone system having a number of selective stages with switches at each stage, selection controlling devices, one for each stage and common to the switches thereat, a recording sender for receiving a designation record, means for connecting the sender to the controlling device at a given stage and for reproducing on such device a part of the record of said sender, means controlled by said device for operating one of the switches at the corresponding stage to extend a connection, said device acting in accordance with the record received to determine the class of the connection, means controlled by said device for reproducing in the sender a record of the class of connection, means for governing the operation of the sender according to the class of the record received from said device, means for connecting the sender to the controlling device at a subsequent stage, and means controlled by said last device for operating a switch at the corresponding stage to further extend the connection.

47. In a telephone system, telephone lines, a sender common to said lines, said sender comprising means for recording impulses translating the record thus established and sending impulses of a different character, means for associating said lines with said sender, a series of selective stages through which the connection may be extended, each selective stage comprising switches and a marker common to said switches for controlling said switches, and means responsive to the impulses sent by said sender for operating said markers.

48. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses translating the record thus established and sending impulses of a different character, means for associating said lines with said sender, a series of selective stages through which the connection may be extended, each selective stage comprising switches and a marker common to said senders, for controlling said switches, and means responsive to the impulses sent by said sender for operating said markers.

49. In a telephone system, telephone lines, senders common to said lines, each said sender comprising means for recording impulses translating the record thus established and sending impulses of a different character, means for associating said lines with said sender, a series of selective stages through which the connection may be extended, each selective stage comprising switches and a marker common to said switches and said senders for controlling said switches, and means responsive to the impulses sent by said sender for operating said markers.

In witness whereof, I hereunto subscribe my name this 20th day of October A. D., 1922.

SAMUEL B. WILLIAMS, JR.