May 15, 1945. W. V. K. LARGE 2,375,856

SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 1

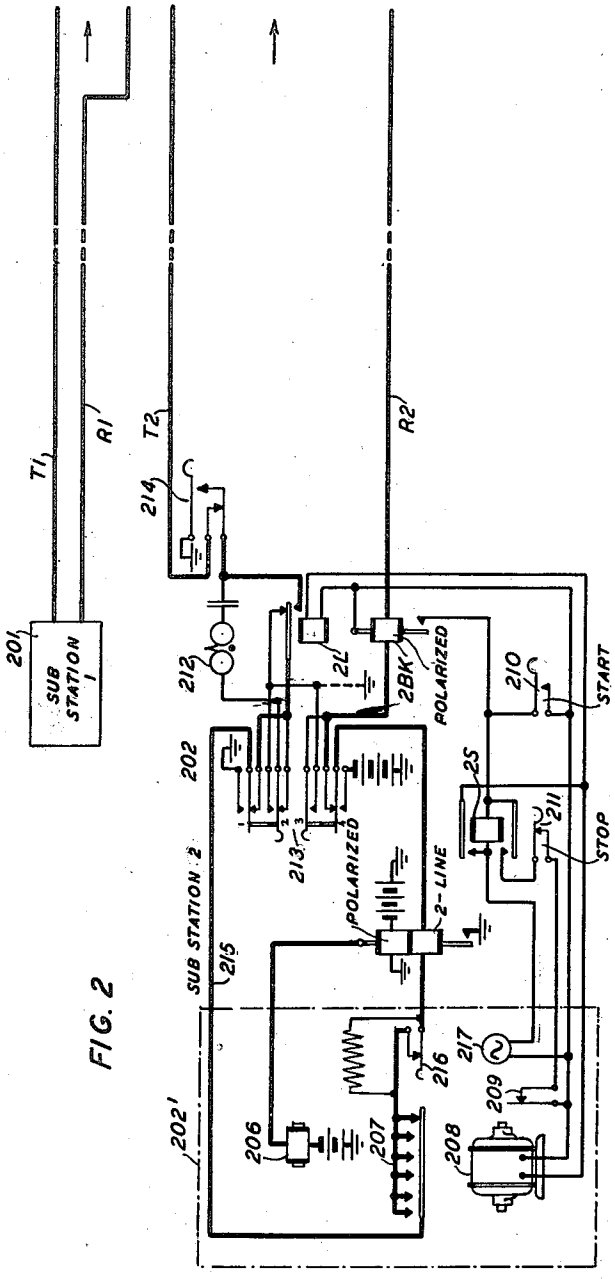
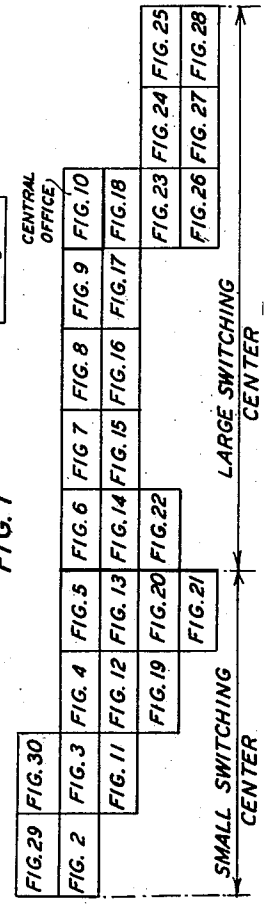


FIG. 2



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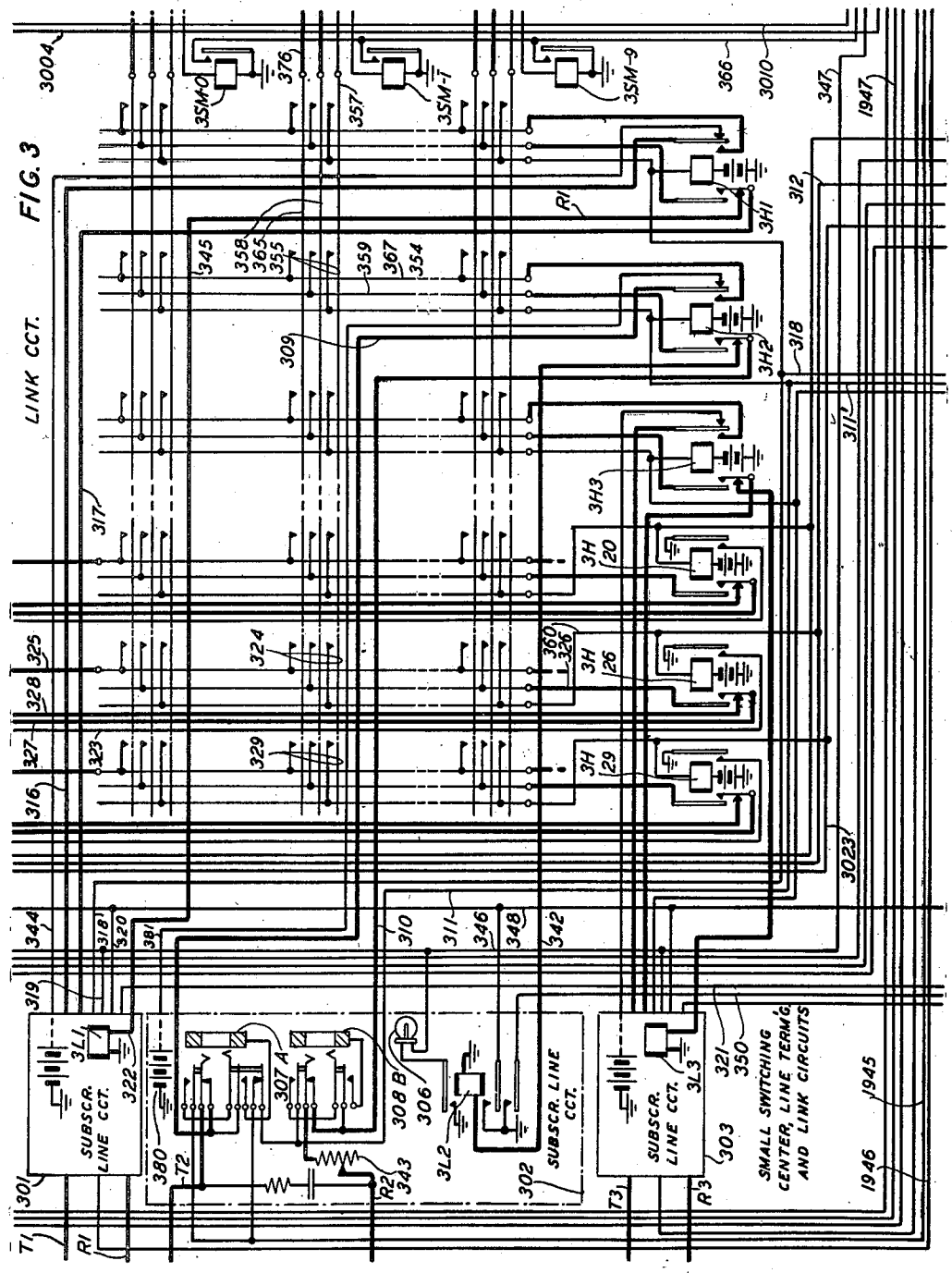
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 2



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 3

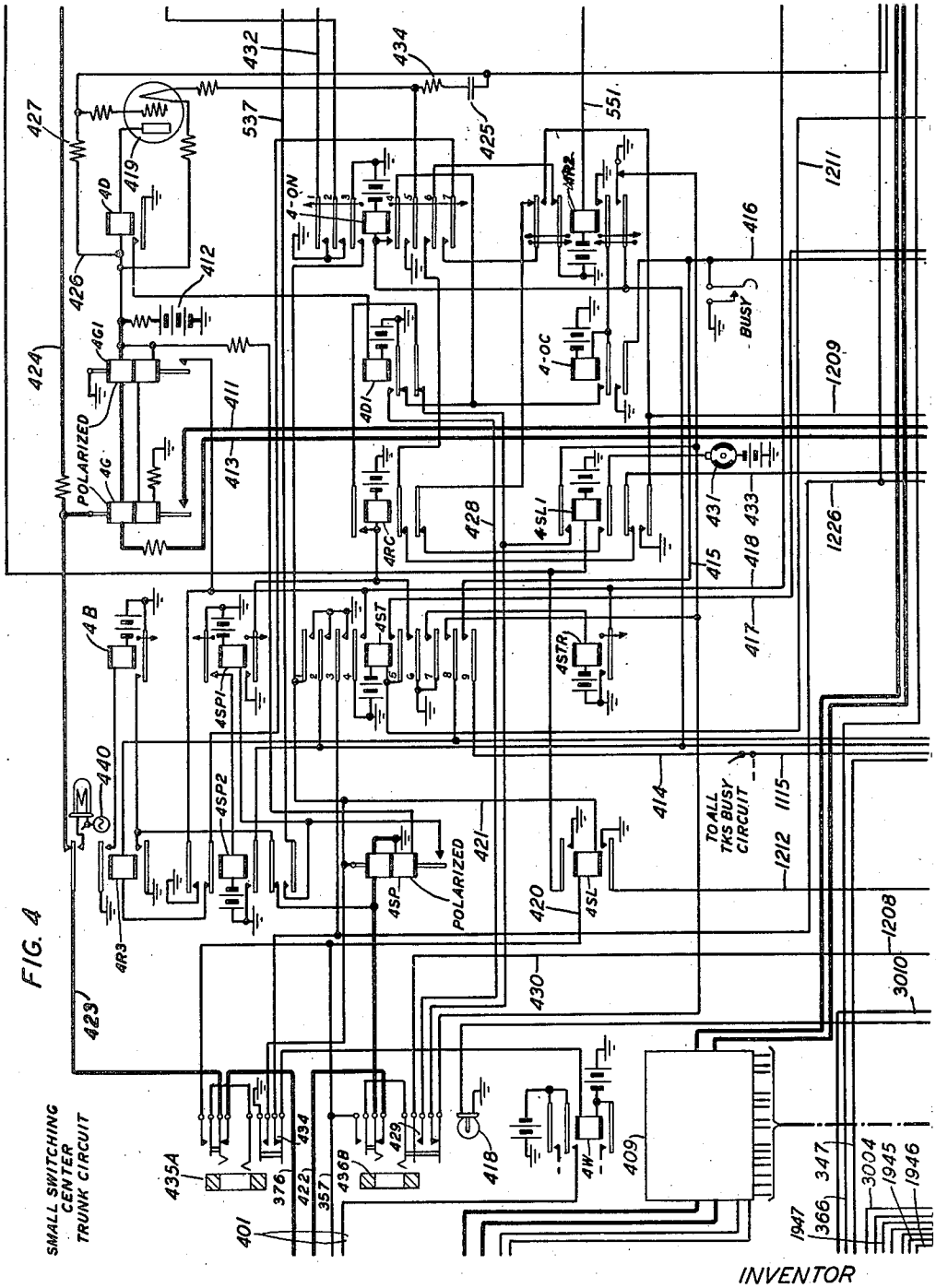

FIG. 4

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 4

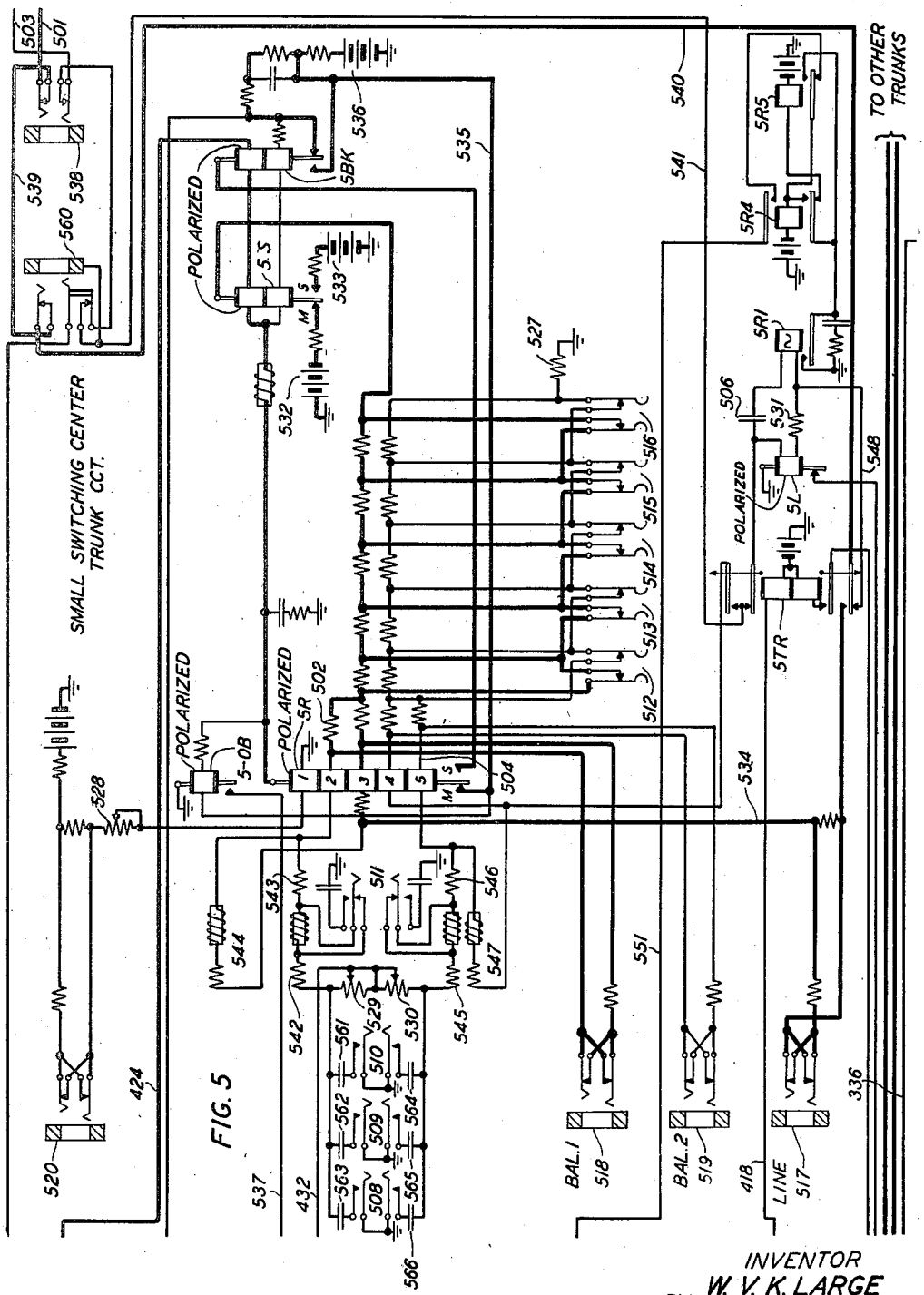

FIG. 5

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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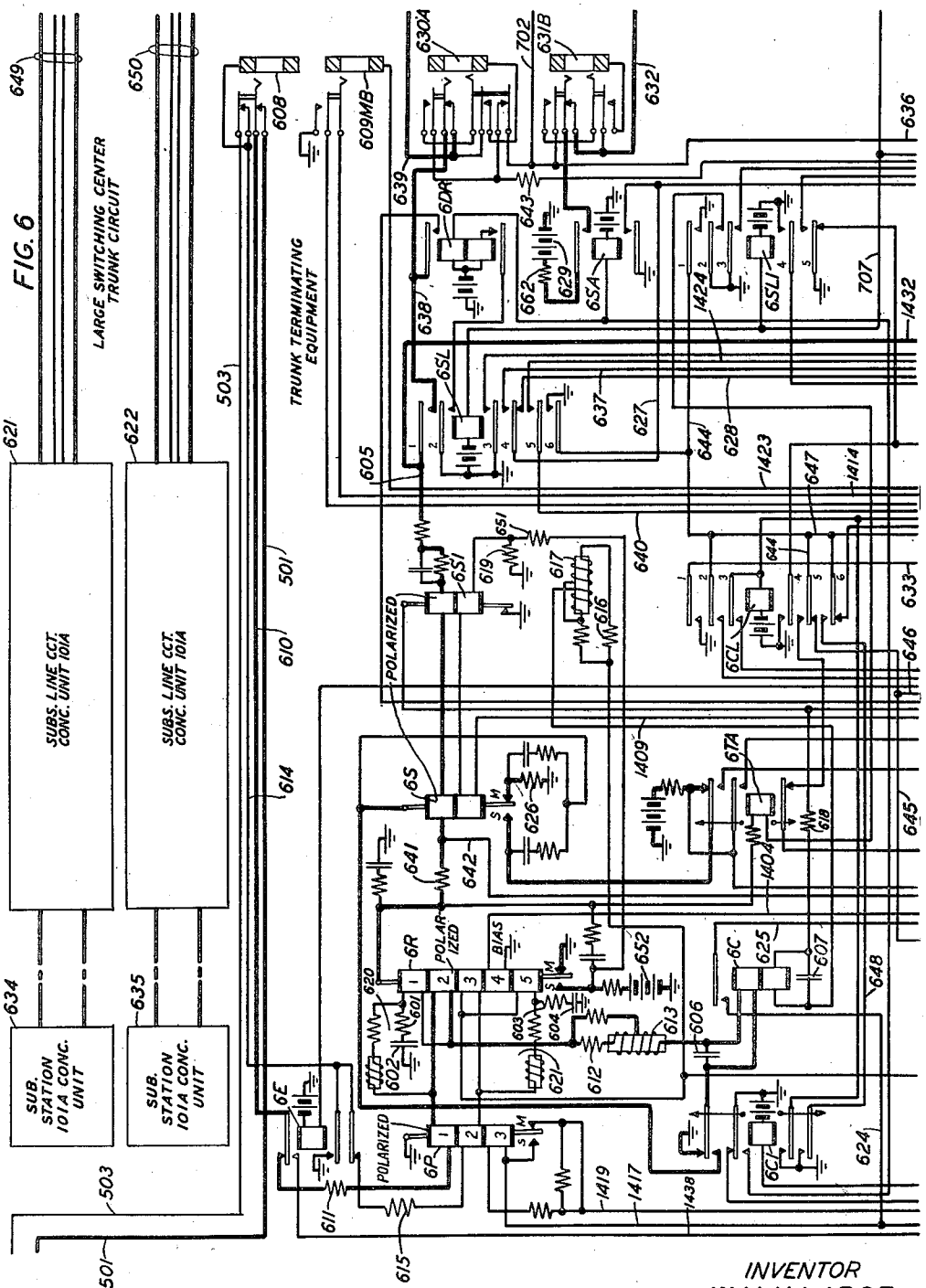

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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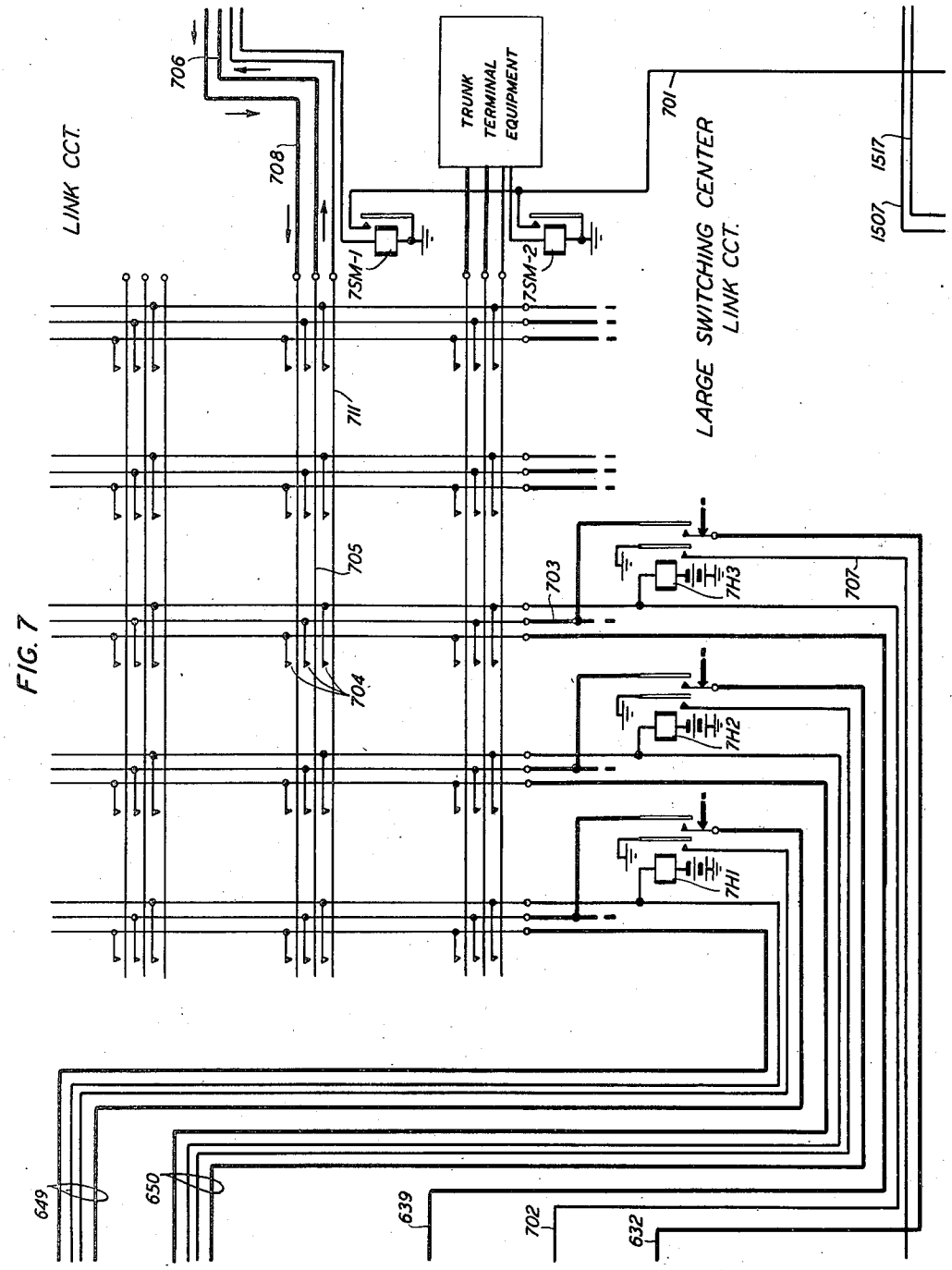

FIG. 7

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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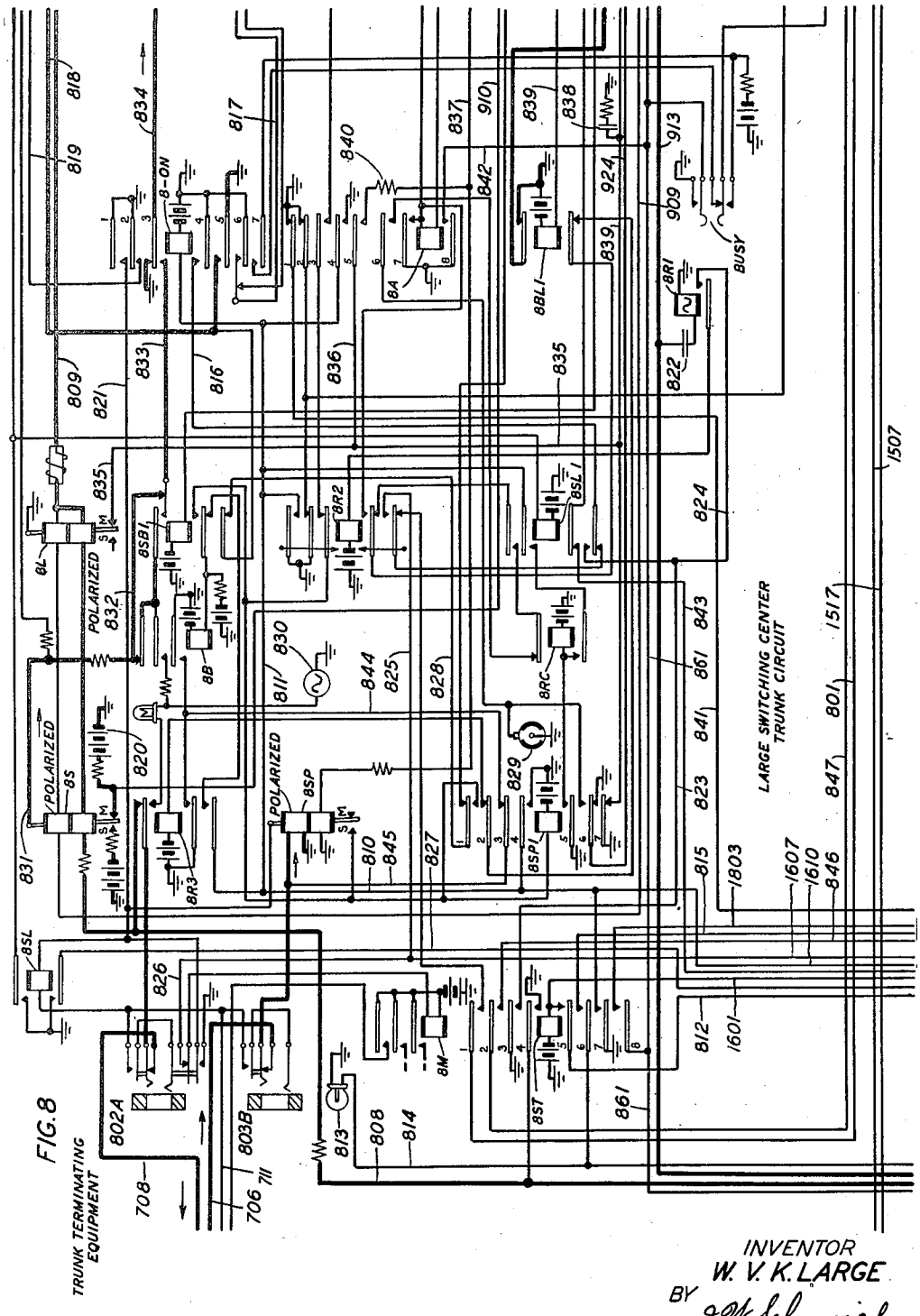

FIG. 8

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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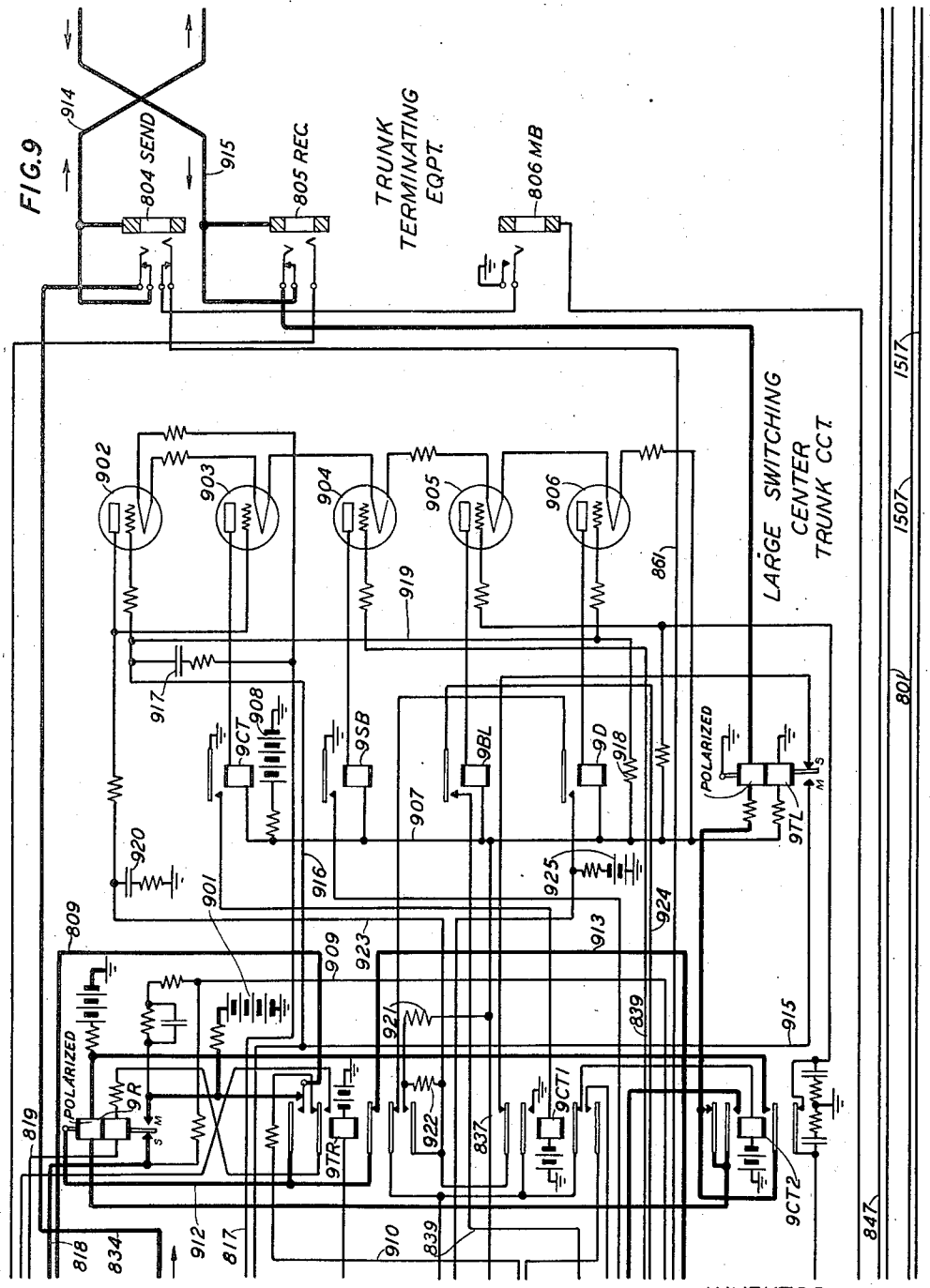
FIG. 9



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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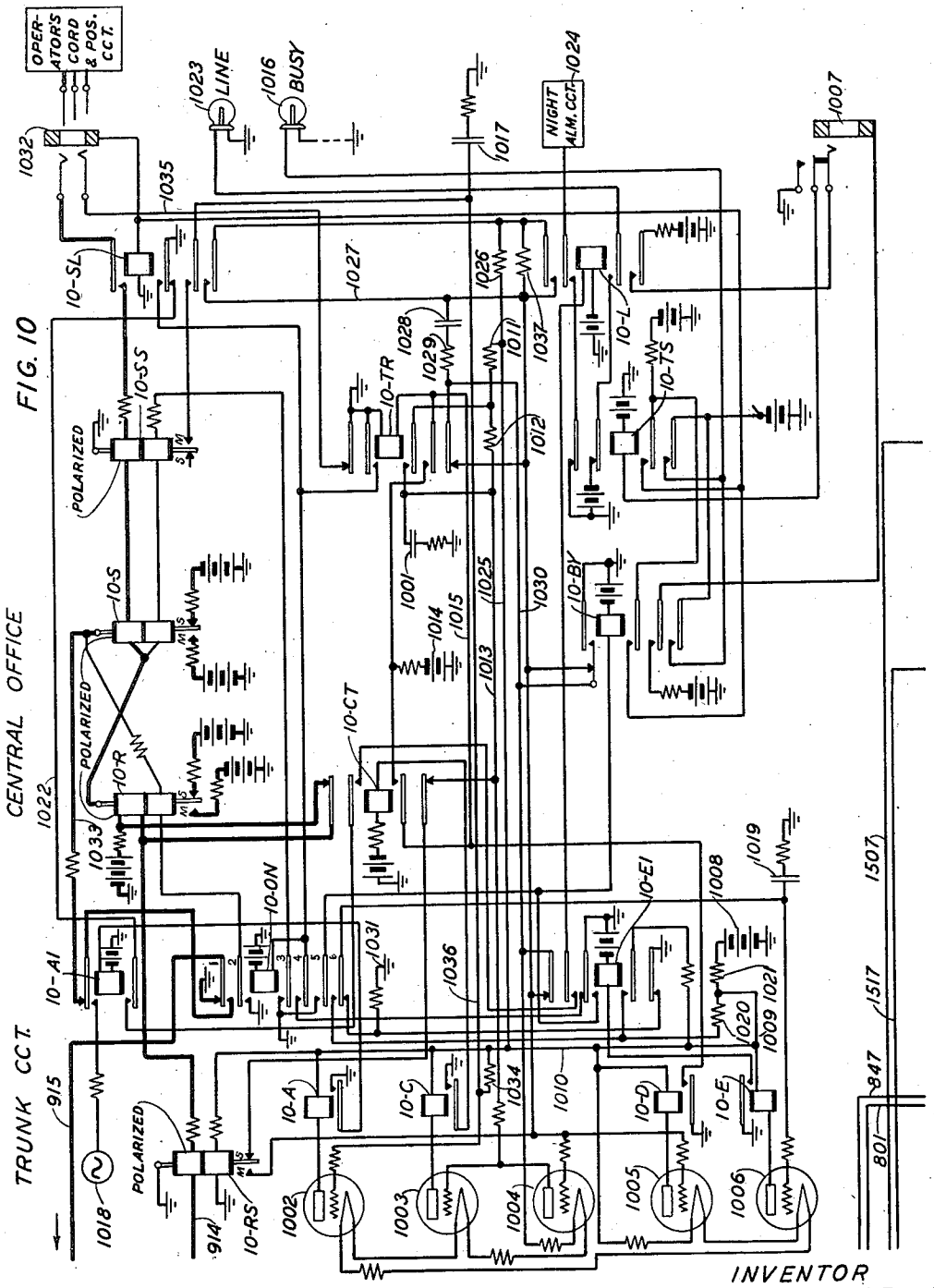

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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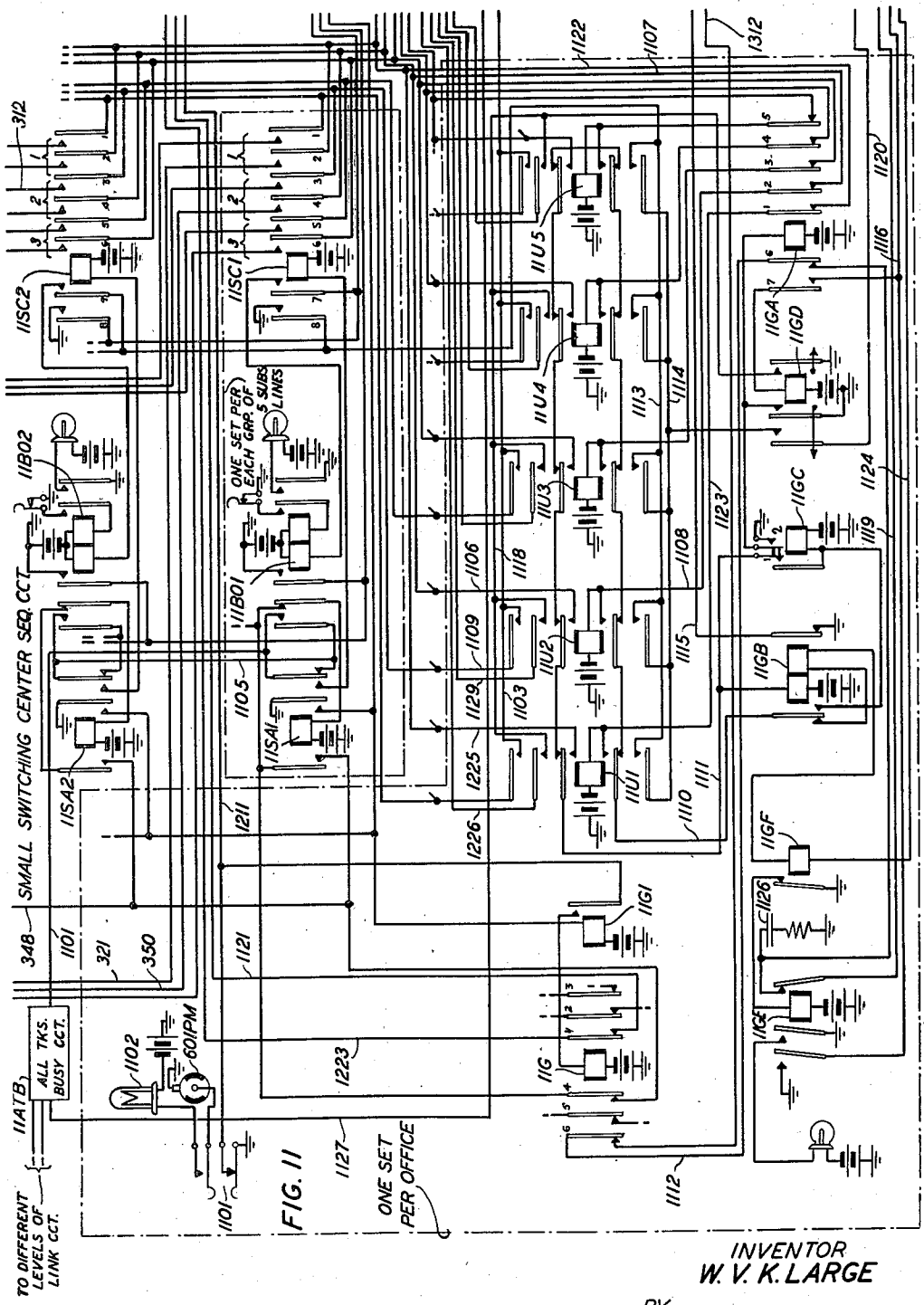

FIG. 11

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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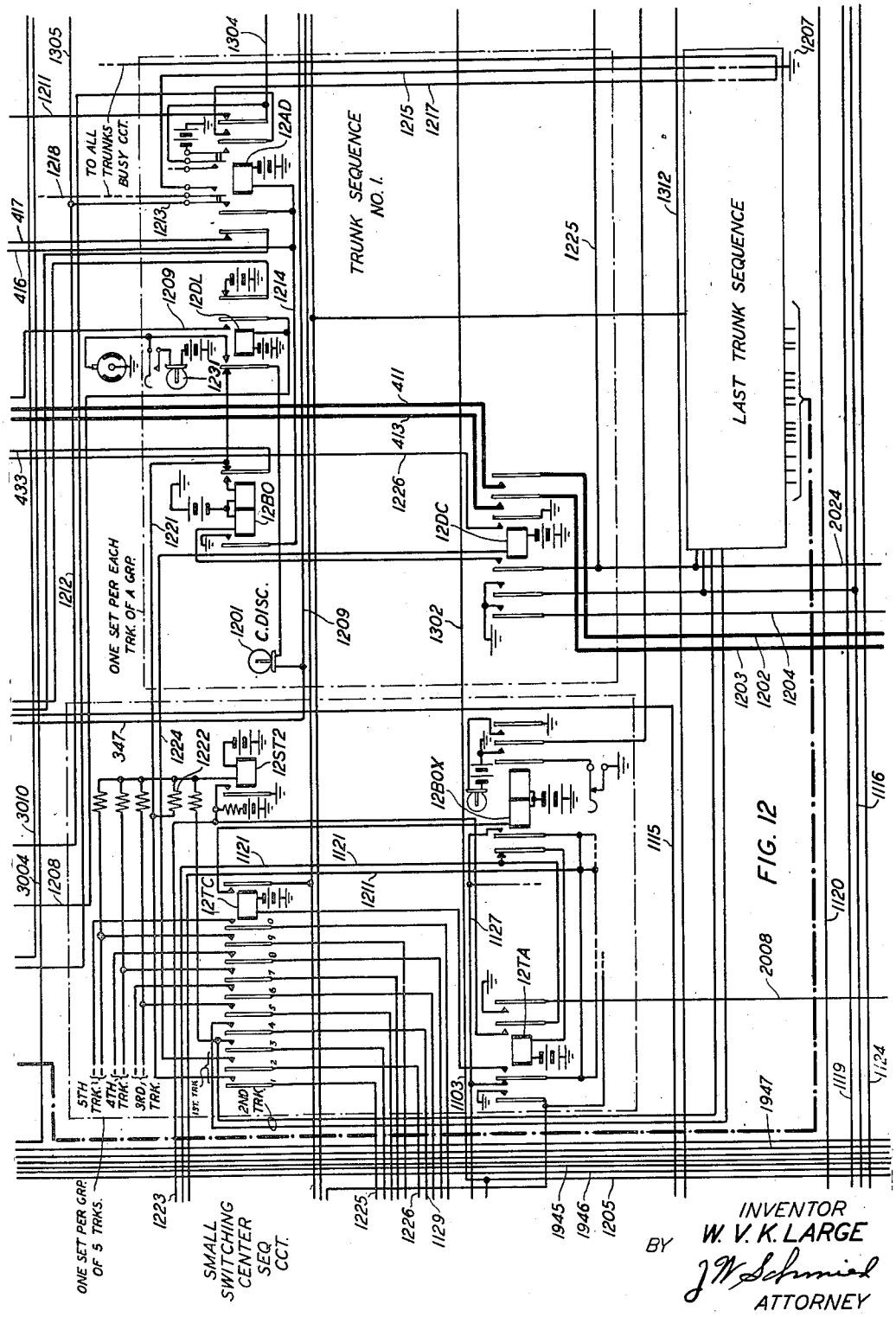

FIG. 12

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May 15, 1945. W. V. K. LARGE 2,375,856

SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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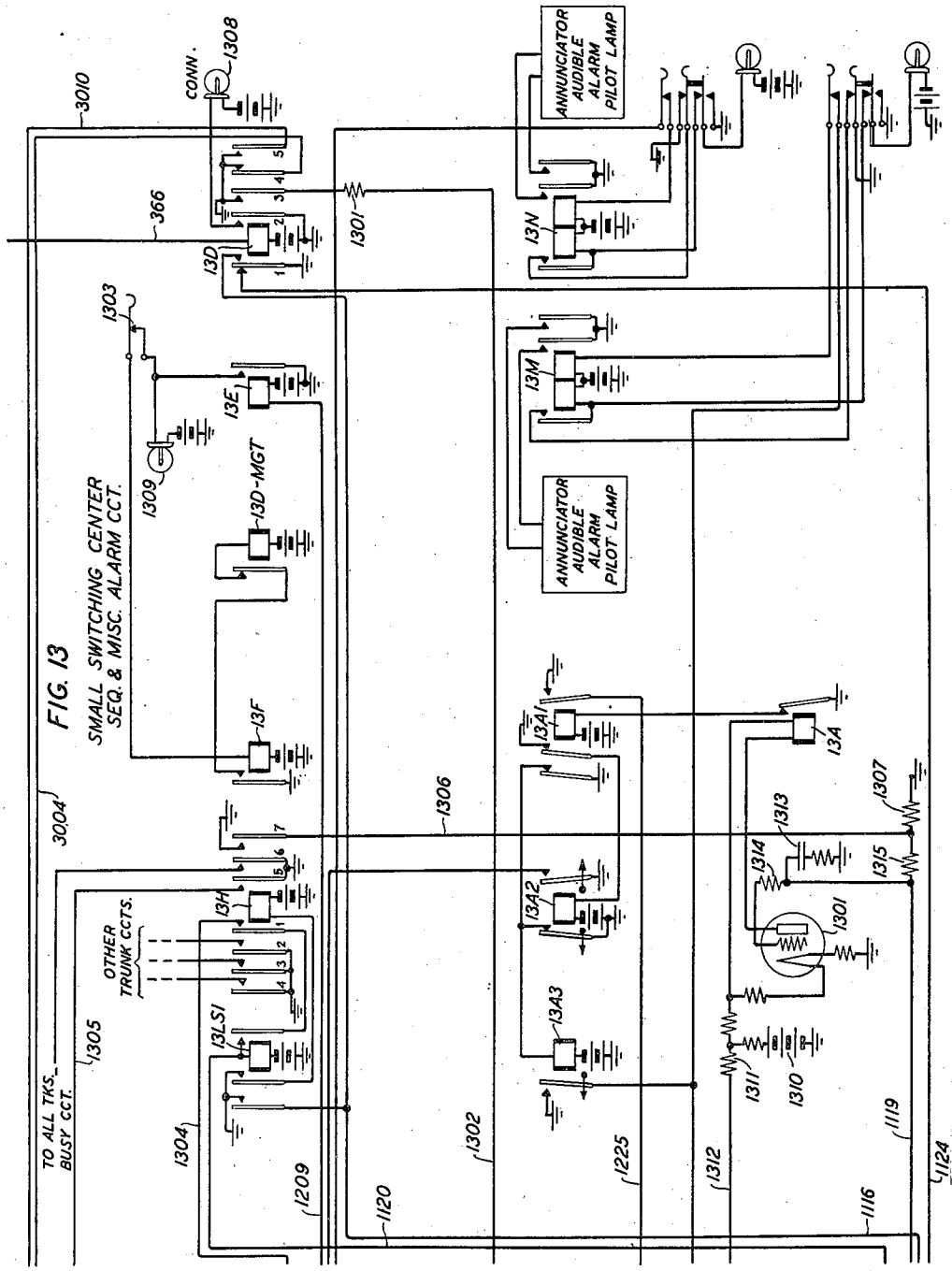

FIG. 13

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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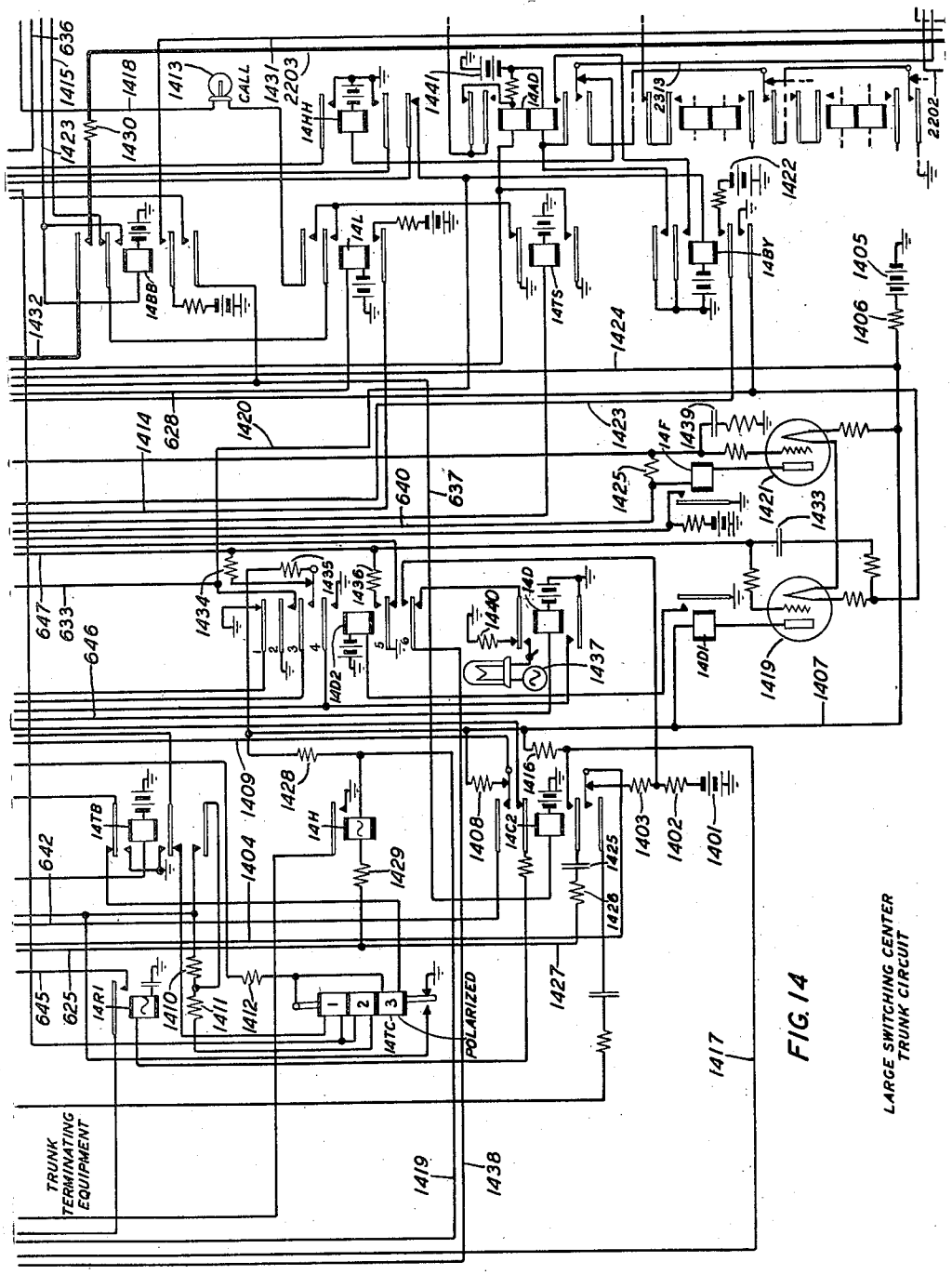

FIG. 14

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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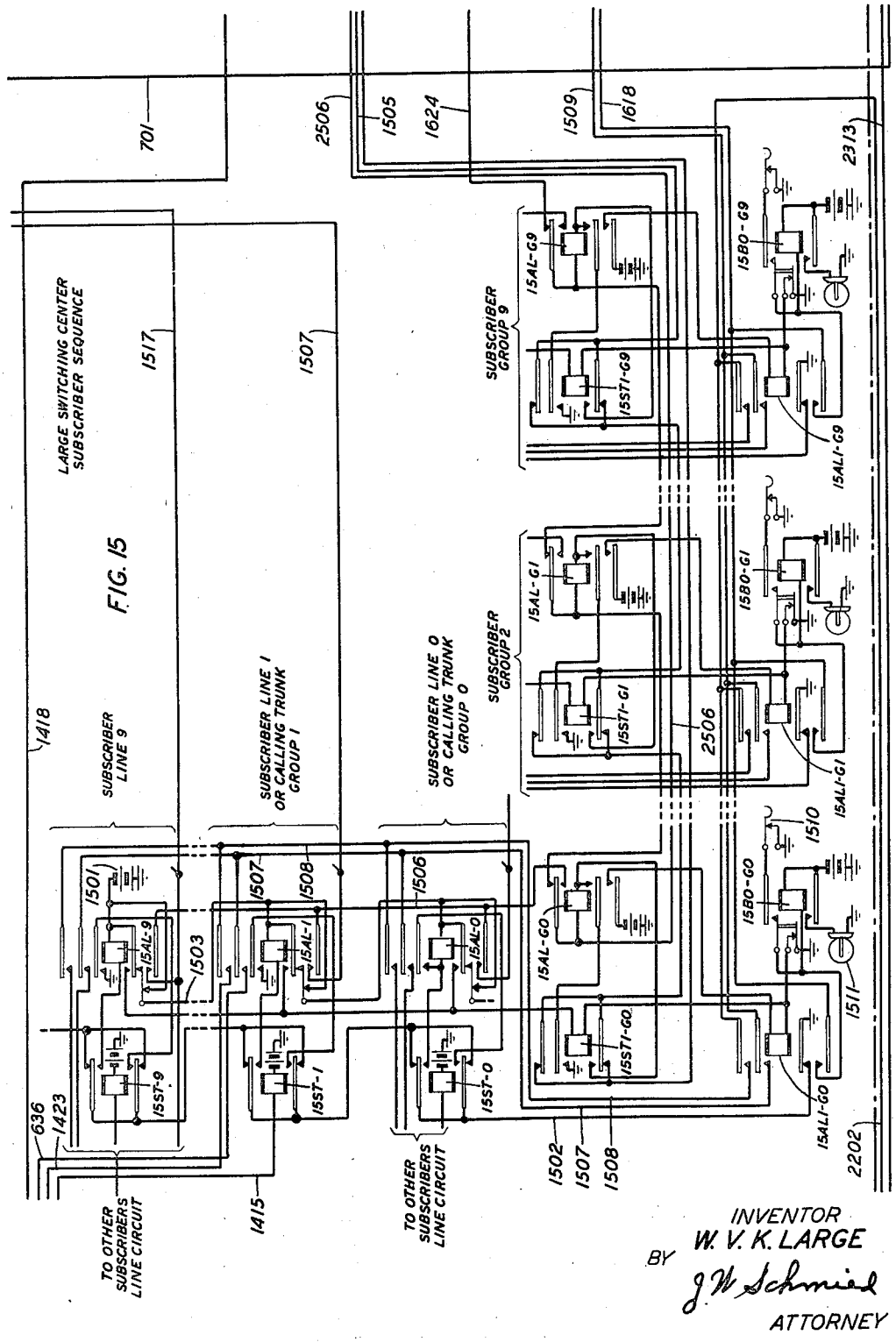

FIG. 15

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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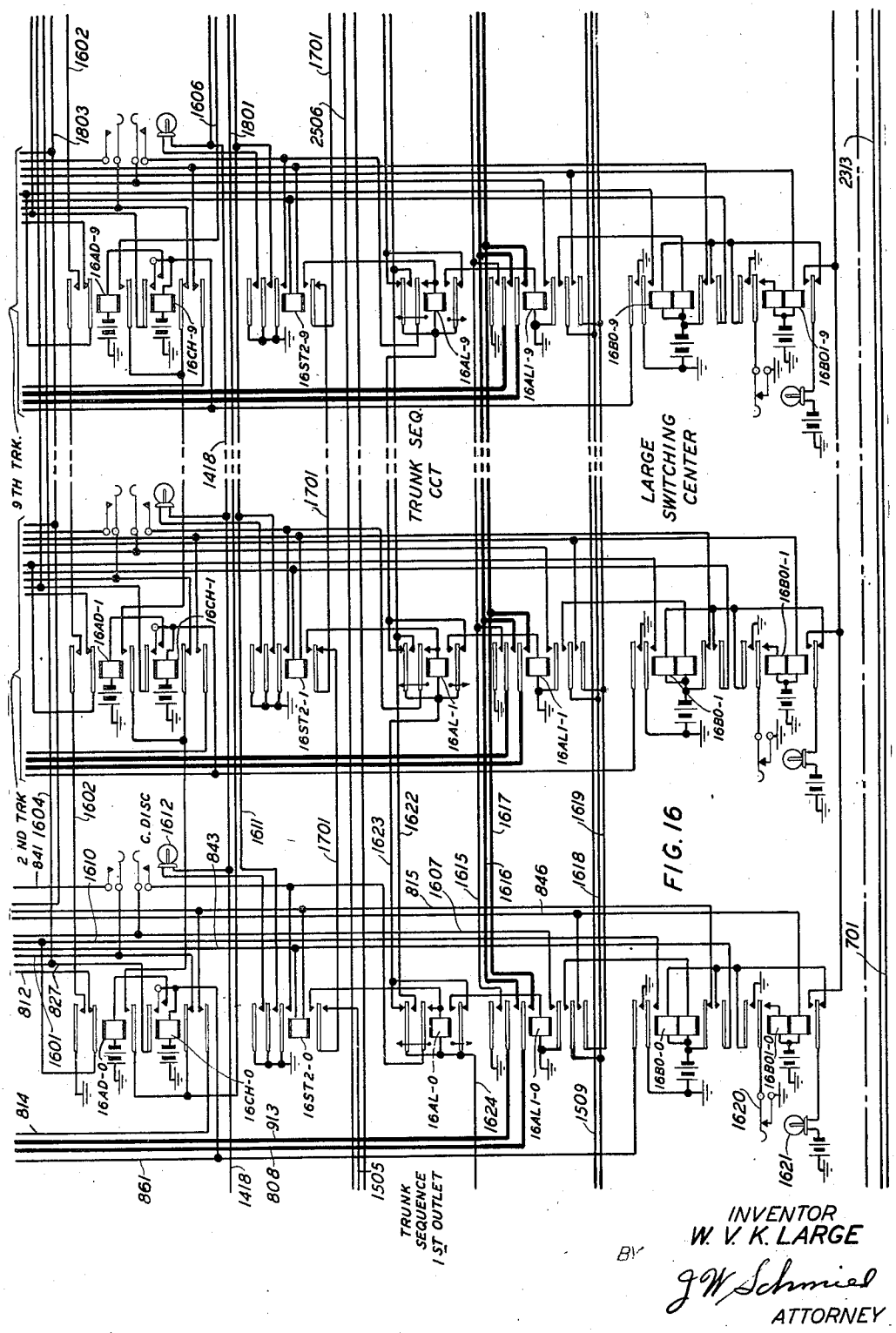

FIG. 16

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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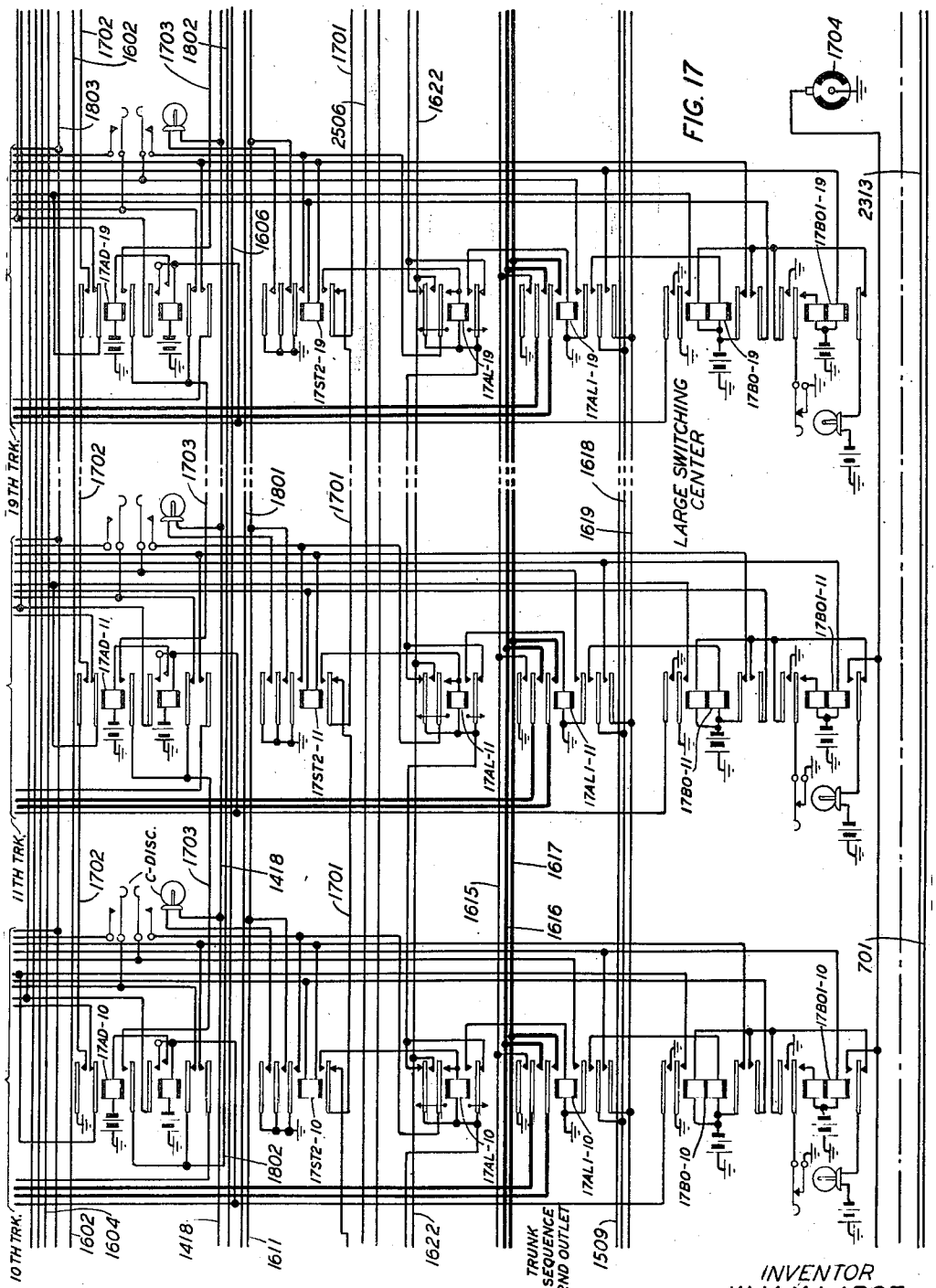

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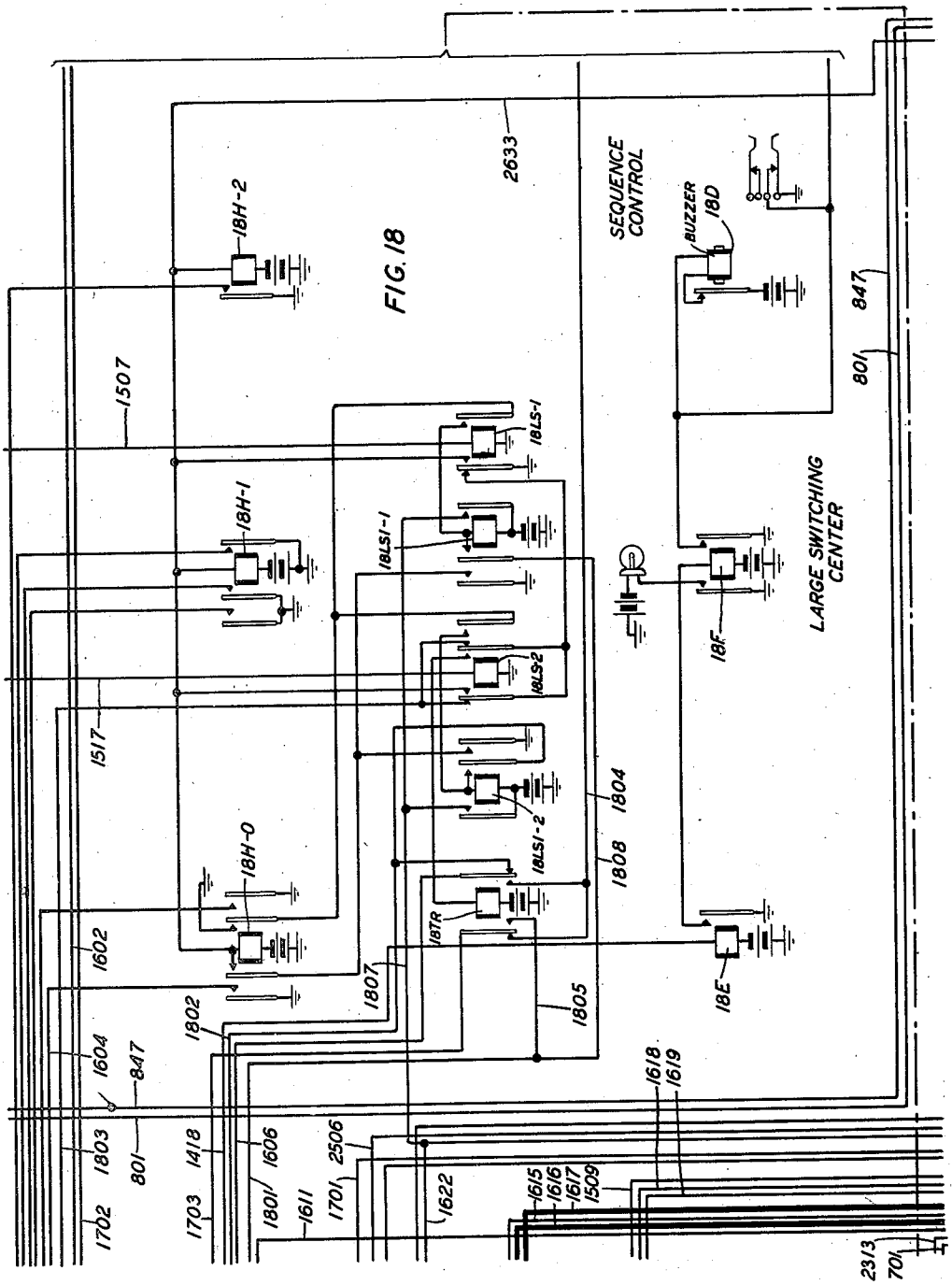
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 17



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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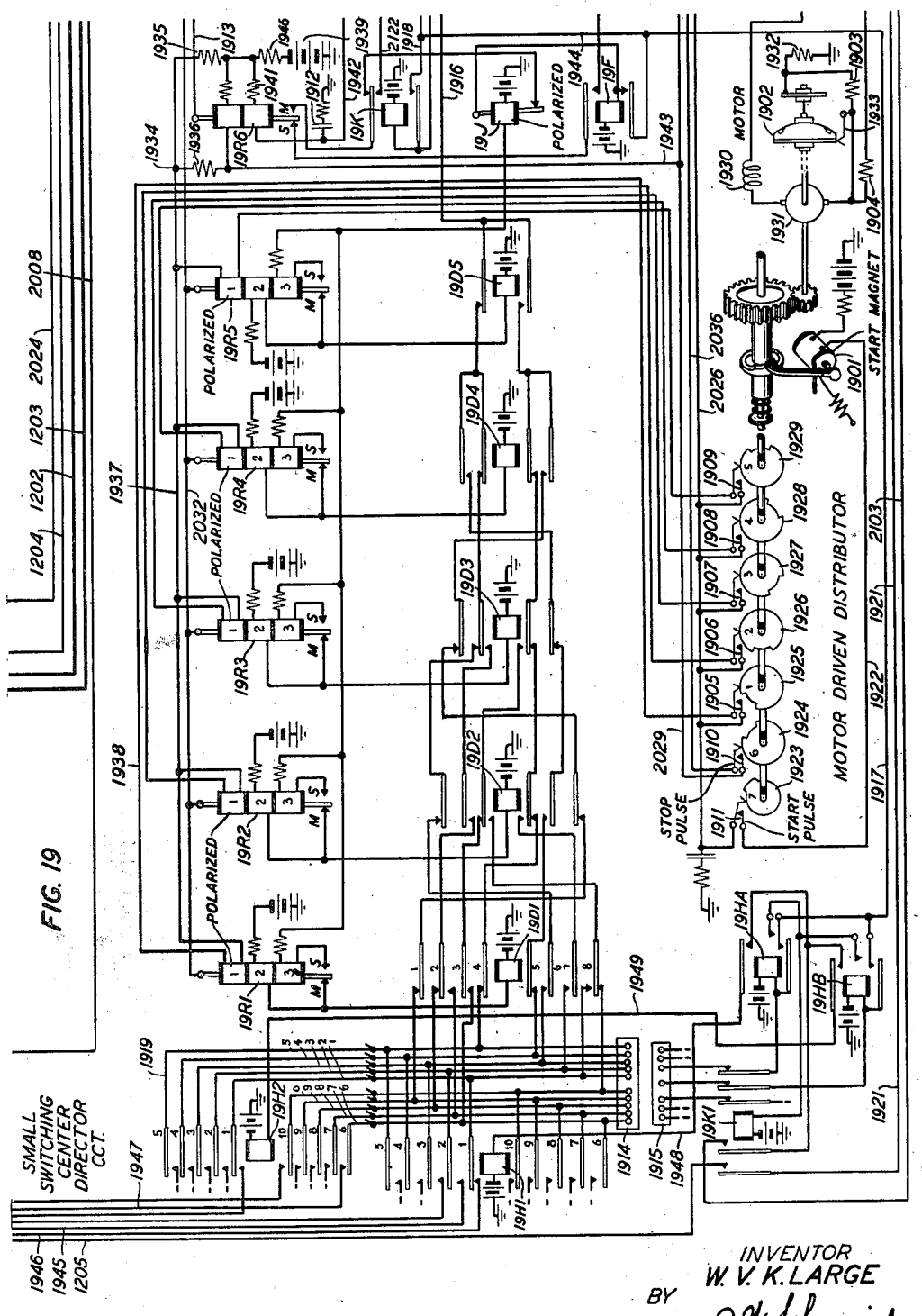

FIG. 19

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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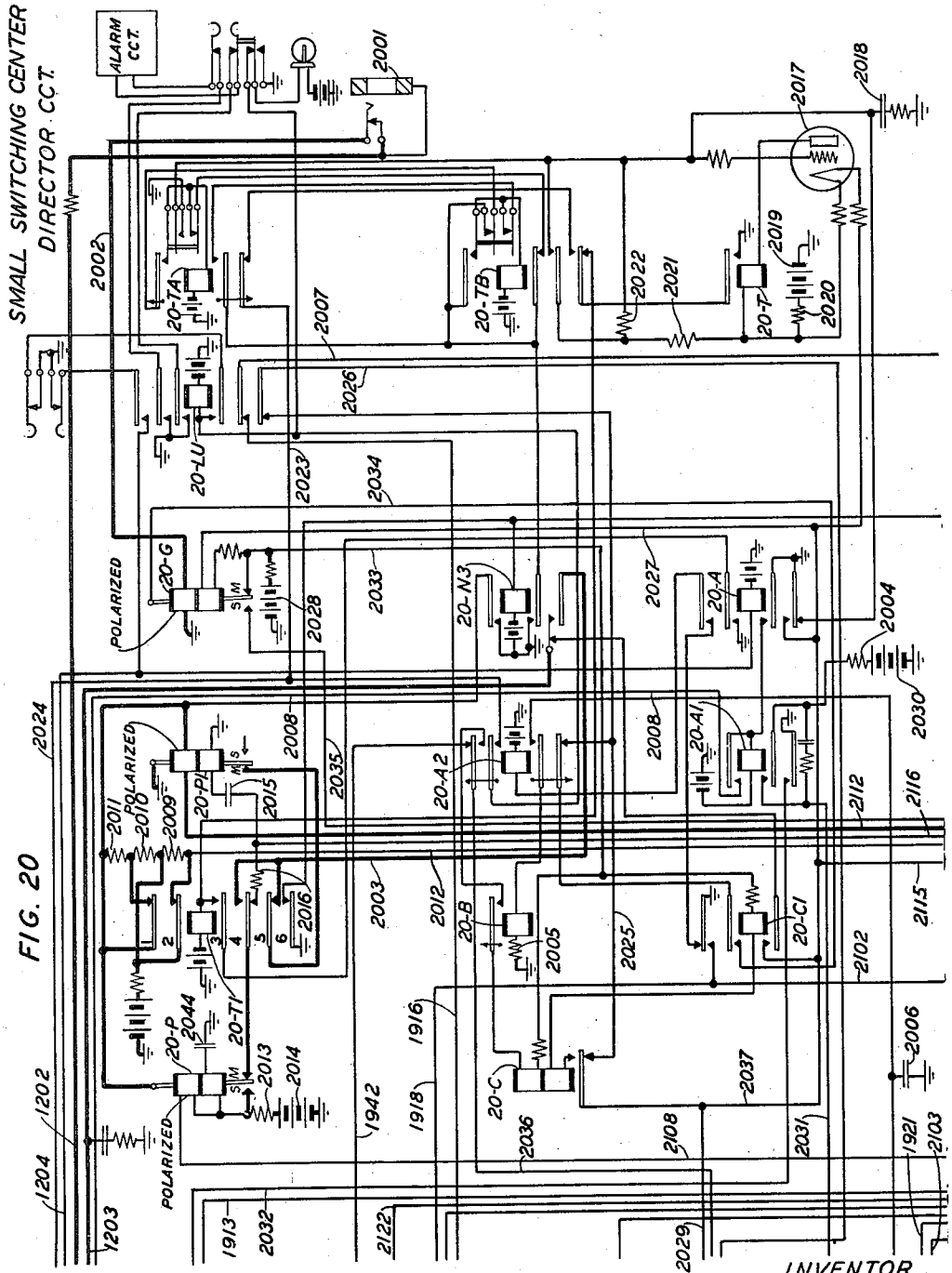

FIG. 20

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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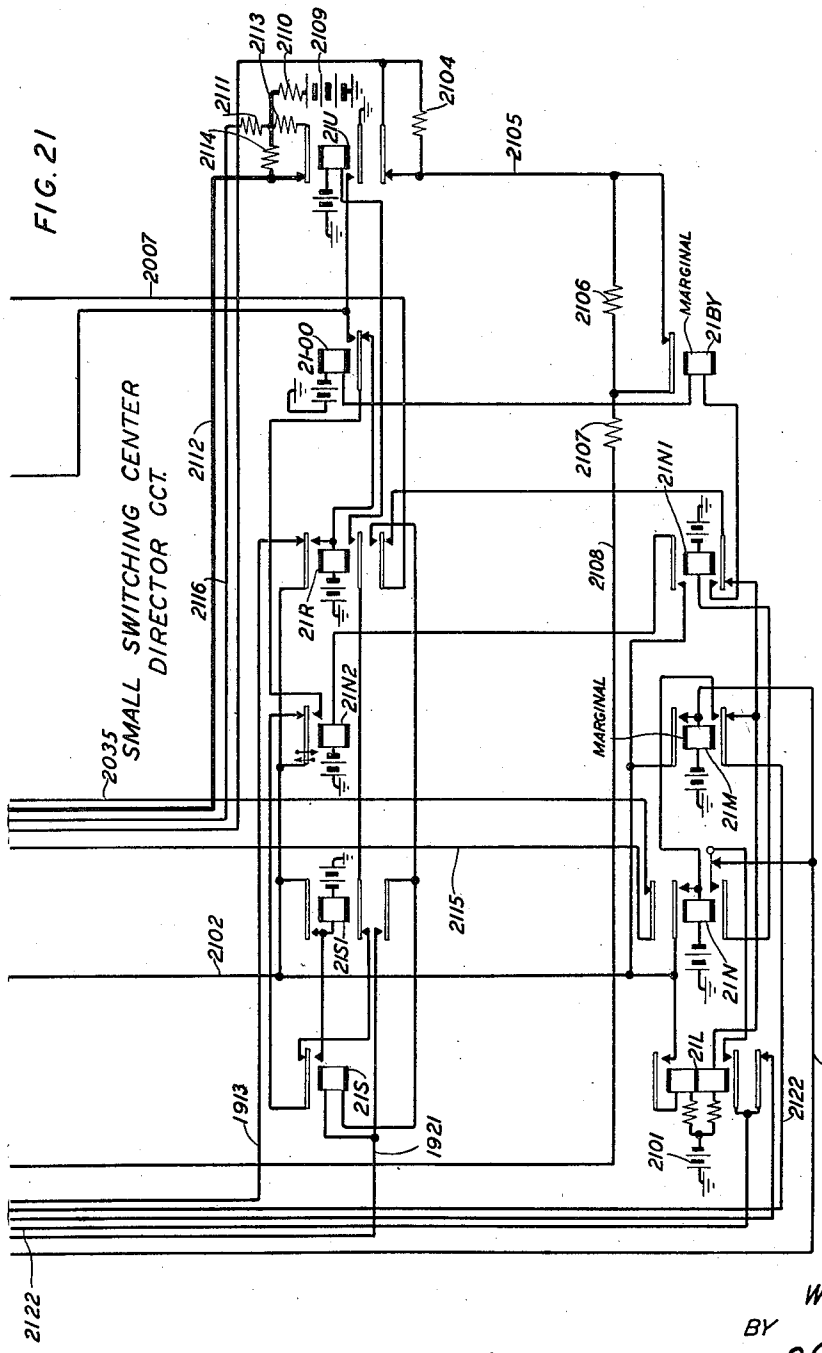
FIG. 21



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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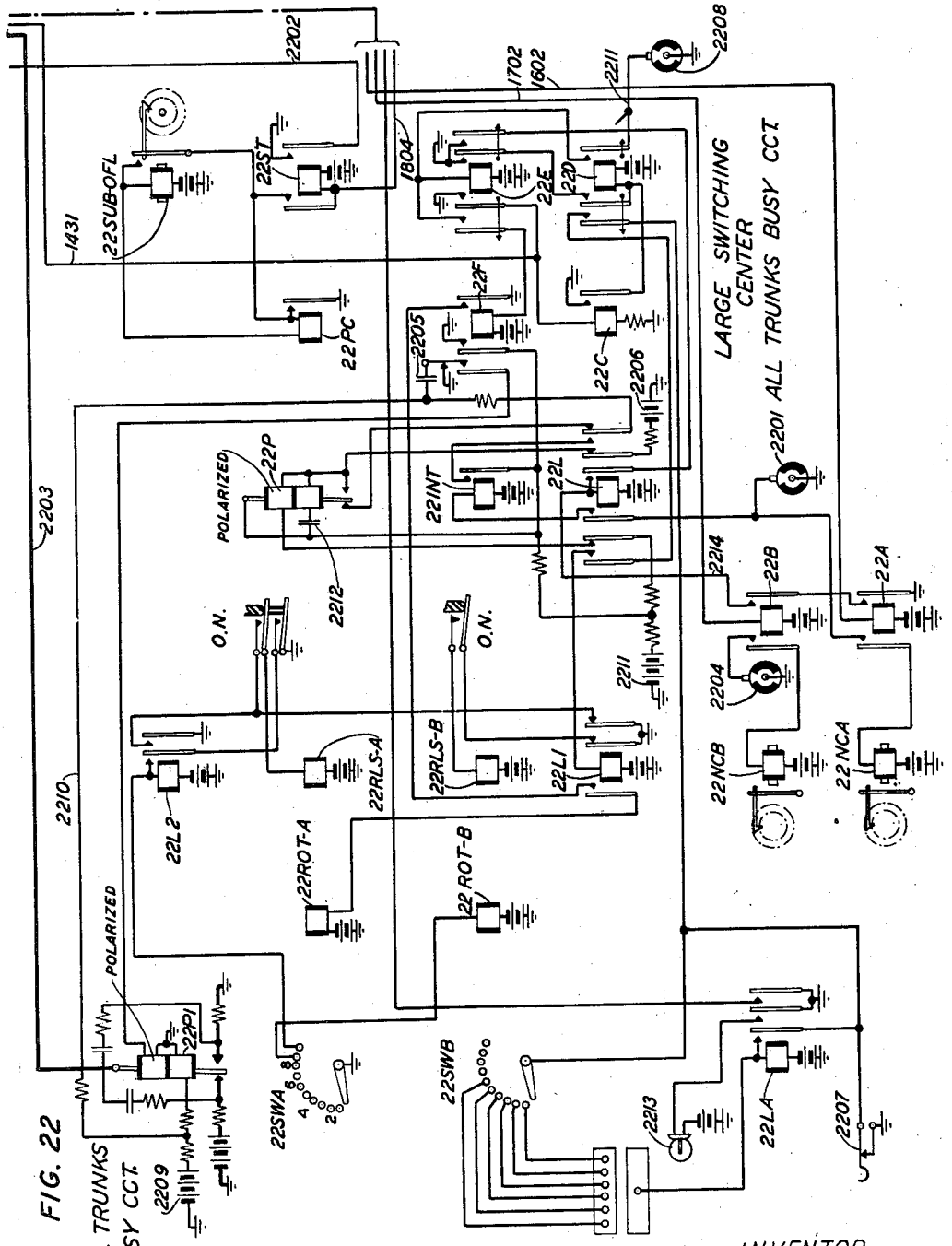

FIG. 22

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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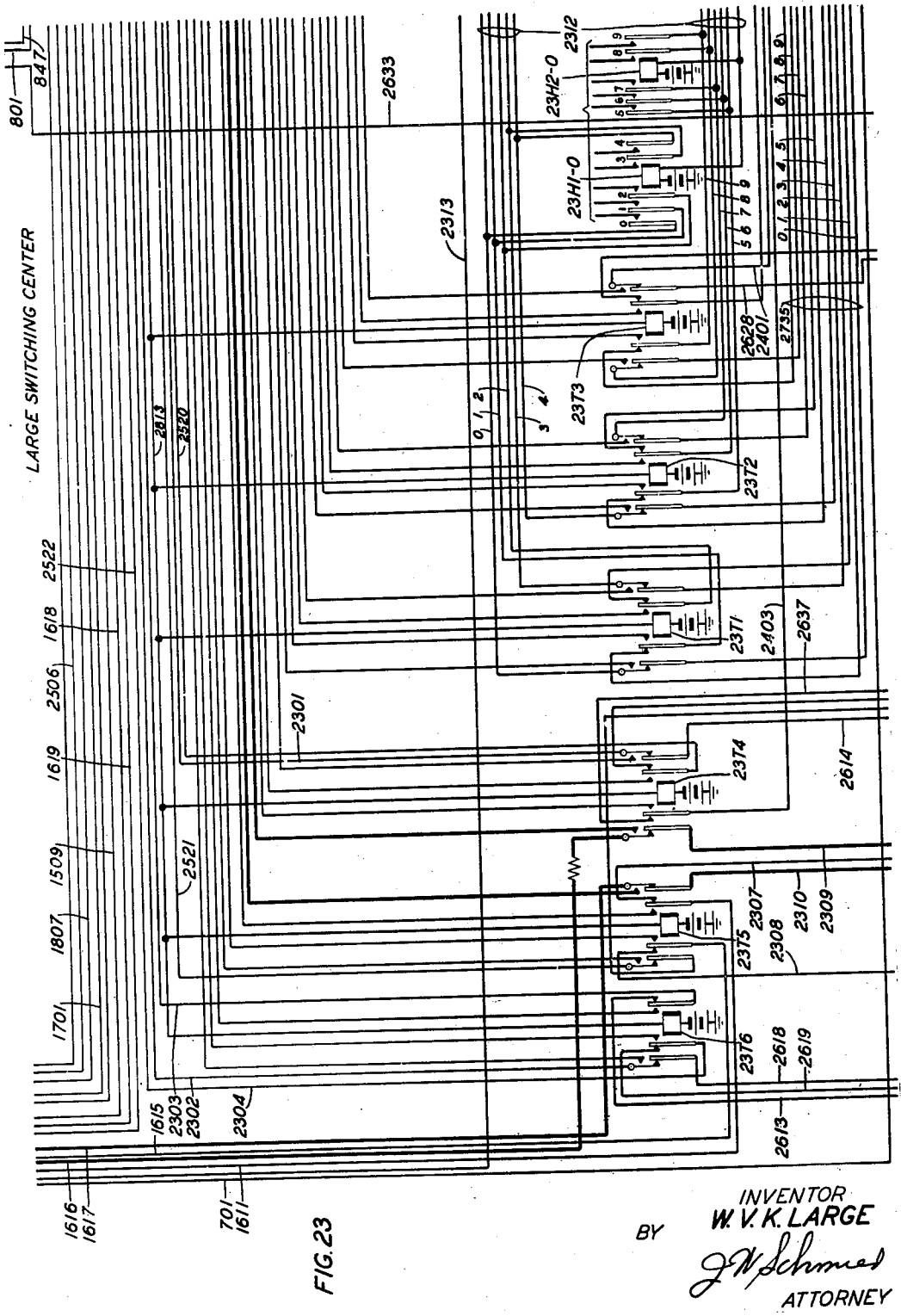

FIG. 23

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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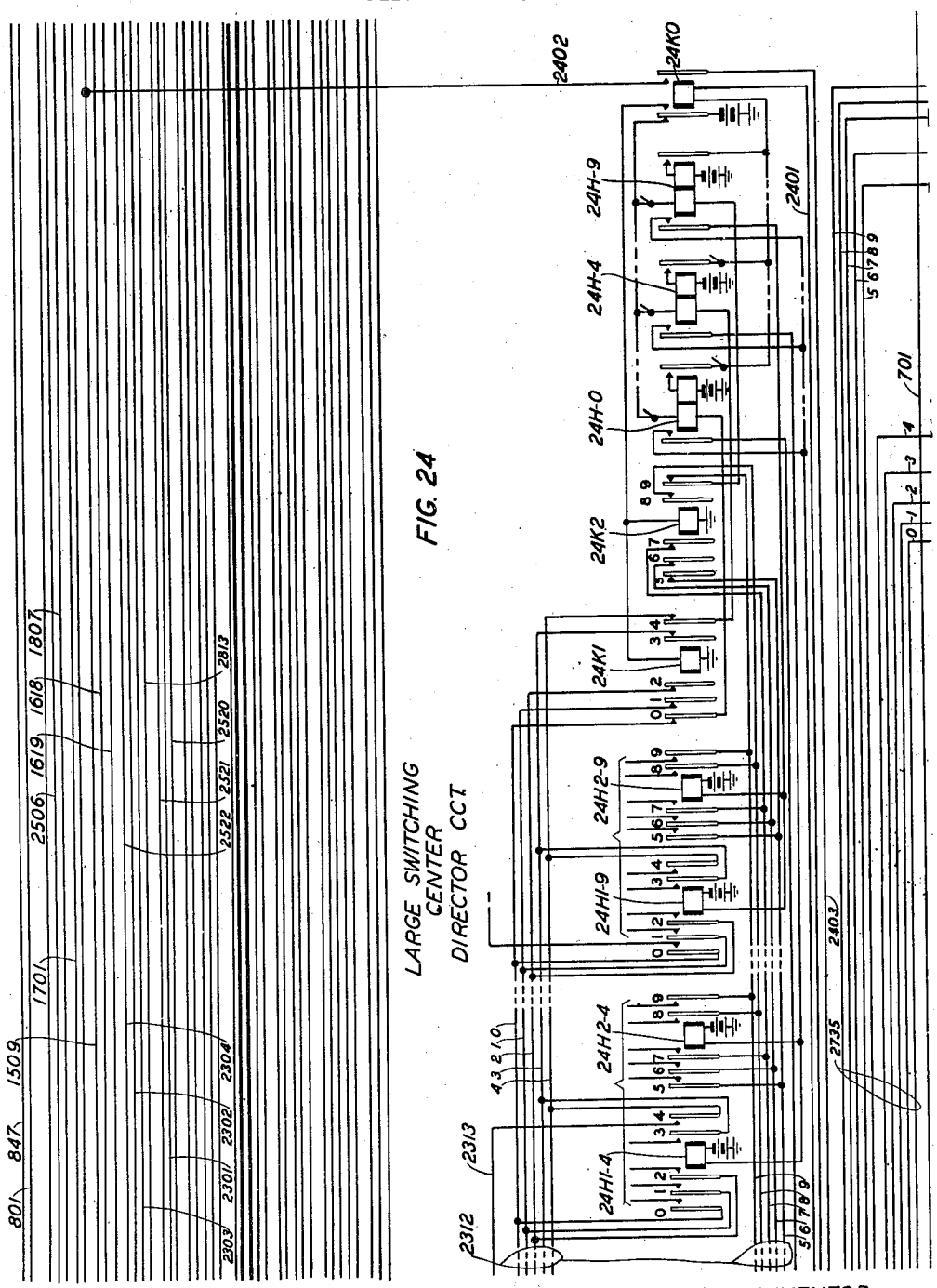

FIG. 24

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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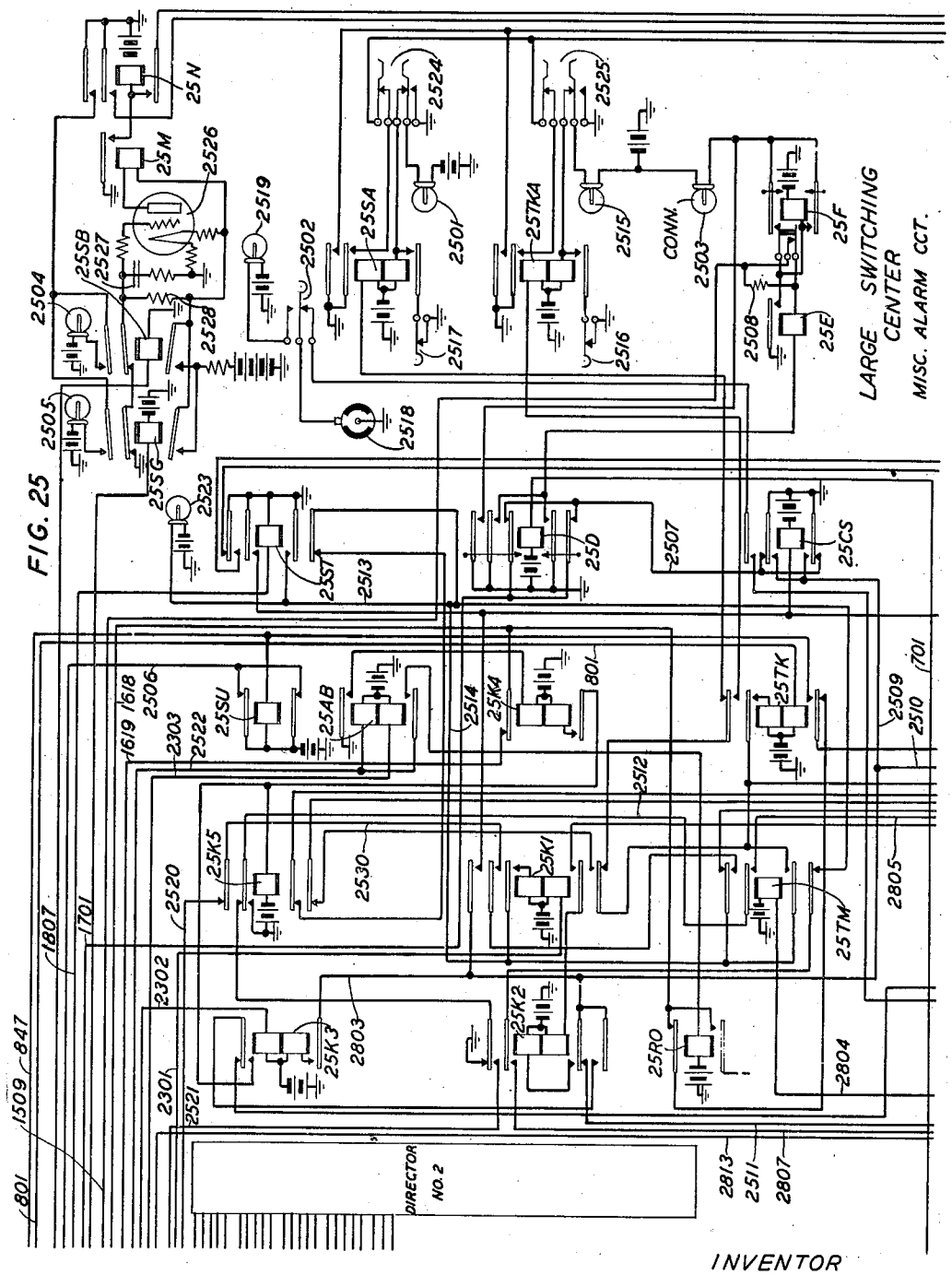

FIG. 25

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 25

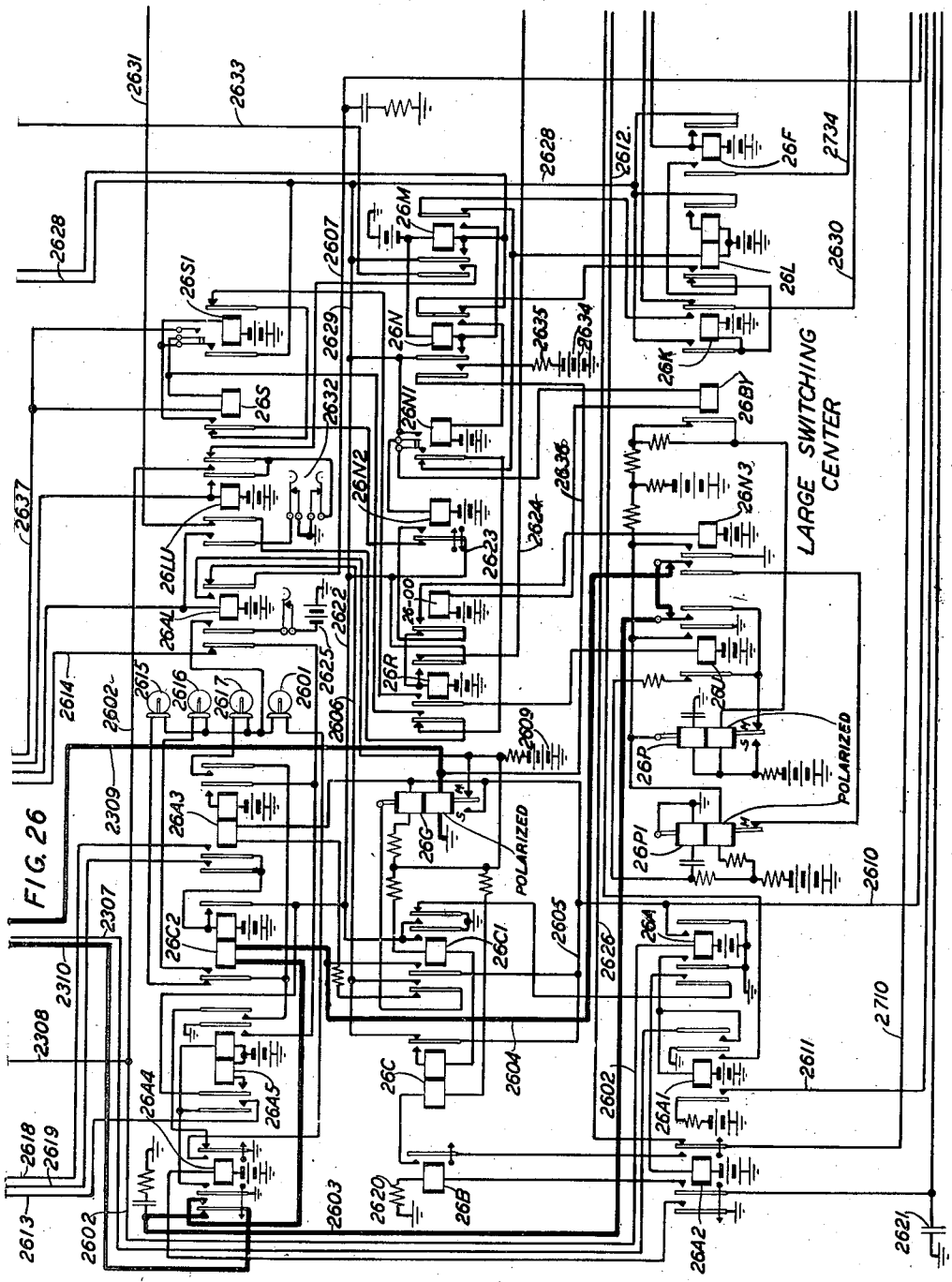

FIG. 26

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 26

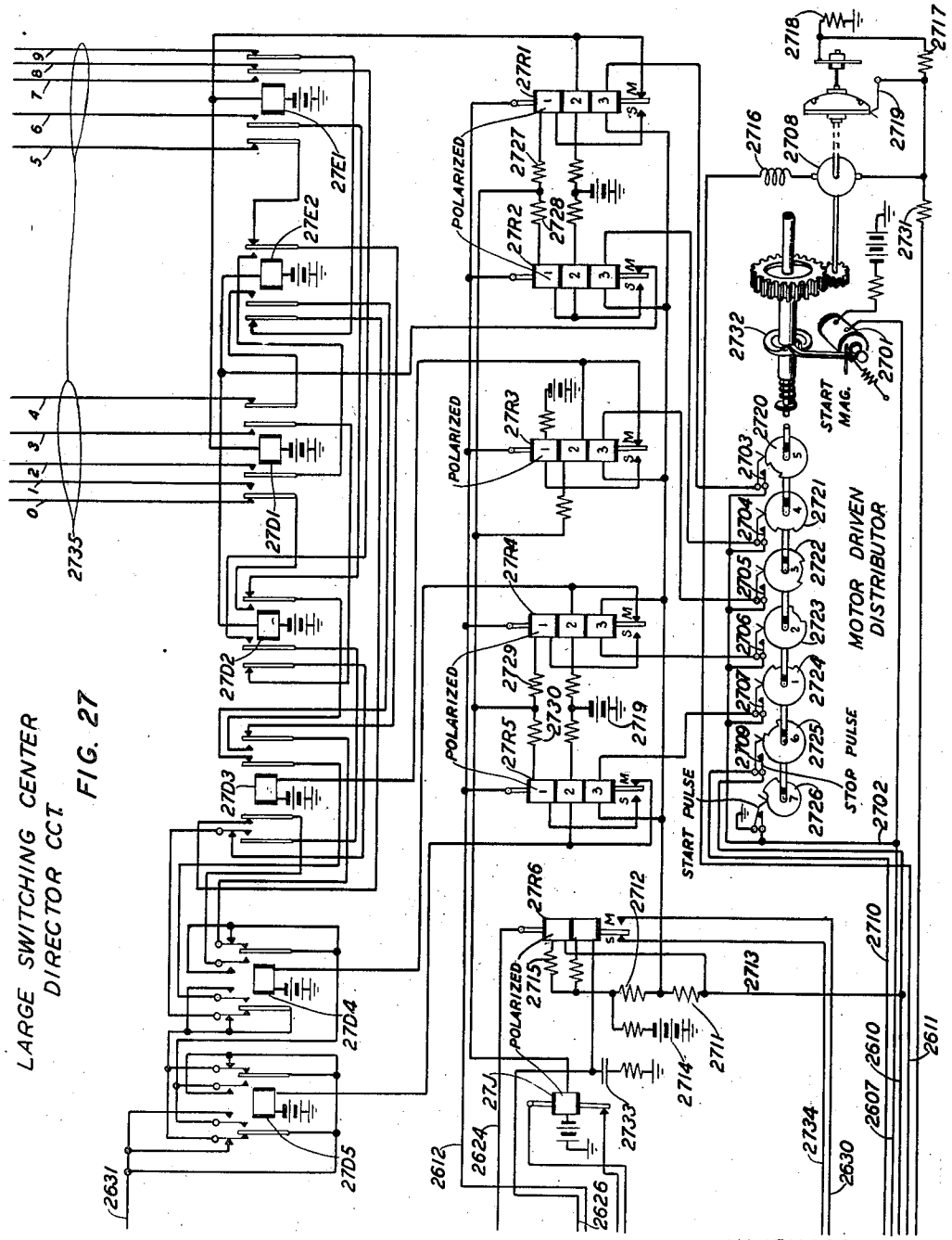

FIG. 27

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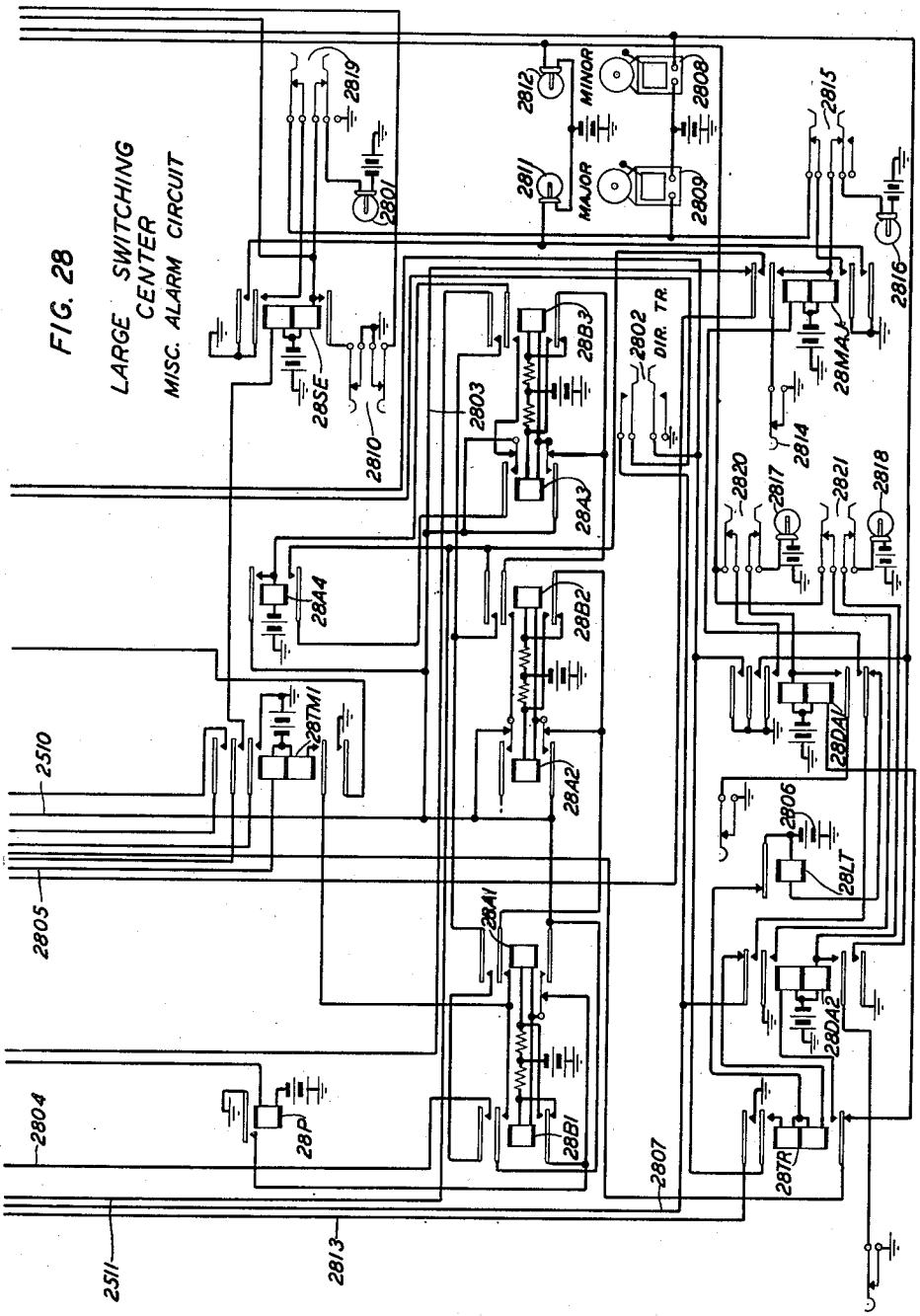
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 27



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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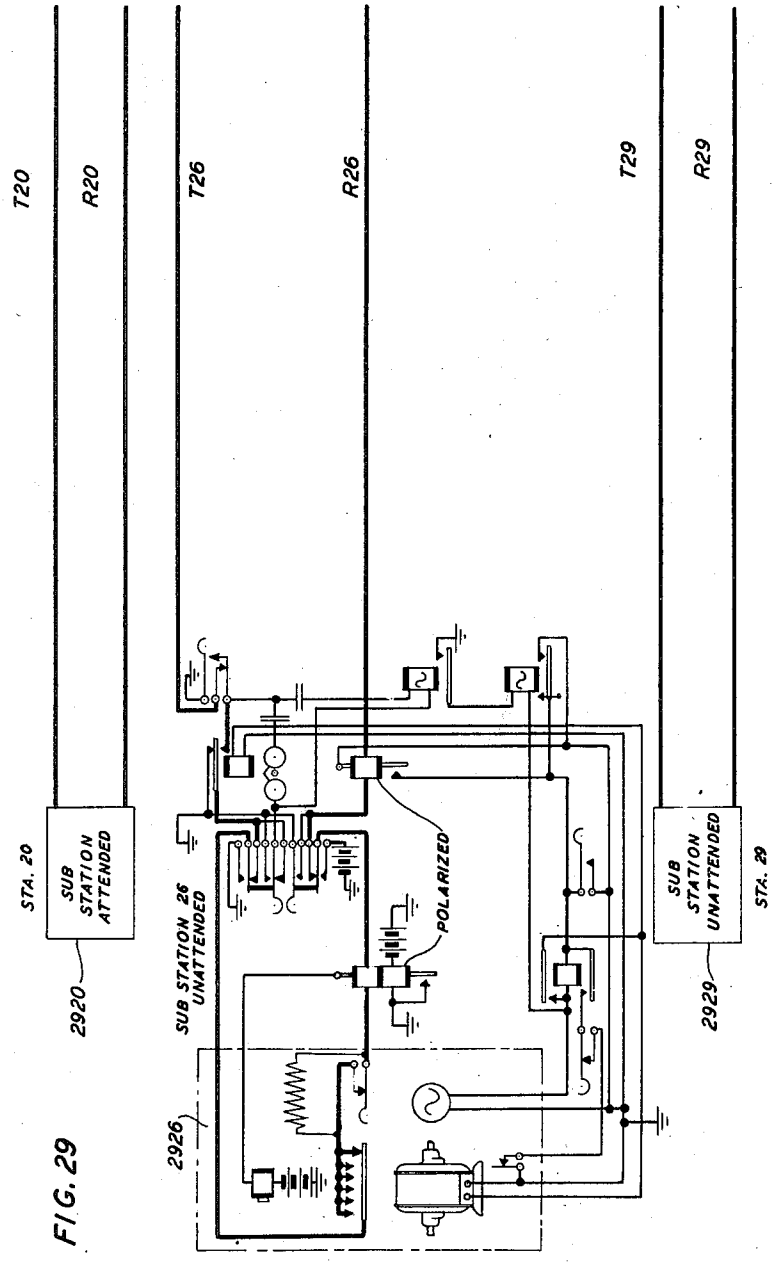

FIG. 29

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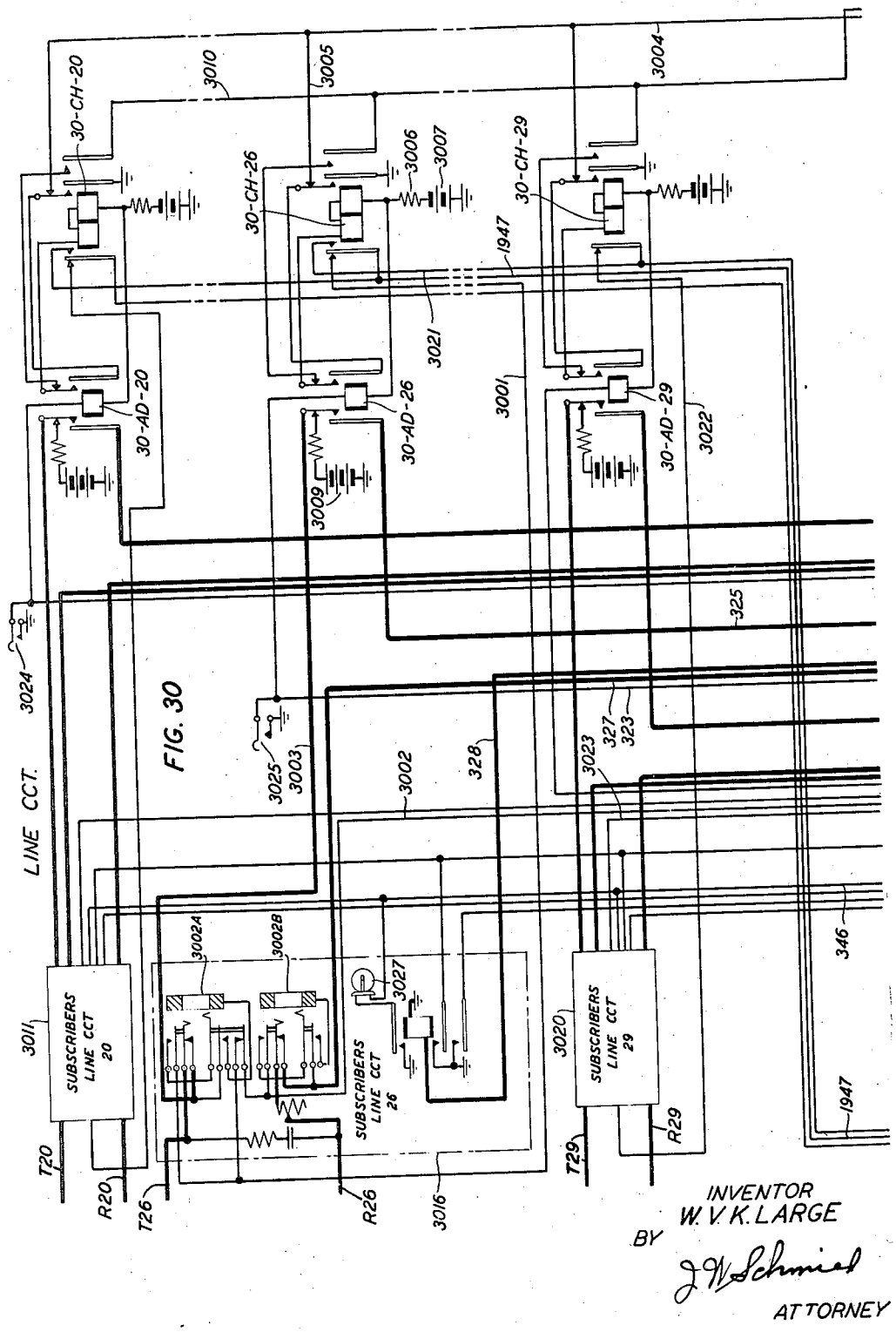
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Dec. 31, 1942 29 Sheets-Sheet 29



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Patented May 15, 1945

2,375,856

UNITED STATES PATENT OFFICE

2,375,856

SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Wayne V. K. Large, Glenwood Landing, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application December 31, 1942, Serial No. 470,729

58 Claims. (Cl. 178—2)

This invention relates to telegraph switching systems and particularly to that class of telegraph switching and transmission systems which includes satellite offices.

The principal elements of a satellite system are, first, a number of outlying stations or subscriber stations located in a particular region in which the traffic is insufficient or where there are other circumstances making it uneconomical or impractical to maintain a central office individual to those subscriber stations. Another element of the system comprises one or more central offices, usually one, and a satellite, or unattended, switching station approximately in the geographical center of the group of subscriber stations. By means of a small number of trunks extending from the central office or offices to the satellite office and individual lines from the satellite office to the outlying stations and/or subscriber stations, combined with automatic switching arrangements at the satellite office whereby interconnections may be made between any of the trunks and any of the outlying or subscriber lines, service may be given to all the subscribers not only for intercommunication with each other but to and beyond the central office.

Systems of this type have already been devised, disclosed and used.

One such system is disclosed in the application of Fitch et al., Serial No. 173,958, filed November 11, 1937. Modified forms are disclosed in Lucek Patent 2,228,279, dated January 14, 1941; Krecek application, Serial No. 348,629, filed July 31, 1940; and Kinkead et al. application, Serial No. 348,628, filed July 31, 1940, now Patent No. 2,340,599, granted February 1, 1944. Each of these prior systems includes full duplex trunks between the central office and the satellite office. A system disclosing trunks arranged to operate half-duplex is disclosed in a copending application of W. V. K. Large and F. J. Singer, Serial No. 462,966, filed October 22, 1942.

The present invention deals with an extension of the problem set forth above and is directed to further extending the use of automatic and remotely controlled switching equipment and more efficient, convenient and effective use of telegraph trunks or channels and lines and a reduction in the number of manual switching stations and the amount of manual switching required.

The nature of the problem will be appreciated from the following outline of the elements of a complete system.

An exchange, which in the exemplary embodiment of the invention disclosed herein is a manual exchange, is an element of the system. This exchange comprises cord circuits by the use of which operators may interconnect local lines terminating thereat with each other or with trunks extending to other exchanges. Such local lines and such trunks extending to other exchanges are well known in the art and, consequently, they are neither disclosed in the accompanying drawings or described in detail nor is their operation gone into in any detail in the following description.

Terminating at the exchange are other trunks extending to a non-attended switching office which may be variously designated as a primary satellite office, a switching point on office or more specifically as a large satellite office. The trunks from the central office to this large satellite office, together with their terminations both at the central office and at the large satellite office, are of a type known in the art and are essentially designed as disclosed in Krecek application Serial No. 348,629. Extending from this large satellite office in a direction electrically away from the central office are three classes of facilities.

The first class comprises individual subscribers' lines which are utilizable for calls to the subscribers as well as calls away from the subscribers by interconnection of the trunks to the central office in the manner essentially as described in the said Krecek application.

A second class constitutes a new feature of the present invention and comprises a line group from the large satellite office to one subscriber arranged in such a way that a call to a subscriber having such a group of lines if directed to a busy line will automatically be completed to the subscriber over an idle line of the group if such a line is available; to this end there is provided a hunting feature whereby a call directed to any lower-numbered line of a group is automatically completed over any higher numbered idle line of a group, if such a line exists. A plurality of such groups may extend to a corresponding plurality of such subscribers.

To illustrate the third class let us now suppose that there exists a considerable number of subscribers located fairly remotely from the large satellite office and also too remote from any central office to be given service therefrom except by means of over repeatered or toll lines. In accordance with previous practice, such repeatered or toll lines were extended to the stations of such subscribers from the large satellite

office. If, however, there are several such subscribers, economy as well as more efficient use of facilities may be accomplished by providing in the region adjacent these subscribers a small satellite office and extending to this small satellite office from the large satellite office a plurality of trunks fewer in number than the number of subscribers to be served by the small satellite office. Inasmuch as a subscriber making a call through this small satellite office never knows which trunk is busy, a trunk from the small to the large office is automatically assigned to him and at the large office a trunk is automatically assigned to extend his call to the central office. Similarly, and as a feature of the invention disclosed herein, an operator at the central office has no means of knowing what trunks, if any, lying between the small satellite office and the large satellite office are idle. Consequently, the system is so arranged that an operator at the central office transmits code combinations designating a particular trunk, but, on the other hand, designating a group of trunks which extend from the large satellite office to the small satellite office. At the large satellite office a trunk hunting arrangement proceeds to hunt along the trunks which are available and to pick the first idle one for connection to the trunk over which the operator has made the call from the central office to the large satellite office. Upon having been assigned such a trunk upon the connection having been completed to the small satellite office a director circuit at the small satellite office is conditioned for reception of code combinations and a "director ready" signal is sent back over the two trunks in tandem to the central office whereupon the operator sends code combinations or permutation code pulses identifying the line of the wanted subscriber which terminates at the small satellite office.

A still further feature resides in the fact that a subscriber at the small satellite office may have sufficient business to justify a plurality of lines and these lines are also arranged in a group with a hunting arrangement so interconnecting them that any call directed to the one having a lower position in the group sequence will initiate a hunting operation to hunt for any idle line extending to that particular subscriber and, if any such idle line is available, to send ringing signals over it to call the wanted subscriber.

From the foregoing it will be perceived that among the objects of the invention are to provide a tandem system of satellite offices; to provide more effective utilization of trunks, in other words, that any given trunk may function to give service to a greater number of subscribers or more service to a given number of subscribers or that a given number of subscribers may receive service with less trunk mileage than heretofore; to increase the use and effectiveness of automatic switching and equipment and to decrease the need for manual switching points to the end that manual exchanges may be larger and, therefore, more efficiently staffed and manned for twenty-four hour service; to provide for trunk hunting whereby a group of short subtrunks may perform the service heretofore performed by a greater number of individual long subscriber lines; and to provide line hunting arrangements whereby subscribers, whose business requires a plurality of lines, may be served as effectively through a satellite office as though they were directly connected to a central office. In previous arrangements subscribers having a plurality of lines directly connected to a central office could utilize those lines interchangeably and the central office operator could always examine each line before reporting that the particular subscriber was busy. The present arrangement permits the subscriber to use the line individually for outgoing calls and electromechanical equipment at any satellite office to which the subscriber may be connected examines all of his lines in the case of calls automatically directed to that particular subscriber before giving a busy indication.

From a generic aspect the invention comprises accomplishment of the above objects and functions and ancillary objects and functions by means, methods and systems within the scope of the claims; from a specific and exemplary aspect use is made of trunks between the exchange and the first satellite office of trunks which are operated full-duplex for supervisory signals and half-duplex for telegraph transmission and of trunks between the two satellite offices which are operated half-duplex at all times. Trunks of the first type are disclosed in Krecek application Serial No. 348,629, filed July 31, 1940, now Patent No. 2,368,666, dated Feb. 6, 1945, and trunks of the second class are disclosed in the present inventor's application Serial No. 462,966, filed October 22, 1942. The second class of trunk has been modified for incorporation in the exemplary system as an element thereof and comprises a special form of trunk adapted for half-duplex operation being provided for inter-connecting any subscriber line local to the small satellite office and a trunk between the large satellite office and the central exchange.

A feature of the invention is the line hunting arrangement wherein a call originating at the central office may be automatically established to any one subscriber line of a group. Certain lines of such group may terminate in subscriber stations arranged for attended service and others may terminate in subscriber lines arranged for unattended service. If a selected subscriber line is busy, then the next higher numbered line that is idle is automatically selected, providing the next higher numbered line is arranged to furnish the same type of service as that of the previous line.

Another feature is the provision of means whereby any line of a group may be primarily selected and if such line is busy, then the next idle one of the higher numbered lines in the group may be automatically selected to establish the desired connection.

Another feature is the giving of both attended and unattended service over a group of lines of which the last or highest numbered only is provided with equipment for unattended service; unattended service calls may be directed to the highest numbered line only whereas other calls may be directed to the lowest numbered line of the group and will be completed over the first idle line including one equipped for unattended service if such is the only line which is idle and available.

In order to differentiate between the two satellite offices, the one having trunks connected directly to the central office is referred to herein as the large switching center, and the other which has trunks connected to the first-mentioned satellite office, is referred to herein as the small switching center. Connection with subscriber stations local to the small switching center are automatically established through the small

switching center over trunks extending to the large switching center and then automatically over the trunks extending to the central office, or vice versa.

An embodiment of the invention is comprised in the system herein described, of the essential elements of the circuit, which are illustrated in the accompanying drawings:

The drawings consist of twenty-nine sheets, showing twenty-nine figures of schematic circuits of which Figs. 2, 3, 4, 5, 11, 12, 13, 19, 20, 21, 29 and 30 represent those located at or associated with the small switching center;

Figs. 6, 7, 8, 9, 14, 15, 16, 17, 18, 22, 23, 24, 25, 26, 27 and 28 represent those located at or associated with the large switching center; and

Fig. 10 shows the terminating equipment of a trunk terminating at the switchboard in the central office.

Fig. 1 is a diagram showing how Figs. 2 to 30, inclusive, shall be placed to form a complete system to illustrate the invention;

Fig. 2 shows in connection to the small switching center, a local subscriber's station in detail, and two other local subscribers' stations in diagrammatic form;

Fig. 3 shows the subscriber line circuits respectively associated with the local subscriber stations of Fig. 2, one of the line circuits being shown in detail. Also shown in Fig. 3 is the link circuit whereby any one of the subscriber stations local to the small switching center may be connected to any one of the trunk circuits extending to the large switching center;

Figs. 4 and 5 show the terminating equipment for two concentrating unit trunk circuits located at the small switching center. The terminating equipment of one of these trunk circuits is shown in detail and the other is shown in diagrammatic form;

Figs. 6 and 14 show the trunk terminating equipment, in detail, at the large switching center which equipment, together with that shown in detail in Figs. 4 and 5, serve with that trunk which will be selected herein for illustrative purposes in describing its operation. Also shown in Fig. 6 are two local subscriber stations with their respectively associated line circuits connected directly to the large switching center, the showing of each being in diagrammatic form;

Fig. 7 shows a link circuit capable of connecting, as desired, a subscriber line local to the large switching center or a trunk circuit extending to the small switching center to a trunk circuit extending to the central office;

Figs. 8 and 9 show the trunk terminating equipment, in detail, of a trunk interconnecting the large switching center and the central office;

Fig. 10 shows the trunk terminating equipment which together with that shown in Figs. 8 and 9 serve that trunk interconnecting the large switching center and the central office;

Figs. 11, 12 and 13 show the subscriber, the trunk and the control arrangement in the sequence circuit. Fig. 13 also shows the miscellaneous alarm circuit. The sequence and the miscellaneous alarm circuit are located at the small switching center;

Figs. 15, 16, 17 and 18 show the subscriber, the trunk and the control arrangement in the sequence circuit located at the large switching center;

Figs. 19, 20 and 21 show the director circuit for the small switching center;

Fig. 22 shows the "all-trunks-busy" circuit for the large switching center;

Figs. 23, 24, 26 and 27 show the director circuit for the large switching center;

Figs. 25 and 28 show the miscellaneous alarm circuit at the large switching center;

Fig. 29 shows in connection to the small switching center, a group of local subscriber stations arranged for line hunting operation when a call from the distant end is for any one of the group, and if such one is busy then for the next higher numbered idle one of the group which is automatically selected to establish the call. Certain of these stations are arranged for attended service; one is shown in diagrammatic form. The others are arranged for unattended service, one of which is shown in detail and another in diagrammatic form;

Fig. 30 shows the line circuits respectively associated with the subscriber stations shown in Fig. 29 and the line hunting circuit provided therefor. The line hunting circuit provides for selecting any one station in a line hunting group for connection to a calling trunk, and if such one is busy the next higher numbered station in such group is automatically selected for the connection providing such higher numbered station is idle.

The numbering of the various pieces of apparatus and parts of the circuit shown on the various figures have been kept to a rigid plan. Thus all relays shown in each of the respective figures have reference characters consisting of numerals and letters, the numerals shown as prefixes corresponding to the number of the figure in which the particular relay is located. All other parts of the circuits are designated by numerals only; for instance, those parts of Fig. 2 are designated with numerals between **200** and **299**, those in Fig. 3 are designated with numerals between **300** and **399** wherein the hundreds numerals designate the figure in which the particular part is found.

In some cases in order to avoid the tracing of a plurality of conductors through one or more sheets, these conductors are shown terminated on one sheet in a dot and dash line designated as a single conductor, the dot and dash line extending through one or more sheets to a point where the plurality of conductors are again shown. The complete operation of the system is set forth hereinafter under various headings as follows:

Local subscriber station connected to the small switching center

In Fig. 2 there is illustrated in schematic form a local subscriber station **202** connected with the small switching center by a pair of conductors such as those designated T and R. Other local subscriber stations **201** and **203** are shown in diagrammatic form. As will be hereinafter described, station **202** shown in schematic form is selected herein for description of operation and detail.

Referring to local subscriber station **202** the subscriber loop comprises conductors **T2** and **R2** and a printing telegraph sending and receiving unit **202'**. Unit **202'** comprises a printer magnet **206**, a set of sending contacts **207** and a suitable motor **208** equipped with a pair of stop contacts **209** which will open by mechanical means when motor stop signals are transmitted or received. External of the printing telegraph set, or unit, are start, or power, switch **210** for starting the printer set motor, a stop, or break, key

211 for stopping the printer set, a ringer, or bell, 212 whereby the central office operator may signal the subscriber station, a test key 213 for testing locally the printer set when the loop circuit is arranged so that the ringer may be operated from the central office, a flash key 214 for signaling the central office and several relays, the function of which will be hereinafter described.

For a complete explanation of the details of an exemplary printing telegraph sending and receiving unit 107, reference may be had to U. S. Patent 1,904,164, granted to S. Morton et al. on April 18, 1933.

Subscriber station line terminating circuit at small switching center

Each of the subscriber station loop circuits shown in Fig. 2 terminates in a subscriber station line terminating circuit at the small switching center as shown in Fig. 3. Only the line terminating circuit 302 associated with printing telegraph sending and receiving units 202 is shown in detail. The line terminating circuits 301 and 303 respectively associated with the other local subscriber stations are shown in diagrammatic form.

The functions of the subscriber station line circuit are as follows:

1. The circuit is arranged to register the subscriber's calling-in signal and start the sequence circuit to permit routing the call to the central office.

2. It lights the call lamp, such as lamp 306 for circuit 302, when the subscriber at station 202 calls, until such call is routed to the central office.

3. When the subscriber line on an outward call is connected to a trunk circuit the subscriber station line terminating circuit returns to normal, releasing the sequence circuit.

4. The subscriber line is provided with a set of test jacks, such as jacks 307A and 308B for circuit 302, which will permit testing of the subscriber line for line conditions and for transmission, and for testing the subscriber line circuits.

5. The jacks, such as jacks 307A and 308B for circuit 302, are also available for manual operation of the unit in case of failure of the automatic apparatus.

6. Jack, such as jack 307A, can be used to make particular line test busy, out-of-order, or unassigned to inward calls.

7. The jacks, such as jacks 307A and 308B, are available for continuous monitoring of the subscriber line by means of a test circuit.

8. The same jacks can also be used to patch a subscriber line to a practice circuit, if such is provided for the subscribers.

9. When all available trunk circuits are busy, this circuit will be connected to an "all-trunks-busy" level on the cross bar switch of the link circuit and will release the sequence circuit. Connection to the "all-trunks-busy" level is maintained until the subscriber disconnects. Two levels are required for each "all-trunks-busy" circuit provided in order that two subscriber stations may be connected to an "all-trunks-busy" circuit at one time.

10. This circuit provides for a line hunting feature for use in cases where a subscriber has more than one line.

When a local subscriber originates an outward call, that is, a call through the concentrating unit switching centers to the central office switchboard, the closure of the subscriber loop circuit by the operation of the power switch, such as start switch 210 at station 202, causes the operation of the line relay, such as relay 3L2 in line terminating equipment 302. The line relay, upon operating, connects ground at each of the two lower armatures and front contacts to two conductors which extend into the subscriber sequence circuit shown in Fig. 11. These ground connections cause the sequence circuit to attempt to route the call through the large switching center to the central office switchboard. The calling subscriber line, or loop, circuit remains in this operated condition until the line is either connected to the trunk or the automatic equipment is either connected to a trunk extending to the large switching center or finds no trunk available.

If the automatic equipment at the small switching center finds no available trunk to the large switching center, the sequence circuit connects the subscriber loop, or line, to a level or horizontal row in the cross bar switch of the link circuit (Fig. 3) which level may be one of two that are provided for connection to the "all-trunks-busy" circuit. One of these levels is shown in Fig. 18 of the copending application of W. V. K. Large and F. J. Singer, Serial No. 462,966, supra. The remaining levels in the cross bar switch of the link circuit are respectively connected to trunk circuits extending to the large switching center. The "all-trunks-busy" circuit upon being engaged by a calling subscriber loop manufactures a "letters" signal or a "K" signal, as required. These "letters" and "K" signals when transmitted to the subscriber, respectively give a busy indication and an idle indication when one trunk of busy group becomes idle. The subscriber may try a new call after disconnecting. The cross bar switches may be of the type shown and described in Reynolds U. S. Patent 2,040,334, issued May 12, 1937.

The link circuit comprises a switching instrumentality well known in the art as a "cross bar" switch. A cross bar switch comprises sets of contacts usually arranged vertically and crossing, or coordinate, sets of contacts arranged horizontally. Horizontally arranged contacts in a horizontal row, or in several horizontal rows in the case of a system using the several switches, are prepared by a selecting magnet, which in the present case, is associated with a trunk. When a horizontal row of contacts is prepared by a selecting magnet and a holding magnet, which is associated with an entire vertical column of contacts, is operated, the set of contacts at the crossing point of the row associated with the selecting magnet and the column associated with the holding magnet are brought into conductive engagement. Immediately thereafter the selecting magnet may be released and other contacts of its horizontal row will not be brought into engagement when other holding magnets are operated but the set of contacts already engaged will remain engaged until the holding magnet which caused them to become engaged, is released. Usually the operation of the holding magnet operates or causes to be operated other contacts which render the line or circuit associated with the holding magnet busy during the time the holding magnet is maintained energized.

If an idle trunk is found and connection to the subscriber loop, or line circuit, is ordered by the automatic equipment, the sequence circuit by

means of a ground connection causes a "hold" magnet associated with the calling subscriber station to operate. Hold magnets 3H1, 3H2 and 3H3 are associated with the subscriber stations 201, 202 and 203, respectively, the operation of any one of the "hold" magnets opens its normally closed contacts and thereby causes the release of the line relay of the calling subscriber line terminating equipment and releases the sequence circuit. The release of the line relay extinguishes the call lamp, such as lamp 306 for the line of subscriber station 202.

Jacks for each of the subscriber line terminating equipment, such as jacks 307A and 308B for equipment 302 when patched to a similar pair, such as jacks 435A and 436B, in the trunk circuit, permit the connection to be established when the automatic equipment fails, that is, a connection between a subscriber line and a trunk is established on a manual basis by the attendant at the small switching center.

Link circuit at small switching center

The link circuit consists of one or more cross bar switches which connect a subscriber line to a trunk circuit extending to the small switching center during the time of communication. As many simultaneous connections as there are trunk circuits may be established. Each subscriber line circuit is connected to a "vertical" of a cross bar switch and each trunk is multipled to a horizontal level on all cross bar switches when more than one switch is used. The "all-trunks-busy" circuit 11ATB is usually multipled to two levels, usually at the top, throughout all switches in order to permit a second subscriber access to an all-trunks-busy circuit at a time when a first subscriber is connected to it. If a second "all-trunks-busy" circuit is provided, as for instance, where the trunks are arranged in two groups, respectively extending to separate switching centers or central offices (two outlet units), the second "all-trunks-busy" is multipled to two other levels. Reference is made to the copending application of Large-Singer, Serial No. 462,966, supra, for a disclosure of a single "all-trunks-busy" circuit connected to a link circuit, the "all-trunks-busy" circuit being shown to one level only.

In the use of a cross bar switch it will be understood that in order to complete a connection between a trunk circuit and a subscriber line circuit, it is necessary to, first, operate a selecting magnet to condition the set of operating contacts which effects the connection, and then to operate a holding magnet to complete the connection. The holding magnet serves to lock the contact set in its operated position although the selecting magnet becomes released.

The functions of the link circuit are:

1. When a cross bar switch selecting magnet, that is one that is associated with a particular trunk circuit, and a "hold" magnet are operated in the proper sequence, the particular trunk circuit will be connected to the subscriber station line circuit with which the operated "hold" magnet is associated.

2. Off-normal contacts on the selecting magnet insure, upon the establishment of a connection, that the magnets are operated in the proper sequence.

3. When the "hold" magnet is operated it will lock under control of the trunk circuit in order that the operated selecting magnet that cooperated in the established connection may be released.

4. The "hold" magnet contacts perform the "cut-off" function required in the associated subscriber line circuit upon establishment of a call.

In an idle condition all magnets are released and the tip and ring conductors of the subscriber loop are connected through the subscriber line terminating equipment circuit. For subscriber station 202 the line, or loop, circuit which comprises tip T2 and ring R2 conductors, will be open at the station when the station is idle.

When a subscriber originates a call as by operating the teletypewriter start switch, the tip and ring conductors of the subscriber line close to complete the loop circuit through the station teletypewriter and the line relay, such as relay 3L2 of equipment 302, will operate to energize a sequence circuit. When the sequence circuit determines that the calling subscriber is next in turn, an idle trunk will be seized. The selecting magnet which is associated with the trunk thus selected, such as magnet 3SM—1 for trunk 401 and magnet 3SM—9 for trunk 409, will be energized to position the selecting fingers of the cross bar switch. The closure of the selecting magnet off-normal contacts will operate relay 13D and relay 13D, upon operating, connects ground through low resistance 1301 to a conductor extending through the sequence circuit to energize the "hold" magnet associated with the calling subscriber line circuit, the hold magnet may be one of those designated 3H1, 3H2, 3H3, etc., which represent a group of five subscriber lines. Operation of the "hold" magnet will cause the closure of the main switching contacts at the intersection corresponding to the selected trunk and the calling subscriber line.

When an inward call is originated by an operator at a switchboard in the distant central office, a trunk is selected in the usual manner by the operator. The selecting magnet associated with the selected trunk is operated in advance of the completed selection of the desired subscriber line. If the desired subscriber station is idle, the closed condition of the selecting magnet off-normal contacts will cause a resistance ground (resistance 1301) to be connected in a circuit extending through the director circuit and the selected subscriber station line to grounded battery, through the winding of the "hold" magnet of the selected subscriber line, the "hold" magnet being one of those designated 3H1, 3H2, 3H3, etc. The conductors T and R of the called subscriber station will therefore be connected through the operated contacts of the cross bar switch of the link circuit to the trunk circuit selected by the operator.

Sequence and miscellaneous alarm circuit at small switching center

The sequence and miscellaneous alarm circuit is shown in Figs. 11, 12 and 13, the miscellaneous alarm equipment being shown in Fig. 13. This circuit is designed to care for the sequence of calls through the small switching center and is arranged to permit the routing of one call only at any one time through the automatic equipment at the switching center.

The sequence circuit permits establishing only one connection at a time through the automatic equipment. It is granted to inward calls (calls from the central office to the small switching center) in preference to outward calls (calls from the small switching center to the central

office). Calls that may be originated while the sequence circuit is in use are served subsequently depending upon the order in which the subscriber lines and trunks are connected. Therefore, calls from the central office have preference over those from the subscribers whose lines are local to the switching center. The sequence circuit consists essentially of four major circuits which are as follows: (*a*) a group of relays common to the subscriber lines and the trunks, and containing the alarm features, this common portion of the circuit comprising the main gate relay 11—G, hereinafter described, which prohibits the seizure of the sequence circuit while a call is being routed in either direction; (*b*) a group of relays to serve a maximum of five subscriber lines, this being referred to as the subscriber sequence circuit; (*c*) a group of relays to serve a maximum of five trunks; and (*d*) a group of relays to serve each trunk of a group of five, this being referred to as the trunk sequence circuit. On outward calls the sequence circuit arranges the link circuit to connect a calling subscriber station to the first idle trunk to the central office or to an "all-trunks-busy" circuit if no trunk is available. On inward calls the sequence circuit connects the calling trunk to the director circuit. After the director circuit has received the selecting pulses, it tests the desired called subscriber line. If the line is idle, the director circuit causes the link circuit to connect the line to the trunk. The sequence circuit then releases the director circuit and is available for routing a new call. If the line is busy, out of order, or unassigned, the operator receives the proper information from the director circuit and the sequence circuit releases the director circuit when the operator takes down the cord circuit. If the operator does not disconnect, the director circuit times out in about 11 seconds and becomes available for a new call.

Visual and audible alarms are given under the following conditions:

(*a*) *Inward and outward calls.*—If the main gate relay 11—G fails to release within about 50 seconds after it has operated, a major alarm is given.

(*b*) *Outward calls.*—A minor alarm is given in about 4 seconds if the sequence circuit fails to seize a trunk. A minor alarm is given if a relay (relay 13H), which prevents release of a trunk circuit while another connection is being established, fails to operate within about 15 seconds.

(*c*) *Inward calls.*—In case the sequence circuit fails to release the director within about 15 seconds, a minor alarm is given. (Director circuit is held for 11 seconds under certain conditions.) A major alarm is also given in about 12 seconds if the sequence circuit fails to seize the director circuit or if the director motor does not attain its normal operating speed. This latter alarm is located in the director circuit.

(*d*) A major alarm always follows a minor alarm at about one-third second, if that portion of the circuit and which caused the minor alarm has not been removed by the circuit operation.

A gate relay such as gate relay 11—G, is so called because it opens paths which prevent or shut out interference with calls being routed. In its unoperated position it permits current to flow over its armatures and contacts and in its operated position opens at its left and its right-hand armature paths extending from the trunk groups and the subscriber line groups to relays in their respective trunk sequence and subscriber line sequence circuits; for example the conductor connected through armature No. 1 of relay 11—G extends from trunk sequence group No. 1 (shown in Fig. 12), and the conductor connected to armature No. 4 of relay 11—G extends from the subscriber line sequence circuit group No. 1 represented by lines respectively extending to subscriber stations Nos. 201, 202, 203, shown in Fig. 2.

The functions of the sequence and miscellaneous alarm circuit are as follows:

1. This circuit is arranged to permit only one subscriber at any one time the privilege of completing a call through the small switching center and that only when no inward call is in process of completion.

2. This circuit is arranged to permit only one call from the central office to seize a director circuit and complete through the small switching center and that only when no subscriber call has seized the routing privilege.

3. In case of trouble on an outward call, this circuit after a time interval of approximately 4 seconds, will release the call from the seized trunk, locking this trunk out of service, will sound an alarm and will endeavor to complete over the next idle trunk.

4. In case of trouble on an outward call which is not trunk trouble, this circuit will lock up the subscriber group in which the originating subscriber line is included and sounds an alarm after an interval of 5, 15, or 50 seconds, depending upon the progress of the call.

5. In case of trouble on an incoming call which exists for 15 seconds the trunk in trouble will be locked out of the sequence chain, an alarm will be sounded and out-of-order signals will be returned to the distant end.

6. This circuit is arranged to allot, in predetermined order, idle trunks to the subscribers calling the distant central office.

7. In case all trunk circuits are busy, this circuit is arranged to measure the length of time this condition exists.

8. This circuit is arranged to advance the trunk chain shown in Fig. 12 to the next idle trunk immediately after each subscriber calling the central office has obtained a routing through the small switching center and before the sequence circuit is permitted to handle the next call in either direction.

9. If one or more trunk calls from the central office are awaiting service this circuit will start and keep the distributor motor "in speed."

10. This circuit is arranged to complete calls both inward and outward on a manual basis if manual service key 1101 is operated.

11. During manual service periods, a lamp, such as lamp 1201 for trunk 401 also serves as a disconnect lamp.

12. This circuit is provided with a night alarm buzzer primarily for use during periods of manual operation to indicate a reception of an inward or outward call.

Subscriber line circuits are connected to the sequence circuit in groups of a maximum of five lines each, relays 11SA, 11BO and 11SC being common to the lines of each group. In a similar manner relays 12ST2, 12TA, 12TC and 12BOX are common to a group of a maximum of five trunks, relays 12AD, 12DC, 12BO and 12DL being individual to each of the trunks of a group. In general, an outgoing call originated by a subscriber must secure the exclusive right to use the sequence circuit for the short time interval required to establish the direct connection through the link circuit. The operation of the remain-

ing relays, such as those indicated as "one set per office," in the sequence and the miscellaneous alarm circuit, when cooperating with the relays mentioned above as common to the subscriber lines of each group and as common to the trunks of each group, assures that all groups of five subscriber lines and all groups of five trunks, other than the first group energizing the sequence circuit, will be excluded. The operation of such remaining relays then excludes all units, subscriber or trunk, in the particular group, other than the one seizing the circuit. In normal operation, a trunk circuit receives preference in the sequence circuit seizure. When a trunk call is successful in securing the sequence circuit, the trunk circuit is connected to a director circuit which translates the pulses received from the switchboard operator at the distant central office into the number of the desired subscriber line.

In case of an emergency such as when the automatic features of the circuit fail, manual service key 1101 will be operated by the attendant. The key, when operated, makes the trunk sequence ineffective so that a director circuit cannot be attached to a trunk and the subscriber portion of the sequence circuit cannot complete its task of automatically selecting an idle trunk and connecting the subscriber station to it. The operation of key 1101 causes manual service lamp 1102 to flash.

Trunk circuit termination at small switching center

The equipment shown in Figs. 4 and 5 terminates at the small switching center, a two-way half-duplex trunk arranged for automatic signaling supervisory features, the opposite end of the trunk circuit terminating at the large switching center. The trunk circuit is shown extended through the second level of the link circuit shown in Fig. 3. A second trunk circuit 409, shown in diagrammatic form, is extended through to the lowermost level of the link circuit. These trunks are arranged in groups and on inward calls are selected at the large switching center in response to signals corresponding to the called number for the group, the signals being transmitted from the central office. The first trunk of a group is selected for extending the call. These trunks are referred to hereinafter as "line trunks."

The trunk terminating circuit at the small switching center, on a call originated by a local subscriber thereto, tests the trunk circuit, through the large switching center, to the central office and registers a call at that point. On a call from the operator at the central office, the trunk is connected, first, to the director circuit at the large switching center, and then, in response to a special code number, to a director circuit at the small switching center. When the called subscriber line code is received in the latter director circuit and translated therein the trunk is extended through to the called subscriber line, if it is idle. The trunk terminating circuit at the small switching center does not release the subscriber line until the subscriber has stopped the teletypewriter motor at the subscriber's station and the cord circuit at the central office has been disconnected by the operator.

The functions of the trunk circuit equipment at the small switching center are as follows:

1. On an outward call from a subscriber station connected directly to the small switching center, the subscriber loop is connected directly to the selected trunk, a continuous "mark" signal is sent to the central office to light the lamp in the operator's switchboard and the sequence circuit is released, the connection being established through the large switching center.

2. While awaiting the answer of the operator at the central office, the subscriber can "flash" the switchboard lamp. Under this condition the circuit sends alternate high resistance ground and "mark" signals to the central office in unison with the operation of the power switch at the subscriber station set.

3. If the calling subscriber abandons an outward call before the operator at the central office answers, this circuit replaces the "mark" condition of the trunk with a high resistance ground which causes the calling lamp in the operator's switchboard to become extinguished and thereby indicate to the operator that a disconnect release is required. Upon receipt of the negative disconnect signal from the central office, the equipment at the small switching center returns to normal.

4. A break signal originated by a subscriber whose station is connected to the small switching center produces no effect on this circuit other than the placing of a spacing signal condition on the line.

5. A prolonged space signal received from the distant subscriber whose station is connected directly to the central office, operates receive relay 5R in this circuit to hold the connection intact. After an interval of six seconds the intermittent closures are placed on the trunk at the central office end to enable the subscriber connected to the small switching center to register a disconnect signal.

6. When the trunk circuit is seized at the large switching center end, ringing current is automatically applied to the trunk at that end for a one-second interval, to condition the terminating equipment at the small switching center for the reception of a call and to secure the director circuit.

7. When the director circuit is attached and ready to receive selecting pulses, the high resistance ground condition on the trunk at the small switching center is replaced by a marking condition to extinguish the cord supervisory lamp in the central office switchboard as an indication that the selecting pulses should be sent.

8. If, after securing the sequence circuit, the calling trunk fails to secure a director circuit or after securing a director circuit, fails to place the call directing pulses, the sequence circuit will time out and energize an alarm circuit. In this case where the director circuit has been secured, it will be released and the trunk will again be terminated in the high resistance ground.

9. When the directing pulses are received from the operator at the central office, they are transmitted to the director circuit which tests the called subscriber loop and energizes the link circuit to establish the connection if the loop is idle.

10. If the called loop is busy, out of order, or unassigned, a signal characteristic of the condition is produced in the director circuit and transmitted to the distant end at the central office.

11. When the trunk circuit is connected to the called loop, the sequence and the director circuits are dismissed and the trunk circuit, again, is terminated in the high resistance ground condition. At the same time automatic ringing is connected to the called subscriber loop if that

feature is desired. If automatic ringing is not specified the operator at the central office sends ringing current over the trunk causing the terminating equipment at the small switching center to connect ringing current to these loops.

12. When the subscriber answers at the called station, this circuit, during the silent interval, disconnects the automatic ringing and sends a marking signal to the central office by replacing the high resistance ground termination with the trunk repeater at the small switching center.

13. After the subscriber has disconnected, the operator can rering the subscriber station by sending a short ringing signal from the central office which again starts the automatic ringing of the subscriber line.

14. The trunk circuit is provided with jacks, such as jacks **435A** and **436B** of trunk **401**, to permit manual connection of a subscriber line in case of failure of the automatic equipment.

15. Jacks are provided for patching a meter by means of a cord circuit to the repeater circuit to measure the current in the line and the biasing circuit and to indicate the differential current in the receive relay, such as relay **5R**, of trunk **501**.

16. Facilities are provided for balancing the repeater for use with composited or non-composited lines or spare cable conductors.

17. Provision is made for polar sending type B polarential operation over a line circuit to a polar receiving type B polarential repeater at the large switching center. The trunk terminating equipment at the small switching center, therefore, comprises a repeater arranged for polar sending and differential receiving, whereas the trunk terminating equipment at the large switching center comprises a repeater arranged for differential sending and polar receiving. Type B polarential operation is disclosed in Fig. 2 of the Cramer United States Patent 2,131,870, October 4, 1938.

18. Equalization networks are provided to reduce the characteristic distortion in the received signals.

The repeater elements of this terminating equipment are designed to operate half-duplex only. The equipment of the trunk shown in detail will now be described in a general way. An adjustable balancing network in artificial line **502** connected to winding No. 2 of receive relay **5R** is provided to balance the telegraph line **501** connected to the repeater. When a balance is obtained between the line **501** and the artificial line **502**, the differential effects of the current in windings Nos. 2 and 3 of receive relay **5R** remain constant during transmission of signals by send relay **5S**. This balance enables signals to be transmitted in either direction over a single conductor **501**.

Duplicate sets of balancing equipment are provided for use when a neutralization conductor, such as conductor **503**, is required. Conductor **503** serves to neutralize voltages induced in transmission conductor **501** from extraneous sources. The balancing set for conductor **501** comprises rheostat **529**, resistance **542** and condensers **561**, **562** and **563** of 1 to 7 microfarads in steps of one microfarad. A similar set is provided for conductor **503** and comprises rheostat **530**, resistance **545** and condensers **564**, **565** and **566**. Conductor **503** is arranged for connection to winding No. 4 of receive relay **5R** and its artificial line conductor **504** is connected to winding No. 5 of relay **5R**. The neutralizing circuit and its balancing network are substantially the same as the operating circuit with its balancing network, so that equal extraneous voltages applied to the neutralizing and operating lines will have equal but opposite effects on relay **5R**.

During the idle condition the large switching center end of the trunk is terminated in ground at the back contact and outer upper armature of relay **6C1**. At the small switching center where the trunk circuit is used for two-wire termination, the second, or neutralizing, conductor **503** forms a loop with the first, or transmission conductor **501**, through resistance **531** of relatively high value, and the winding of relay **5L**, the two latter elements being shunted by an alternating current relay **5R1** and condenser **506**. The repeater relays **5S** and **5BK** and the filament of vacuum tube **419** are not energized. The receive relay **5R** is energized through its No. 1 winding which is provided for biasing purposes and all the other relays, except gate relays **4G** and **4G1** are normal. Relays **4G** and **4G1** are held in their left-hand positions as shown by current in their lower windings.

In the case of emergency such as when the automatic equipment fails to operate, jacks **435A** and **436B** of the trunk are manually patched by the attendant to a similar pair, say jacks **307A** and **308B**, in the desired subscriber line circuit so that the trunk is connected through to the desired subscriber's loop. When the double plug of the patching cord is inserted in the double jack of the trunk, the selecting magnet associated with the trunk, say magnet **3SM—1** for the trunk shown in detail, is prevented from operating and off-normal relay **4—ON** operates. When the trunk so engaged is returned to automatic operation the desired subscriber line remains busy until the patching cord is removed. Similarly, the trunk is prevented from securing a director circuit.

Three balancing keys **508**, **509** and **510** are provided for controlling the capacity balance for the operating (transmission) and the neutralizing conductor. By connecting the capacity for the operating conductor and the neutralizing conductor on the same set of keys a duplicate balance on each of the wires is assured.

Key **511** is provided for connecting and disconnecting the composite balancing equipment in the artificial line circuits of the operating and the neutralizing conductors. Both sets of composite balancing equipment are connected through the same key so that they are connected or disconnected at the same time.

Five apex keys **512** to **516** are provided to control the resistances in the apexes of the operating and the neutralizing conductors. Each of these keys is arranged to affect the resistances in each of the apex circuits alike.

The repeater is equipped with four jacks **517** to **520**, so that a test unit meter may be patched into various circuits of the repeater in order to facilitate adjustment and balance. Line jack **517** is provided in series with the operating line of the repeater for checking the line current and permitting observation of signals transmitted over the line conductor and the reading indicated on the test unit meter is the value of the actual line current. Balance jack **518** is provided for connecting the test unit meter to indicate the differential current between the operating line conductor and its associated artificial line circuit and the reading on the meter is the value of the actual differential current. Balance jack **519** is provided

for connecting the test unit meter to indicate the interference on the neutralizing wire conductor for comparison with the interference on the operating wire conductor. Bias jack **520** is provided for connecting the test unit meter in the biasing circuit (winding No. 1) of receive relay **5R** so that the biasing current can be adjusted to the proper value for polarential operation; the resistance shunt on the bias jack being so proportioned with the value of current indicated by the meter when the bias current is properly set will be equal to the current obtained with the meter in balance jack **518** when a spacing signal is transmitted from the polar receiving repeater. This biasing circuit is arranged to provide the correct biasing current through the smaller number of turns in the biasing winding to make their magnetic effect equal to that of the turns in the line winding No. 3 of relay **5R**. A meter suitably adapted for the present system is of the single coil type, which has a double indicating scale with a zero midpoint and is designed to operate in opposite directions in accordance with the direction of the operating current. This meter is known as a milliammeter and is disclosed in Cummings' United States Patent 1,809,026, June 9, 1931.

The bias potentiometer **528** is provided in the biasing circuit of relay **5R** so that the value of current in the biasing circuit may be properly adjusted. The current range in the bias circuit may be extended beyond the value obtaintd with the potentiometer by strapping a portion of the fixed resistance. The balanced resistance potentiometer consists of two units **529** and **530** mounted on a single shaft and is used to obtain direct current balances in the artificial line circuit of the operating and the neutralizing wire.

Receive relay **5R** is provided for receiving signals over the trunk shown extending from the large switching center and retransmitting them to the desired local subscriber loop. This relay is equipped with five windings which are respectively arranged for connection in five circuits. Winding No. 1 is used for biasing the relay, winding No. 3 is connected to the lint circuit, winding No. 2 is connected to an artificial line circuit which is used for balancing the line circuit, winding No. 4 is connected to the neutralizing wire and winding No. 5 is connected to an artificial line circuit for balancing the neutralizing wire.

Relay **5S** is provided for receiving signals from the local subscriber loop and retransmitting them to the line trunk circuit. This relay is equipped with two windings one of which is connected in series with the subscriber loop and the other winding is connected in series with an artificial line.

Relay **5BK** is connected in series with relay **5S** and is used for "breaking" during half-duplex operation. Its normal function is to disable relay **5R** until a spacing signal is being sent from the subscriber station. This is accomplished by connecting grounded battery **536**, through the contacts of relay **5BK**, to the spacing contact of relay **5R**. When relay **5BK** operates to its spacing contact, the grounded battery normally connected to the spacing contact of relay **5R** is removed and the spacing and marking contacts of relay **5R** are connected together.

In adjusting the line balance key **511** it should be operated for all composited lines and for lines having a heavy capacity value such as simplex phantom cable lines. Key **511** should be normal for all other lines. With the meter of the test unit connected to jack **518** and while slowly opening and closing the "send" loop of the repeater at jack **435A**, vary the balance resistance potentiometer **529** until the steady deflection of the milliammeter is the same with the loop open as it is with the loop closed. Vary the artificial line capacity by operating the capacity balance keys **508, 509** and **510** until the kick of the milliammeter needle in either direction caused by slowly opening and closing the "send" loop is a minimum. It may be necessary to repeat this operation in order to determine whether or not the apparent capacity unbalance is due to interference rather than the capacity difference between the operating line and the artificial line. For simplex phantom cable circuits it may be necessary to make use of the composite balancing network by operating key **511** in order to provide sufficient capacity.

When a two-wire line circuit is used as where neutralization is required, the balance on the second wire is made identical to the balance on the first wire. This is accomplished by connecting the balancing arrangemtnt of the second wire to the controls used for the balancing arrangement for the first wire.

For polarential operation of a trunk circuit polar signals are transmitted in one direction and differential signals are transmitted in the other direction. In the system herein described the small switching center is equipped with a repeater arranged for polar sending and differential receiving and the large switching center is equipped with a repeater arranged for differential sending and polar receiving over a trunk interconnecting switching centers. At the polar receiving end the marking potential is ground. When the spacing battery is the same polarity at both ends, the system is called type B polarential. On a polarential system without leakage or ground potential the current in the operating line of the trunk and the balancing winding of the receive relay, such as relay **5R**, of a polar sending repeater have equal effects on the relay when the distant end of the operating line is connected to ground. The receive relay is held on marking by the current through the biasing winding. The current in the biasing winding is adjusted to be half as effective as the current in the operating line and the balancing winding when a spacing signal is transmitted from the distant or large switching center.

Type B polarential operation permits transmission in either direction over a single conductor without requiring a readjustment of the repeater balance at either end of the line for changes in line leakage as disclosed in Fig. 2 of Cramer's United States Patent 2,131,870, supra.

Equalizing networks **544** and **547** each consisting of retardation coils and resistances connected in series are provided for reducing the characteristic distortion in the received signal. These networks are bridged between the line and the artificial line circuit therefor on the trunk side of relay **5R**. When the repeater is arranged for two-wire operation as shown herein the networks are required, one is bridged between the operating line and its artificial line and the other between the neutralizing line and its artificial line, both networks being on the trunk side of relay **5R**. The strapping of the resistances should be the same in each network and should be chosen to obtain the best transmission over the circuit. Equalizing networks are essential on long simplexed phantom cable circuits. There appears to be little gained by their use on other types of facilities,

Director circuit at small switching center

This circuit is designed for use in the small line switching center to receive the directing, or selecting, pulses sent by the operator at the distant central office and retransmitted at the large switching center, and to decipher these pulses thereby causing the selection of the called subscriber line. The director circuit may be considered as having two portions; one portion is the distributor proper; the other is the portion which deciphers and registers the received impulses. This second portion thus has a registering function and may be called a "register"; it also has the function of marking or identifying a selected line or group of lines and hence may also be styled a "marker." The circuit is shown in Figs. 19, 20 and 21.

The functions of the director circuit are as follows:

1. Upon receipt of an inward call from the central office the sequence circuit will connect the director circuit to the trunk circuit on which the call is awaiting. The distributor motor is then started and after it has attained proper speed, a director-ready signal will be transmitted to the distant central office to indicate to the operator that the call may be routed through both the large and small switching centers.

2. The distributor motor may be stopped after the director circuit has been dismissed unless there is another incoming call awaiting completion. In the latter case the motor will be kept running but the other part of the circuit will be restored to normal awaiting the new call.

3. The start magnet is held operated while the distributor motor is coming up to speed to reduce clutch drag.

4. A "figures" teletypewriter character received from the distant central office will indicate that the operator has recognized the director-ready signal and will cause the director circuit to accept the next two characters transmitted from the central office as the called subscriber station number.

5. The next two teletypewriter characters received from the central office are separated into dot elements by the receiving distributor causing the proper selecting relays to be operated.

6. Upon receipt of the first digit of the call directing pulses, the director circuit will select the group of ten lines which contains the desired subscriber line.

7. Upon receipt of the second digit of the call directing pulses the director circuit will select and test the desired subscriber line and disregard any additional character sent to the director circuit.

8. If the called subscriber line has been made out of order, there will be transmitted for a one-second interval to the distant central office a series of signals for recording on the operator's teletypewriter a series of "Q" or "1" characters as an indication of this condition.

9. If the called subscriber line is busy because of a previously established call or because of a busy condition placed on it by the test circuit, a series of "K" or "½" characters will be recorded for a one-second interval on the operator's teletypewriter at the distant central office.

10. If the manual operator at the central office has transmitted first and second digits of a number for which no subscriber line is assigned, or has transmitted an impossible combination of digits, a series of "V" or "⅜" characters will be recorded on the operator's teletypewriter at the central office for a one-second interval.

11. If the subscriber line is idle, the director circuit will cause the link circuit to connect the called subscriber line to the trunk circuit. The director circuit will then be released and restored to the idle condition in preparation for the routing of the next inward call.

12. If the director circuit becomes off-normal and is not released within ten seconds, a series of "T" signals referred to herein as a recorder signal, is sent to the central office for one second and the director circuit is then released and a disconnect signal is sent over the trunk to the central office.

The director circuit is a part of the system which provides an unattended, or automatic, switching arrangement at a point distant from the central office whereby a small group of trunks extending from the central office may serve a larger number of subscribers whose lines are concentrated at the switching point known as a line concentrating unit switching center. The director circuit functions only on inward calls from the central office, receiving and deciphering the called subscriber station number, typed and transmitted by the switchboard operator at the central office, and causing the selection of the called, or desired, subscriber line.

When an operator at the central office seizes a trunk to the large switching center, the associated trunk terminating equipment in conjunction with the sequence and the director circuit at the large switching center functions in response to directing teletypewriter pulses corresponding to the called number of a group of trunks extending to the small switching center, to extend the connection over an idle trunk of the called group to the small switching center whereat the sequence circuit is caused to attempt connection of the extended trunk to the director circuit at the latter switching center. When the trunk terminating equipment at the small switching center receives permission to route the call to the desired subscriber station loop, the director circuit at the small switching center transmits the "director-ready" signal to the operator at the central office, disregarding all typing and line interference until a "figures" signal is received and then responds to the next two character signal combinations to select the called subscriber line. As soon as the director circuit at the small switching center is released by the sequence circuit it is available for succeeding calls.

Terminating equipment at the large switching center, for the trunk circuit extending to the small switching center

This equipment provides a termination in the large switching center for half-duplex trunk circuits extending to the small switching center. The trunk side of the repeater is arranged for half-duplex operation over two line conductors, as hereinbefore stated in connection with the trunk's termination at the small switching center. One conductor is identified as the operating line and the other provided for neutralizing induced voltages. The local side is arranged for operation into a link circuit which also serves a plurality of local subscriber station lines connected directly to the large switching center. Other trunk circuits such as that designated 409 may be provided for termination at the link circuit at the large switching center in the same manner as the trunk circuit shown in Figs. 6 and 14.

The functions of the trunk circuit at the large switching center are as follows:

1. During the idle condition all relays are normal and non-energized except relays 6S and 6R which are held to their marking and spacing contacts, respectively, by local circuits.

2. When a call is originated at the small switching center end of a trunk, current will flow in the line resulting in energizing a path extending to the sequence circuit of the large switching center to secure a trunk to the distant central office. When the trunk is allotted and connection secured thereto, a marking condition is placed on the trunk to initiate a call and thus light the calling lamp in the operated switchboard at the distant central office.

3. The transmission of normal teletypewriter and break signals in either direction will not cause false supervisory signals.

4. When a subscriber station connected directly to the small switching center disconnects the closure at relay 5TR of operating conductor 540 to neutralizing conductor 541 to form a loop at the small switching center results in the removal of the terminating grounded battery 532 from the path extending to the outer upper armature and contact of relay 5TR, conductor 541 and neutralizing conductor 503 of the trunk circuit which extends to the large switching center. This removal of grounded battery 532 from conductor 501 results in lighting the cord lamp at the operator's switchboard at the distant central office.

5. The subscriber connected directly to the small switching center may recall the operator at the distant central office by sending a disconnect followed at an interval of approximately two seconds by a new call.

6. A call received in the large switching center for a subscriber connected directly to the small switching center will result in the seizure of the first idle trunk extending to the small switching center. This in turn will cause a timed interval of 20-cycle ringing current to be automatically sent over the seized trunk extending to the small switching center to condition the equipment at the latter center and to secure thereat a director circuit. The "director-ready" signal from the small switching center is a marking condition placed on the transmission circuit. This marking signal is transmitted back to the originating operator at the distant central office who will then send the teletypewriter characters corresponding to the desired subscriber station. The reception of these signals at the small switching center will cause the connection of the trunk to the desired subscriber station loop and will place an open, or spacing, condition on the trunk. This condition results in lighting the operator's cord lamp as a signal that the operator may ring on the circuit or that the station is being automatically rung if that feature is used. When the subscriber answers the trunk circuit returns to the marking condition and the cord lamp is extinguished.

7. In this supervisory system no provision is made for registration of the trip or subscriber answer during the period in which the subscriber station is being rung. The subscriber answer may be registered during the silent interval in the ringing period.

8. The operator at the distant central office may rering the subscriber connected directly to the small switching center, following his disconnect by applying ringing current to the line.

9. When both the subscriber connected directly to the small switching center and the operator at the distant central office disconnect, the trunk circuit after an interval of two seconds, places a two-second negative potential on the line to release the equipment at the small switching center and at the end of that period restores to normal.

10. Facilities are provided for balancing the repeater for use with composited or non-composited lines, or spare cable conductors.

11. Provision is made for equipping the repeater with 60-cycle interference filters when required.

12. Equalization networks are provided to reduce the characteristic distortion in the received signal.

13. Provision is made for polar receiving type "B" polarential operation over a trunk circuit from a polar sending type "B" polarential repeater at the small switching center end of the trunk.

This repeater, like that at the small switching center end of the trunk, is designed to operate half-duplex only. An adjustable balancing network is provided to obtain an approximate balance for the higher frequency components of the signal. No direct current path is provided in the balancing network. The balance obtained is a compromise value between a perfect circuit balance and one giving the best possible reception of signals. During transmission to the polar sending repeater both the marking and spacing line current are in the same direction and hold relay 6R of the polar receiving repeater on its marking contact.

The balancing network consists of resistance 601 which may be one or more elements and condenser 602 which likewise may be one or more condensers. The condensers provide a capacity of 4 to 10 microfarads, say in two microfarad steps, and are strapped according to the type and length of the trunk circuit.

A duplicate set of balancing equipment, resistance 603, which may be one or more elements and condenser 604 which likewise may be one or more condensers, is provided for use with the neutralizing wire 503. The balancing networks for both the transmission conductor 501 and the neutralizing conductor 503 are adjusted alike to provide the same balance for each conductor.

Relay 6R is provided for receiving signals from the small switching center end of the trunk circuit and for retransmitting the signals to the trunk circuit extending to the distant central office. It has five windings, winding No. 2 is connected to the transmission conductor 501, winding No. 1 is connected to an artificial line which is used for balancing transmission conductor 501, winding No. 3 is connected to the neutralizing conductor 503, winding No. 5 is connected to an artificial line circuit which is used for balancing the neutralizing conductor 503 and winding No. 4 is connected to a local holding circuit which serves to normally hold the relay in its marking position when the trunk circuit is in the idle condition.

Relay 6S is provided for receiving signals from the large switching center and for retransmitting the signals to the small switching center. This relay is equipped with two windings, the upper winding is connected to the transmission conductor 605 and the lower winding is connected to an artificial line circuit.

Relay 6P has three windings, winding No. 1 is connected in series with the transmission line conductor 501, winding No. 2 is connected in series with the neutralizing line conductor 503 and

winding No. 3 is connected to a holding circuit to prevent the relay from operating on small induced line currents when the line is open or grounded at the small switching center. Relays 6P and 6R follow the signals received from the small switching center. During transmission to the small switching center the absence of any winding in the artificial line circuit causes relay 6P, under some conditions, to leave the marking contact. During transmission from the small switching center each transition of the signal as received by relay 6P causes a surge of current through the winding of relay 14H. These surges in conjunction with a direct current from the contact of relay 6C hold relay 14H operated during transmission condition.

Relay 6C has two identical windings, the upper winding is connected in the apex of the transmission line conductor 501 and the lower winding is connected in the apex of the neutralizing line conductor 503. Relay 6C remains operated except during certain transmission periods in the signal. Operation of relay 6C in turn operates relay 14H which is used for supervisory purposes. During the transitory period of the signals when relay 6C releases, the surges from relay 6P cause relay 14H to remain operated. The windings of relay 6C are shunted by condensers 606 and 607 respectively to by-pass a large part of the signaling frequencies to improve telegraph transmission.

During the idle condition, the trunk circuit of the small switching center is connected through resistance 531 of relatively high value to form a loop with the neutralizing line conductor 503. At the large switching center transmission, or operating, line conductor 501 may be traced through the normally closed tip contacts of jack 608, conductor 610, upper armature and back contact of relay 6E, resistance 611, winding No. 1 of relay 6P, winding No. 2 of relay 6R, resistance 612 and retardation coil 613, through the upper winding of relay 6C to ground at the outer upper armature and back contact of relay 6C1. The neutralizing line conductor 503 may be traced over normally closed contacts associated with the tip spring of jack 608, conductor 614, outer lower armature and contact of relay 6E, resistance 615, winding No. 2 of relay 6P, winding No. 3 of relay 6R, resistance 616 and retardation coil 617, through the lower winding of relay 6C, resistance 618 to ground at the armature and contact of relay 6S1. Grounded battery 1401 is connected to a circuit extending through resistances 1402 and 1403, lower normally closed make-before-break contact of relays 14C2, conductor 1404, through winding No. 4 of relay 6R to ground, to hold relay 6R operated to its spacing contact. Grounded battery 1405 is connected to a circuit extending through resistance 1406, conductor 1407, resistance 1408, upper make-before-break contacts of relay 14C2, conductor 1409, through the lower windings, in series, of relays 6S and 6S1, resistance 619, to ground, which circuit holds relay 6S on its marking contact.

A noise killer consisting of resistance 612 and retardation coil 613 is provided in the apex of the transmission line circuit as a noise suppressor. Similarly, resistance 616 and retardation coil 617 are provided in the apex of the neutralizing line circuit as a noise suppressor. In this manner the transmission line circuit and the neutralizing line circuit have equal impedance.

Equalizing networks 620 and 621 are provided for reducing the characteristic distortion in the received signal. These networks are bridged between each of the transmission line conductor 501 and neutralization line conductor 503 and their respective artificial line circuits on the trunk side of relay 6R. Each of the equalizing networks may have one or more resistance elements and one or more retardation coils as desired and the strapping of the resistances should be the same in each network and should be so chosen as to obtain the best transmission over the trunk circuits. Equalizing networks are essential on long simplex phantom cable circuits.

Two trunk circuits of this type when connected together by means of an operator cord circuit tend to oscillate when the two subscriber loops at opposite ends have been opened. This oscillation is such that the relays, such as relay 6C in each of the terminating equipments at the switching centers on opposite sides of the operator's cord circuit are held operated by the operation of their respectively associated relays, such as relay 6P, as they follow the oscillation pulses and thus no disconnect condition is registered in the operator's cord circuit. Relays 6TA, 14TB, 14TC and 6S1 are required to eliminate this condition. Slow-release relay 6TA will operate when relay 6R is operated to its spacing conact, opening the operating circuit of normally operated, slow-release relay 14TB. The operation of relay 6TA replaces grounded positive battery on the spacing contact of relay 6S by ground from a contact of relay 14TB. If the spacing condition of relay 6R is of sufficient duration, relay 14TB will release adding resistance 1410 of relatively high value in series with winding No. 2 of relay 14TC and connecting the spacing contact of relay 6S to ground through winding No. 3 of relay 14TC. If a break originates from the cord circuit at this time relay 6S operates to its spacing contact, connecting negative grounded battery at the small switching center to ground through winding No. 3 of relay 14TC. Relay 14TC operates replacing this ground with grounded positive battery thus placing a spacing or break condition toward the small switching center. In the disconnect condition before the cord is taken down ground is presented to the trunk circuit in both marking and spacing condition and the tendency to oscillate by charging the trunk line capacity is eliminated.

Relay 14TS is operated when connection is made to the automatic signaling trunk jack circuit such as that controlled by jack 609. Relay 14TS, upon operating, (1) operates relay 14AD to cause the director circuit shown in Figs. 23, 24, 26 and 27 to skip the trunk circuit under test when a call for the small switching center is received, and (2) removes ground from the upper armatures and contacts of relay 14L which will prevent the lighting of call lamp 1413 or the connection of the trunk circuit to the sequence circuit shown in Figs. 15, 16, 17 and 18 on calls from a subscriber at the small switching center. Calls from the small switching center will, however, cause the operation of relay 14L to apply grounded battery to conductor 1414 which extends to the automatic signaling trunk jack circuit including jack 609 to light a calling lamp in the jack circuit.

Sequence circuit at the large switching center

This circuit differs in several details from that hereinbefore described for use at the small

switching center. However, it is so arranged as to permit the routing of only one call at a time in either direction through the large switching center.

The functions of the sequence circuit are as follows:

1. This circuit is arranged to permit only one subscriber at any one time the privilege of completing a call through the large switching center when no inward call is in the process of completion.

2. This circuit is arranged to permit only one call at any one time from the central office to seize a director circuit and to be routed and established through the large switching center, provided the routing privilege has not been seized by a subscriber calling the central office.

3. In the case of trouble on an outward call attributed, after a two-second interval, by the alarm circuit in general to the subscriber line terminating circuit or trunk to the small switching center, the link circuit or any part of this circuit used on an outward call, this circuit is arranged (1) to attempt to free the sequence circuit, (2) to remove and lock out of future outward service, under control of the release key, the particular subscriber station and the particular group of subscriber stations containing the calling subscriber station, and (3) to light a lamp indicating the group placed out of outward service.

4. In case of trouble on an outward call in the trunk conductors or parts of the repeaters or trunk relay equipment at the line concentrating unit or the central office, as indicated by the alarm circuit after a two-second interval, this circuit is arranged (1) to attempt to free the sequence circuit, (2) to remove and hold the trunk out of outward service under control of a release key, (3) to flash a lamp indicating the trunk removed from outward service. If the outward path to the central office is not faulty, the calling subscriber station is connected to the next satisfactory trunk available.

5. This circuit is arranged to allot, in a predetermined order, idle trunks to subscribers calling the distant central office. If the large switching center is arranged for a single outlet or two outlets without overflow provisions between outlets, this circuit is arranged to hunt for an idle trunk in the trunk group to which the calling subscriber station is predeterminedly connected or to which he desires access and failing to find one to connect to the "all-trunks-busy" circuit associated with that group of trunks.

6. This circuit is arranged to cause the selected trunk circuit to repeat a calling signal to the distant central office when seized by a calling subscriber.

7. In case all trunks of a group are busy, this circuit is arranged to cause the "all-trunks-busy" circuit to measure the length of time this condition persists.

8. In case of a subscriber placing an outward call when all trunks to which he might be connected are busy, this circuit is arranged to connect the calling subscriber station to the "all-trunks-busy" circuit which manufactures an "all-trunks-busy" signal which is sent to the subscriber station.

9. This circuit is arranged to advance the trunk chain (Figs. 16 and 17) to the next idle trunk immediately after each subscriber calling the distant central office has obtained a routing through the large switching center and before the sequence circuit is permitted to handle the next call in either direction.

10. This circuit is arranged to keep the trunk chain in a "fixed" condition during the entire period that the sequence circuit is attempting to route an outward call through the unit.

11. This circuit is arranged to permit the miscellaneous alarm circuit to function to time the duration required for routing an inward call through the large switching center.

12. In the case of a failure to complete the routing of an inward call where it has been determined that trouble may be in the trunk or trunk sequence circuit, the miscellaneous alarm circuit causes this circuit to function to (1) remove or hold trunks out of service under control of a key, at the same flashing a lamp associated with the trunk circuit, (2) to attempt to free the sequence circuit and (3) to send the characteristic reorder signal to the distant end if the out-of-order period has exceeded ten seconds.

13. In case of a failure to complete the routing of an inward call when it has been determined that the trunk or trunk sequence circuit has not caused failure, the miscellaneous alarm circuit causes the sequence circuit to act as described in the immediately preceding paragraph except that the trunk is removed temporarily under control of a marking signal from the central office and the lamp lights steadily instead of flashing.

14. If one or more trunk calls from the central office are awaiting service, this circuit is arranged to start and keep the distributor motor "in speed."

15. This circuit is provided with a night alarm buzzer primarily for use during periods of manual operation to indicate the reception of an inward or outward call.

Each subscriber line terminating equipment is equipped with an ST and an AL relay such as relays 15ST—0 and 15AL—0 for a subscriber line terminating equipment such as 621 or 622. Relays 15ST—1 and 15AL—1 are assigned to the trunk comprising inductors 501 and 503 and extending to the small switching center, which trunk is equivalent to a subscriber line, such as lines 649 and 650, connected directly to the large switching center. Each group of subscribers including one or more trunk circuits extending to the small switching center is equipped with an ST1, AL, and AL1 and B0 relays such as relays 15ST1—G0, 15AL—G0, 15AL1—G0 and 15B0—G0 for the first, or zero group. All these relays of each group are used in routing through an outward call except the B0 relay which is used to remove the group from outward service. In general, subscribers of a group seek the privilege of the use of the subscriber line sequence circuit. The subscriber obtaining the privilege has permission to use the subscriber group sequence circuit and, if permission by the latter circuit and the trunk sequence circuit is given, to route his call through the large switching center. Each trunk to the distant central office is provided with an ST2, an AL, an AL1, a B0, a B01, CH and AD relay and one of the "make" contacts on one of the H or H1 relays, such as relay 16ST2—0, 16AL—0, 16AL1—0, 16B0—0, 16B01—0, 16AD—0 and 16CH—0 shown in the provision for the first trunk and the upper armature of the CH relay in each set is connected to one of the "make" contacts on an H relay, such as relays 18H—0, 18H—1 and 18H—2, the number of H relays required depending upon the number of groups of trunks. For practical rea-

sons a group consists of one to six trunks. The "make" contact on an H relay holds the trunk chain and advance circuit consisting of the CH and the AD relay of each trunk set in a "fixed" condition while a call is being routed through the concentrating unit. In general, the trunk circuit receives normal preference in the sequence circuit chain. When a trunk call obtains permission to be routed through the line concentrating unit, the trunk circuit is connected to a director circuit which translates the pulses received from the operator at the distant central office into the number of the desired subscriber line of lines such as those designated 649 and 650 or trunk extending to the small switching center. As common office equipment, the sequence circuit provides relays 18LS—1 and 18LS1—1 as a common start circuit for the first group of trunks, that is, a group extending to a single outlet, or one central office. Relays 18LS—2, 18LS1—2 and 18TR are supplied in case there is a second trunk group existing in the switching center extending to a second outlet, that is, another central office. Relay 18TR, if provided, is designed to change the order of the trunk chain and advance circuit in such a manner that all trunks in the preferred group are tested for busy before a trunk is selected in the other group existing in the switching center, although all trunks of both groups are available to a calling subscriber.

The subscriber sequence circuit consists of two parts which are used for outward calls. The first part, designated subscriber line sequence circuit permits any one of ten subscribers to establish an outward call through the circuit, subsequent calling subscribers in the group being served in accordance with their position in the sequence. The second part, designated subscriber group "sequence circuit" permits any subscriber connected through a subscriber line sequence circuit to establish an outward call through the group sequence circuit, subsequent calls from other subscriber line sequence circuits being served in accordance with their positions in the sequence.

On outward calls, the sequence circuit arranges for the link circuit to connect the calling subscriber line to the first idle trunk circuit extending to the central office, or to the "all-trunks busy" circuit, if required.

The trunk sequence circuit permits any call from the operator at the central office to be served before a call from the subscriber group sequence circuit. Subsequent calls from the operator at the central office are served in accordance with their positions in the sequence.

On inward calls the sequence circuit connects the calling trunk to the director circuit. When the director circuit has determined the called subscriber line the link circuit connects such line, if it is idle, to the calling trunk. The sequence circuit then releases the director circuit and is available for routing a new call. If the line is busy, out of order, or unassigned the sequence circuit releases the director when the operator disconnects after receiving this information from the director circuit, or at the end of about eleven seconds if the operator does not disconnect.

In case trouble is encountered on an outward call, due to failure of the subscriber line circuit, link circuit or sequence circuit, the subscriber group in which the calling line is included, is removed from operation in the sequence circuit and from service, and visual and audible alarms are given. In case trouble is encountered on an outward call, due to failure of the trunk circuit, either at the large switching center or the central office or between the switching center and central office the trunk is removed from operation in the sequence circuit and from service, and visual and audible alarms are given.

In case trouble is encountered on inward calls, due to failure of the trunk or trunk sequence circuit, the trunk is removed from operation in the sequence circuit and from service, and visual and audible alarms are given.

In case trouble is encountered on an inward call, but not due to failure of the trunk or trunk sequence circuit, the trunk is removed from service temporarily as long as a "mark" signal is received from the operator at the central office, and is restored to the sequence circuit for future operation as soon as it is released at the central office.

Link circuit at the large switching center

This circuit acts as a selectable connecting medium between trunk circuits from the central office and (1) subscriber line circuits, and (2) trunk circuits extending to the small concentrating unit switching center.

The functions of the circuit are as follows:

1. When a selecting magnet and a holding magnet are operated in the proper sequence, the trunk circuit with which the selecting magnet is associated will be connected to the subscriber line circuit with which the holding magnet is associated. In the case where a trunk from the central office is connected to a trunk extending to the small switching center the selecting magnet is associated with the trunk circuit from the central office and the hold magnet is associated with the trunk extending to the small switching center.

2. Off-normal contacts on the selecting magnets insure upon the establishment of a connection that the magnets are operated in the correct sequence.

3. When the holding magnet is operated it will lock under control of the trunk circuit in order that the selecting magnet engaged in the same established connection may be released.

4. The holding magnet contacts perform the "cut-off" function required in the associated subscriber line circuit or trunk circuit to the small switching center, as the case may be, upon establishment of a call.

5. This circuit may be provided with a key to enable the attendant to disconnect the attendant's line from the trunk circuit.

In the idle condition all magnets are released and the tip and ring conductors of the subscriber line are connected through the subscriber line circuit over the T and R conductors. These conductors will be open at the subscriber station in the idle condition. The link circuit at the large switching center serves herein to illustrate the manner in which a trunk extending to the small switching center is connected to a trunk extending to the central office and therefore the diagrammatic showing of two subscriber stations respectively connected by lines 649 and 650 extending through terminating equipments 621 and 622 is deemed sufficient to show the relation of the trunk circuit extending to the small switching center to any subscriber station that may be connected to the large switching center.

The link circuit like that hereinbefore described for the small switching center consists of one or more cross bar switches. As many simultaneous connections as there are trunks may be estab-

lished. Each subscriber line circuit and each line trunk extending to the small switching center are connected to individual verticals on a cross bar switch.

Terminating equipment located at the large switching center of a trunk extending to the central office

This circuit is designed as the terminating equipment at the concentrating unit end of a two-way trunk extending to a manual central office. This trunk circuit possesses automatic signaling supervision features and is arranged to be connected between the large switching center and the central office with full-duplex standard toll line facilities. To differentiate from the line trunks extending to the small switching center this trunk will be referred to herein as one of the main trunks.

The functions of the circuit at the large concentrating unit switching center are as follows:

1. On an outward call from a concentrating unit subscriber or from a line trunk circuit extending to the small switching center, the main trunk is preselected by the sequence circuit at the large switching center and sends a continuous "mark" signal to the central office whereat the trunk-busy lamp lights.

2. When this circuit sends a continuous "mark" to the central office and lights thereat the trunk-busy lamp it awaits the reception of "ringing" from the central office as a trunk verification test before ordering the link circuit to connect the particular calling subscriber station or the line trunk extending to the small switching center to the main trunk circuit.

3. This circuit simultaneously with the sending of the "mark" signal to the central office connects ground to conductor **801** which extends to the miscellaneous alarm circuit where the interval required for the routing of the outward call is timed.

4. If the link circuit has connected the calling subscriber station or a line trunk extending to the small switching center to a main trunk circuit extending to the central office the sequence circuit is dismissed and the subscriber station or the line trunk is held connected to the main trunk circuit under control of the power switch at the subscriber station while the main trunk circuit is made busy to other calling concentrating unit subscriber stations and to calling trunk circuits extending to the small switching center.

5. Under the condition of paragraph 3 if an interval as determined by the miscellaneous alarm circuit has been exceeded without the reception of "ringing" or continuous current transmitted from the central office, the miscellaneous alarm circuit orders the trunk-busy lamp extinguished, the particular main trunk circuit removed from service, the calling subscriber being given an opportunity to attempt to place his outward call over the next idle available main trunk circuit while a characteristic trouble signal is sent from the sequence circuit to the main trunk for retransmission to the central office.

6. While awaiting the answer of the operator at the central office the subscriber can "flash" the operator. Under this condition this circuit sends "mark" and "space" signals to the central office in unison with the operation of the power switch at the subscriber station.

7. If the calling subscriber abandons an outward call before the operator at the central office answers, this circuit sends a permanent "space" signal to the central office and when the reception of continuous ringing ceases, orders the link circuit to disconnect the subscriber line or a line trunk from the main trunk circuit, removing the busy appearance of the main trunk circuit to other calling subscribers and also extinguishing the trunk-busy lamp.

8. When the operator at the central office answers the outward call, the continuous ringing current is replaced by a "mark" signal, upon the reception of which this circuit advances to the half-duplex transmission stage in which it is capable of distinguishing between normal teletypewriter signals, break signals or disconnect signals from either end.

9. When a prolonged "space" signal is received from the concentrating unit subscriber this circuit transmits a "space" to the central office and after approximately two-thirds of a second ascertains if the subscriber has disconnected. If the subscriber has disconnected this circuit continues to send a "space" signal to the central office, returns to the full-duplex system of transmission but remains in condition to permit the "rering" of the disconnected subscriber station. If the "space" signal is the result of a subscriber "flash" the circuit functions as if he had disconnected during the "off" operation of the power switch and returns to half-duplex transmission transmitting a "mark" as soon as the switch is again turned "on." If, however, the "space" signal from the subscriber station resulted from the transmission of a "break" from the subscriber station this circuit replaces the "space" signal sent to the central office by "ringing" for the remainder of the "break" signal received from the subscriber, remaining at the same time in the half-duplex transmission condition. At the conclusion of the "break" this circuit transmits a "mark" to the central office.

10. When a prolonged "space" signal is received from the central office this circuit continues to send a space signal to the subscriber station. After two-thirds of a second has elapsed followed by the reception of "ringing" current from the central office this circuit remains in the half-duplex transmission condition and continues to send a space signal to the subscriber station. After 5.5 seconds of space signal to the subscriber station this circuit sends periodic mark and space signals to the subscriber station as long as the reception of "ringing" from the central office continues. When a mark signal is received from the central office at the end of the ringing period this circuit sends a mark signal to the subscriber station.

11. Under the conditions of paragraph 10 if a continuous space signal is not followed by "ringing" current the circuit acts exactly as described under paragraph 10 provided the subscriber's disconnect signal has not been registered in the main trunk. If a subscriber's disconnect signal has already been registered the reception of a spaced signal of one-second duration from the central office causes this circuit to order the link circuit to disconnect the subscriber line or line trunk from the main trunk circuit, and return the main trunk circuit to normal.

12. When the main trunk circuit is seized at the distant central office for an inward call this circuit receives a mark signal which after one-half of a second has elapsed results in ordering the sequence circuit to connect a director circuit to the main trunk circuit, at the same time

marking the main trunk busy to outward calls and lighting the trunk-busy lamp.

13. If the attached director circuit fails to get ready to receive teledirecting pulses, the miscellaneous alarm circuit after an interval orders the sequence circuit to manufacture a characteristic trouble signal, and transmit it to the main trunk circuit for retransmission to the central office, removing the director circuit and extinguishing the trunk-busy lamp.

14. When a director circuit is attached and ready to receive teledirecting pulses it orders this circuit to send a continuous mark signal to the central office.

15. With the director circuit attached if a prolonged space signal is received from the central office as a result of the operator's disconnect signal this circuit after one-third second orders the sequence circuit to dismiss the director circuit and after one second returns to normal.

16. With the director circuit attached if a two-thirds second space signal followed by "ringing" current is received as a break signal from the operator, this circuit orders the sequence circuit to release the director circuit. If at the conclusion of "ringing" current a mark signal is received, the sequence circuit is again ordered to connect a director to the main trunk, but if at the conclusion of ringing current a space signal is received, the main trunk returns to normal.

17. When the teledirecting pulses are received they are transmitted to the director circuit which decodes the information and tests the called subscriber line, or a line trunk extending to the small switching center, ordering the link circuit to connect the called line or called trunk to the main trunk if the called line or called line trunk is idle. If the called line or called line trunk extending to the small switching center is busy, out of order or unassigned, signals characteristic of these conditions are produced in the director circuit transmitted to the main trunk and retransmitted to the central office.

18. The called line trunk extending to the small switching center is attached to the main trunk, the sequence circuit and director circuit are dismissed and the line trunk again sends a space signal to the central office; at the same time automatic ringing of the called subscriber line over the line trunk extending to the small switching center is begun if the circuit is so arranged. If the circuit is not arranged for automatic ringing the inward operator at the central office sends a ringing current signal which in this circuit orders ringing to be connected to the called line trunk.

19. When a subscriber answers at the called station, this circuit during the silent interval disconnects the automatic ringing, sends a mark signal to the central office and advances into half-duplex transmission stage in which it is capable of distinguishing between normal teletypewriter signals and break or disconnect signals from either end.

20. If the called subscriber line is to be started on an unattended basis, continuous ringing is received from the central office causing continuous ringing to be sent to the subscriber station.

21. After continuous ringing has exceeded 9 seconds in an attempt to start an unattended station this circuit sends a permanent mark to the called station. If the subscriber station has been started this circuit sends a mark to the central office and advances to the half-duplex transmission stage. If the station has not started after 9 seconds the circuit continues to send a space signal to the central office and a mark to the subscriber station until appropriate action is taken by the central office operator.

22. After a subscriber has disconnected the operator at the central office can rering the subscriber station.

23. This circuit is provided with jacks, such as jacks **802A** and **803B** for the circuit shown in detail to permit manual connection of subscriber lines, or line trunk circuits extending to the small switching center in case of failure of the automatic equipment.

24. Jacks, such as those designated **802A**, and **803B**, are also provided to permit the testing and routining of the main trunk circuit by means of the test circuit (not shown herein but disclosed in Krecek application Ser. No. 348,629, supra).

A third conductor may be provided for neutralizing voltages induced in either of the transmission conductors as disclosed in the copending applications of C. A. Dahlbom and R. B. Hearn, Serial No. 396,818, filed June 6, 1941.

The full automatic supervision facilities are capable of differentiating between telegraph signals, break and disconnect signals from either end. In general, a disconnect signal is a continuous space, and a break is a limited space signal followed by a 20-cycle ringing current signal for the remainder of the "break." Due to the 0 to 20-milliampere subscriber loop transmission, the condition of the subscriber station cannot be ascertained during the transmission of a space signal to the subscriber station. This circuit recognizes this impossibility and orders a periodic mark signal sent to the subscriber station during which it can determine the conditions at the subscriber station. In the normal condition of the circuit, both send and receive conductors to the central office are "spacing" and battery drain is removed from the loop repeater and the vacuum tube.

Director circuit at the large switching center

This circuit is designed to receive directly the directing teletypewriter pulses sent by the operator at the distant central office and to decipher these pulses thereby causing the selection of the called subscriber line connected to the large switching center, or a line trunk extending to the small switching center.

The functions of this circuit are as follows:

1. Upon receipt of an inward call from the operator at the central office, the sequence circuit will connect the director circuit to the trunk circuit on which the call is waiting. The distributor motor is then started and after it has attained proper speed, a "director-ready" signal will be transmitted to the operator at the central office to indicate that the call may be routed through the large switching center.

2. The distributor motor will be stopped after the director circuit has been dismissed unless there is another incoming call awaiting completion. In the latter case the motor will be kept running but the other part of the circuit will be restored to normal waiting the new call.

3. The start magnet **270I** is held operated while the distributor motor is coming up to speed to reduce clutch drag.

4. A "figures" teletypewriter character received from the central office will indicate that the operator has recognized the "director-ready" signal and will cause the director circuit to accept the next two characters transmitted from the

distant central office as the called subscriber station number or the number of the line trunk extending to the small switching center.

5. The teledirecting pulses, or characters, received from the central office are separated into dot elements by the receiving distributor causing the proper selecting relays to be operated.

6. In the case of paragraph 4, upon receipt of the first digit of the call directing teletypewriter pulses, the director circuit will select the group of ten lines which contains the desired subscriber line or the desired line trunk group extending to the small switching center.

7. Upon receipt of the second digit of the call directing pulses the director circuit will select and test the desired subscriber line or the desired line trunk and disregard any additional characters sent to the director circuit.

8. If the called subscriber line or the desired line trunk group has been made out of order, a series of "Q" teletypewriter signals will be recorded on the operator's teletypewriter at the central office as an indication of this condition.

9. If the called subscriber line or the desired line trunk group is busy because of previously established calls or because of busy conditions placed on it by the test circuit a series of "K" signals will be recorded on the operator's teletypewriter at the central office.

10. If the operator at the central office has transmitted digits for which no subscriber line is assigned or has transmitted an impossible combination of digits, a series of "V" signals will be recorded on the operator's teletypewriter.

11. If the subscriber line or a called line trunk is idle the director circuit will cause the link circuit to connect the called subscriber line or the desired line trunk to the calling main trunk. The director will then be released and restored to the idle condition in preparation for the routing of the next inward call.

12. The miscellaneous alarm circuit is arranged to allow 2 seconds for the director circuit to become off-normal, 4 seconds to complete its self-imposed preliminary test and give satisfactory evidence to the alarm circuit and a total of 10 seconds for the director circuit to complete its test at any event.

13 If the director circuit is not off-normal in 2 seconds, the miscellaneous alarm circuit removes the calling main trunk from service, but puts the director circuit back into service.

14. If the director circuit becomes off-normal but the distributor motor fails to get up to speed in 4 seconds, the director circuit is removed from service but the main trunk is taken out temporarily. Lamp **2601** lights and a minor alarm is sounded.

15. If the director circuit is not released in 10 seconds, a recorder or "T" series of signals will be recorded at the central office for a period of one second followed by a disconnect condition.

16. If the "director-ready" signal fails to reach the associated loop repeater or a "mark" from the main trunk is not registered in the distributor circuit, both director circuit and the main trunk are removed from service. In this case a minor alarm is sounded and appropriate tell-tale lamps are lighted.

17. In a line concentrating unit containing two director circuits in the case of the condition described in paragraphs 14 and 15, the miscellaneous alarm circuit after freeing the director circuit in trouble from the sequence circuit causes the transfer portion of the director circuit to function, removing the director circuit placed in the "stuck" condition from service and replacing it by a spare available director circuit.

Miscellaneous alarm circuit at the large switching center

This miscellaneous alarm circuit is arranged primarily to time the interval during which the sequence circuit is in use and is arranged to give appropriate alarms, if a specified time limit is exceeded, giving at the same time an indication of the possible circuit in trouble. The circuit is also arranged to give an alarm when the battery or grounded chain of the sequence remains open.

The functions of the circuit are as follows:

1. On an outward call from a subscriber station or a calling line trunk extending from the small switching center, the miscellaneous alarm circuit times the interval in which the sequence circuit is used to see that it does not exceed 2.5 seconds.

2. On an outward call when the sequence circuit is in use for more than 2.5 seconds the miscellaneous circuit is arranged to indicate whether the trouble is in the trunk alone or in any of the other circuits called into use. In case the miscellaneous alarm circuit decides that the trunk is in trouble, it is arranged to give a minor alarm flash a trunk lamp and to cause the removal of the particular main trunk from service. In case the miscellaneous alarm circuit determines that any of the other circuits in use on the particular call are in trouble, the circuit is arranged to light lamp **2501** and to give a minor alarm, and to cause the removal from outward service of the subgroup of subscriber stations containing the calling subscriber station or line trunk.

3. After removing the particular main trunk or the particular subgroup of subscriber stations and/or line trunks from service, the miscellaneous alarm circuit is arranged to detect the ability of the sequence circuit to return to normal and to light lamp **2801** and bring in a major alarm if it fails to do so within one-half second.

4. On an inward call to a local subscriber station or a line trunk the miscellaneous alarm circuit begins timing, as soon as the inward call has received preference from the sequence circuit, being arranged to time the interval required to obtain a director circuit and to give an alarm if this period exceeds 2.5 seconds. In this case the miscellaneous alarm circuit is arranged to cause the removal from service of the main trunk in trouble, flash the lamp associated with the main trunk and at the same time lights lamp **2501** bringing in a minor alarm. The alarm circuit continues to function as indicated in paragraph 3.

5. When informed over the conductor **2301** that the director circuit has moved off normal, the miscellaneous alarm circuit waits a total of 4 seconds for the director circuit to place ground on conductor **2302**. The director circuit places ground on conductor **2302** if the distributor motor has attained speed, if the director-ready signal reached the associated loop repeater and if a mark signal sent over the main trunk from the central office has been registered in the distributor circuit.

6. If the miscellaneous alarm circuit times out before conductor **2302** is grounded but after conductor **2301** was grounded, the alarm circuit is arranged

(*a*) To cause the associated director circuit to lock in a "stuck" condition;

(b) To bring in an audible and visual alarm associated with the director circuit;

(c) After the director circuit has been locked up in a "stuck" condition to remove the main trunk from service under control of a key and cause a lamp associated with this trunk to flash or if conductors **2303** and **2304** are connected to ground when the alarm circuit times out to remove the main trunk from service temporarily under control of a "mark" signal sent from the central office, causing a lamp associated with the main trunk to light steadily;

(d) After allowing approximately one-half second, the director circuit having been locked in a "stuck" condition, the miscellaneous alarm circuit is arranged to test for failure of the sequence circuit to release and to bring in an audible major alarm and light the lamp **2801** if the sequence circuit fails to release;

(e) If the sequence circuit has been released the miscellaneous alarm is arranged to replace the "stuck" director circuit with another spare director circuit if one is available.

7. If conductor **2302** is connected to ground the miscellaneous alarm circuit permits the director circuit 10 seconds to complete all of its functions.

8. If the miscellaneous alarm circuit times out after 10 seconds the alarm circuit is arranged to function as follows:

(a) Connects a source of signals corresponding to a series of "T" characters to the main trunk for one second as a reorder signal and then removes the trunk circuit from service under control of a "mark" signal received from the distant end lighting a lamp associated with this trunk circuit but returns the director back to service;

(b) After approximately one-half second test for failure of the sequence circuit to release and if the sequence circuit fails to release, brings in an audible major alarm and lights the lamp **2801**.

9. If two director circuits are provided in the unit, the miscellaneous alarm circuit in taking a director circuit out of service will give a minor alarm provided the spare director circuit is available and not in trouble. If the second director circuit is in trouble the circuit will give a major alarm.

10. The circuit is arranged to permit manual transfer from one director to another at a time when the sequence circuit is not in use due to the routing of a call through the switching center and when the director circuit transferred to is available and not in trouble.

11. The circuit is arranged to prevent the use of a sequence circuit on a new call for one-half second after the sequence circuit has otherwise returned to normal after timing out.

12. The circuit is arranged to furnish a time delay between the operation of the selector magnet of the cross bar switch and the application of ground for the operation of the "hold" magnet of the cross bar switch.

13. The circuit is provided with keys associated with each type of trouble indicator to permit removal of the audible alarm leaving a lamp to indicate the trouble condition and with keys to release the locked-in trouble indication and also alarm cut-off key **2502** which prevents the alarm circuit from timing out.

14. This circuit is arranged to light connection lamp **2503** as an indication that a selecting magnet of the link circuit has operated.

15. This circuit is arranged to prevent the director circuit from interfering with the miscellaneous alarm circuit when both director circuits fail or if the single director fails in a single director circuit unit.

16. If the grounded battery or ground chain of the sequence circuit remains open for approximately 45 seconds, this circuit is arranged to give a major alarm and lights sequence battery lamp **2504** or sequence ground lamp **2505** to indicate which chain is open.

17. This circuit is arranged to prevent the routing of a call if the selecting magnet of a link circuit is falsely operated and to give an alarm if this condition persists for approximately 45 seconds.

All-trunks-busy circuit at the large switching center

This circuit is designed for use in a line concentrating unit as an originating source of "no circuit" signal and "K" signals sent to the calling subscriber under certain conditions, at the same time providing "no circuit" time integrating registers in addition to subscribers' overflow registers.

The functions of this circuit are as follows:

1. When all trunks reaching a given outlet are busy this circuit is arranged to measure the length of time this condition persists.

2. When all circuits associated with this circuit are busy the circuit is designed to:

(a) produce and send to each calling subscriber a "letters", "no circuit" signal;

(b) registers on the subscriber's overflow register the number of attempts subscriber made during the all-trunks-busy period;

(c) measures the continuous duration of the production of these "letters" signals given an audible and visual alarm if the time exceeds a predetermined interval;

(d) continues to produce the "letters" signal as long as any subscriber keeps his loop open.

3. Whenever a trunk becomes idle this circuit is arranged to produce "K" signals at a speed of approximately forty words per minute and send these signals instead of the "letters" to the waiting subscribers.

Terminating equipment of the trunk circuit at the central office

This circuit provides a termination having automatic signaling supervisory features and a teletypewriter switchboard at the central office for main trunks extending to the large switching center. The companion terminating circuit at the large switching center is arranged to operate with 0.020-ampere metallic local lines along with single conductor transmission trunks extending to the small switching center and arranged for two-way transmission on a half-duplex operation basis.

The functions of this circuit are as follows:

1. In the idle condition both the inward and outward transmission paths are spacing.

2. A call from the concentrating unit switching center will be received as a marking signal on the outward path. This action will be followed in one-half second by the lighting of the busy lamp, application of a busy test potential to the sleeve multiple, and the application of 20-cycle dot signals to the inward path. After one-half second additional time the line lamps will light. Marking signals of less than one-second duration will not be registered as calls.

3. In the call-before-answer period if the sub-

scriber recalls, the disconnect intervals will return the outward path to spacing and will extinguish the line lamp, the resumption of the call will relight the line lamps.

4. If the subscriber abandons the call before the operator at the central office has answered, the outward path will return permanently to spacing and the line lamp will be extinguished. The 20-cycle dot signals will be removed from the inward path after 4 seconds and the busy condition will be removed after an additional one and a half seconds.

5. When the operator at the central office answers the call, the line lamp will be extinguished and a marking condition will supplant the 20-cycle dot signals on the inward path. The busy lamp will remain lighted.

6. During communication, signals from the subscriber toward the operator office will be transmitted over the outward path. Signals from the central office to the subscriber will be transmitted over the inward path. Between the full and half-duplex converting repeater and the connected cord circuit signals in both directions will be transmitted over the tip conductor circuit. No supervisory action will take place as a result of teletypewriter signaling. The ring or supervisory conductor to the cord will therefore remain open during communication.

7. A "break" from the cord circuit will be repeated to the inward path as a spacing signal which will be supplanted by 20-cycle dot signals after a delay of two-thirds of a second. At the end of the break the inward path will return to marking. A break from the subscriber will appear as a spacing condition on the outward path followed in two-thirds of a second by 20-cycle dot signals. Throughout the entire break interval, however, a spacing condition will be applied toward the cord circuit. No supervisory action will result from break signals in either direction.

8. A disconnect from the subscriber will return the outward path to spacing. After one second ground connection will be applied to the ring conductor of the cord to light the supervisory lamp.

9. A recall from the subscriber is the same as a disconnect followed by a new call. When the outward path returns to marking as the result of the new call the ground connection will be removed from the ring conductor to cause the supervisory lamp in the cord circuit to flash.

10. When the operator at the central office connects to the trunk to originate a call a marking condition will supplant the idler or spacing condition of the inward path, ground connection applied to the ring conductor circuit will light the supervisory lamp of the cord circuit.

11. When the large and the small switching centers are, in turn, prepared to receive the signals corresponding to the call directing characters, the outward path will become marking. The action of remotely controlling the directing of a call to a desired line or line trunk through the agency of the operator's teletypewriter at the central office and the director circuit at the concentrating units will be referred to hereinafter as teledirection. This will permit removal of ground from the ring conductor to extinguish the supervisory lamp.

12. After the operator at the central office has sent the call directing pulses and the desired subscriber line or desired line trunk has been selected, or the operator has teledirected, the outward path will return to the spacing condition to relight the supervisory lamp.

13. When the called subscriber answers, the outward path will again become marking to extinguish the supervisory lamp. Thereafter the circuit will be conditioned to perform the functions outlined in paragraphs 6, 7, 8 and 9.

14. If the desired subscriber line or desired line trunk is busy, out of order, or unassigned the concentrating unit at either the small or the large switching center will transmit to the central office teletypewriter signals to indicate which of the three conditions exist.

15. When the operator abandons the call after receiving the busy, out-of-order busy, or unassigned signal by disconnecting from the trunk, the equivalent of a break signal will be sent to dismiss the concentrating unit call directing equipment. When this equipment has been dismissed the outward path will be returned to spacing and this will, after five seconds, cause a spacing condition to supplant the 20-cycle dot signals applied to the inward path; after one and one-half additional seconds the busy condition will be removed from the main trunk.

16. If the operator at the central office disconnects the cord circuit in error during communication, the circuit will revert to the call-before-answer condition as outlined above in paragraph 3 which may be abandoned by the subscriber as outlined in paragraph 4, if the operator fails to reestablish the connection.

17. When the operator at the central office disconnects from the trunk at the end of a communication following the subscriber's disconnect, the inward path will return to the idle or spacing condition. After a delay of one and a half seconds the busy condition will be removed.

18. In the idle condition both the inward and outward transmission paths are spacing. No relays or vacuum tubes are energized except the relay **10**—RS which is held to spacing by the spacing condition of the outward path. Relay **10**—RS will keep condenser **1001** discharged during the idle condition.

Operator cord circuit and position circuit at the central office

The operator's cord circuit and position circuit may be the same as disclosed in the copending application of C. W. Lucek, Serial No. 431,854, filed February 21, 1942, and W. V. K. Large-F. J. Singer, Serial No. 462,966, supra.

Detailed Description of Operation

Call originating at a subscriber station connected directly to the small switching center

For the purpose of illustrating an outward call, that is, a call originating at a subscriber station and extended in turn, through the small and the large switching center to the central office, it will be assumed that the call originates at subscriber station **202** which is shown herein in detail. In Fig. 1 there is illustrated in schematic form a local subscriber station **202** connected directly to the small switching center by a pair of conductors T2 and R2. In an idle condition conductor T2, known as the tip, is connected to ringer **212** so that incoming calls to this station will be indicated by the sounding of the ringer **212** through the application of ringing current to the tip T2 at the switching center. When the station is in use, switch **210**, referred herein as the power, or start, switch is operated to cause conductor T2 to be connected over the normally closed contacts

of call key 214, front contact and armature of relay 2L, lower contact normally in engagement with spring member 1 of key 213, conductor 215, transmitting, or pulsing, contacts 207, break key 216, through the lower winding of relay 2-line, spring member No. 4 in engagement with its upper contact of key 213, through the winding of break relay 2BK, through the ring side of the line, conductor R2. Under certain conditions to be explained hereinafter, current will flow through this circuit at a value about 20 milliamperes for a marking condition and zero for a spacing condition. With steady marking current established by the condition at the small switching center the operation of the pulsing contacts 207 in series with this circuit will reduce the current to the spacing value.

The biasing winding of relay 2-line has a current of an intermediate value flowing therethrough so that with no current flowing through the lower winding in the spacing condition the armature will remain on its spacing contact, but with the marking current flowing through its lower winding the biasing winding will be overcome and the relay will move to its marking contact. Incoming marking and spacing signals will therefore operate printer magnet 206 in the proper manner and these same current variations caused by the operation of pulsing contacts 107 will cause the operation of relay 1-line to again operate the printer magnet 206 for the purpose of making local copy.

Briefly stated, the operations performed in response to a subscriber originating a call by operating the power switch, such as switch 210 at station 202, to the "on" position, are as follows: First the operation of the power switch closes the loop circuit and causes to operate the associated subscriber line relay, such as relay 3L2 at the small switching center and causes the sequence circuit to connect an idle trunk to the calling subscriber line. The sequence circuit drops out of the connection after the trunk has been selected. If all the trunks are in use the sequence circuit causes the subscriber line to be connected to the all-trunks-busy circuit not shown but described in the copending application of W. V. K. Large-F. J. Singer, supra.

As soon as the subscriber line is connected to a trunk termination, a trunk relay such as relay 5TR in the trunk termination shown, removes the high impedance ground effected by resistance 531 having a value of approximately 18,000 ohms, from the trunk conductor 501 and connects conductor 501 to the trunk repeater (winding No. 3 of receive relay 5R and the armature of send relay 5S); thereupon marking (negative) potential from grounded battery 532 is applied to the trunk conductor 501 and the trunk circuit terminating at the large switching center receives the negative marking potential which operates relay 6C through its upper winding. Relay 6C, upon operating, operates relay 14H which in turn operates relay 6C1. Relay 6C1, upon operating, operates relays 6CL, 6SA and 6DR. Relay 6SA, upon operating, operates relay 14L to light the call lamp 1413 and to place a ground connection on the start conductor 1415 to operate relay 15ST—1 of the sequence circuit, relay 15ST—1 together with relay 15AL—1 is associated with the trunk line comprising conductors 501 and 503 and extending from the small switching center. Accordingly, relays 15ST—0 and 15AL—0 are associated with subscriber station line 649 and its terminating equipment 621 and relays 15ST—9 and 15AL—9 are associated with another subscriber station line and terminating equipment, not shown, but corresponding to line 649 and terminating equipment 621 which is connected directly to the large switching center. The grounding of the start conductor 1415 to the sequence circuit results in the connection of the first idle trunk extending to the central office by operation of the link circuit holding magnet 7H2 which is associated with the trunk comprising conductors 501 and 503 and extending from the small switching center. The call is ultimately repeated by the trunk to the distant central office to light a line lamp in the switchboard multiple. The operator at the central office connects a cord circuit to a trunk jack associated with the lighted lamp and receives the number of the called, or desired, subscriber station from the calling subscriber at station 202.

When start switch 210 was operated it closed a circuit from one side of power supply 217, through the winding of relay 2S to the other side of the power supply causing relay 2S to operate. Relay 2S, upon operating, locks up through its lower contacts, contacts of stop key 211, motor control contacts 209 of the printer. Upon operating, relay 2S closes a path through its upper contact to start the motor for the printer set and also to operate relay 2L. The operation of relay 2L opens the bell ringer circuit over the tip conductor T2 of the loop, removes ground from the ring side R2 of the loop and closes the tip and ring conductors of the loop through the subscriber station set to operate relay 3L2 at the small switching center. This last circuit is traceable from grounded positive battery 380, conductor 381, back contact and right-hand armature of hold magnet 3H2, conductor 309, normally closed contacts at the tip spring of jack 307A, conductor T2, through the loop at the subscriber station, conductor R2, resistance 343, normally closed contacts at the tip spring of jack 308B, conductor 310, normally closed make-before-break contacts of hold magnet 3H2, conductor 342, through the winding of relay 3L2, to ground and relay 3L2 operates.

Lamp relay 3L2, upon operating, first closes at its upper armature and contact an operating circuit for call lamp 306 which is traceable over conductor 346 (which is common to the call lamps associated with the subscriber stations shown), conductors 347 and 1209, through the winding of relay 13E, to grounded battery, and relay 13E operates (relay 13E is effective at night only to cause an audible signal as well as a visual signal alarm when the audible alarm cut-off key 1303 is released in the position shown); also relay 3L2, upon operating, (1) closes to ground at its inner lower armature and contact a circuit extending over conductor 348, contact and armature No. 4 of the main gate relay 11G, contact and middle left-hand armature of relay 11BO1, through the winding of relay 11SA1, to grounded battery, and relay 11SA1 operates; (2) connects at its lower armature and contact a ground connection to a path extending over conductor 350 in preparation for a circuit which will presently be closed by the operation of relays 11SC1 and 11U2. Relays 11BO1 and 11SA1 together with relay 11SC1 constitute a group which is individual to that group of five subscriber lines of which line 202 is a part.

Relay 11SA1, upon operating, (1) locks up at its left-hand armature and contact directly to grounded conductor 348; (2) closes at its inner

right-hand armature and contact an operating circuit for gate relay 11G1; (3) closes at its outer right-hand armature and front contact a circuit traceable from battery, through the winding of relay 11SC1, front contact and outer right-hand armature of relay 11SA1, conductor 1101, through the all-trunks-busy circuit 11ATB (as shown in the copending application of W. V. K. Large et al., supra), back through conductor 1127, back contact and inner left-hand armature of relay 12TA, conductor 1211, to ground at the normally closed contacts of manual service key 1101, and relay 11SC1 operates. The operation of relay 11SC1 depends upon relay 12TA and the corresponding relay in each of the other groups of five trunks being in a non-operated condition. Also relay 11SA1, upon operating, opens at its back contact and outer right-hand armature a path extending over conductor 1105 to the operating circuit of the relays corresponding to relay 11SC1, in all succeeding groups of five subscriber lines. Relay 11SC2 is in the second group of five subscriber lines. This assures that even in the case of simultaneous origination of calls in two subscriber line groups only one 11SC relay will be operated.

The operation of gate relay 11G1 closes a circuit extending from grounded battery, through the winding of gate relay 11G, contact and armature of relay 11G1, to ground at the normally closed lower contacts of manual service key 1101 and relay 11G operates and thereby opens at each of its left-hand armatures the circuit of each of the subscriber station groups and at each of its right-hand armatures the circuit of each of the trunk groups. The subscriber group engaged in the inward call is held operated by the locking circuit of relay 11SA1.

Relay 11SC1, upon operating, (1) extends conductors 350 and 311 from the calling subscriber line terminating equipment over two paths, respectively, only one of which, namely, that including conductor 350, is at this time completed, its path extending over the contact and armature No. 4 of relay 11SC1, conductors 1106 and 1107, contacts and armature No. 2 of relay 11GA, conductor 1108, through the winding of relay 11U2, to grounded battery, and relay 11U2 operates to further extend the other path including conductor 311, over contact and No. 3 armature of relay 11SC1, conductor 1109, outermost upper armature and contact of relay 11U2, to conductor 1103 which is common to the selecting relays 11U1 to 11U5, inclusive. The selecting relays 11U1 to 11U5 are common to all subscriber groups and all trunk groups and are used for selecting the particular subscriber station line or particular trunk circuit. Relay 11U2, upon operating, (1) locks directly to ground at the outer lower armature and contact of lamp relay 3L2, the circuit being traceable from grounded battery through the winding of relay 11U2, front contact and inner lower armature of relay 11U2, back contact and inner lower armature of relay 11U1, conductor 1110, left-hand armature and front contact of relay 11GB, armature and No. 1 contact of relay 11GC, conductor 1111, innermost upper armature and back contact of relay 11U1, innermost upper armature and front contact of relay 11U2, conductor 1106, No. 4 armature and contact of relay 11SC1, conductor 350, to ground at the outer lower armature of lamp relay 3L2. (Relays 11GB and 11GC are operated at this time as hereinafter described.) (2) Extends conductor 1109 of the other path of subscriber station 202, over the outermost upper armature and front contact of relay 11U2, conductor 1103 to conductor 1302 and resistance 1301 for future effectiveness; (3) extends at its outer lower armature and contact, conductor 1113, through conductor 1114, and the contact and outer left-hand armature of relay 11GD, a function not useful at this time; (4) extends grounded conductor 1106, through the innermost upper armature and front contact of relay 11U2, back contact and innermost upper armature of relay 11U1, conductor 1111, through the left-hand winding of relay 11GB to grounded battery, whereby relay 11GB operates from the ground at the outer lower armature and contact of relay 3L2; (5) releases normally operated relays 11GF and 11GE because the operating circuit for relay 11GF is opened at the back contact and left-hand armature of relay 11GB, relay 11GB being of a differential type is normally maintained in a released condition although both of its windings having equal resistance values are normally energized; (6) causes through the release of relay 11GE the timing circuit of vacuum tube 1301 to start; and (7) connects ground at the No. 8 armature and contact of relay 11SC1, over its contact and outer lower armature to conductor 1114 for the future operation of relay 13LS1, that is, when relay 11GD operates.

Relay 11GB, upon operating, (1) operates relay 11GC in a circuit traceable from grounded battery and winding of relay 11GC, front contact and left-hand armature of relay 11GB, conductor 1110, inner lower armature and back contact of relay 11U1, inner lower armature and front contact of relay 11U2, conductor 1108, No. 2 armature and contact of relay 11GA, conductors 1107 and 1106, No. 4 armature and contact of relay 11SC1, to grounded conductor 350; and (2) removes ground at its contact and right-hand armature, from conductor 1115 which extends to the all-trunks-busy circuit and also to all the trunk circuits over contact and armature No. 9 of relay 4ST. Relay 11GC, upon operating, locks over its left-hand armature and contact in a circuit extending over conductor 1111, innermost upper armature and back contact of relay 11U1, innermost upper armature and front contact of relay 11U2, conductor 1106, armature No. 4 and contact of relay 11SC1 to grounded conductor 350. Relay 11GC, upon operating, also closes at its contacts No. 2 an operating circuit for relay 11GA which operates. Relay 11GA is what is known herein as the units gate relay which opens the operating circuit for all the relays 11U1 to 11U5. Relay 11GA, upon operating, closes at its outer left armature and contact an operating circuit for relay 11GD, the circuit being traceable from grounded battery, through the winding of relay 11GD, conductor 1116 to ground at the outer left-hand armature and contact of relay 11GE. 11GD, upon operating, (1) closes at its inner left-hand armature and contact a locking circuit for relay 11GA, which locks in an operated position; and (2) connects ground at its right-hand armature and contact to a path extending over conductors 1117 and 1118, contact and middle upper armature of relay 11U2, conductor 1119, to armature No. 4 of relay 12TC, a function not useful at this time; and (3) operates relay 13LS1 in a circuit traceable from ground at the No. 8 armature of relay 11SC1, conductor 1113, contact and outer lower armature of relay 11U2, conductor 1114, contacts and outer left-hand armature of relay 11GD, conductor 1120, through the winding of relay 13LS1, to grounded battery,

Relay 13LS1 operates and (1) closes an obvious operating circuit for relay 13H; (2) extends its own operating ground from conductor 1120 via its contact and right-hand armature and No. 1 armature and contact of relay 13H, to conductor 1304, outer right-hand armature and contact of relay 12AD, conductor 1211, through the winding of relay 4ST, to grounded battery; and (3) applies at its contact and outer left-hand armature an additional holding ground for relay 11GD, the circuit being traceable over conductor 1116, contact and outer left-hand armature of relay 11GA, through the winding of relay 11GD, to grounded battery.

Relay 13H, upon operating, extends the ground on conductor 1120 over the circuit just traced and start relay 4ST operates. The operation of start relay 4ST in the first idle trunk places a calling condition toward the large switching center and closes at its No. 3 armature and contact an operating circuit for relay 4W which operates. Relay 4W, upon operating, closes at its armatures and contacts, individual operating circuits for the cross bar switch selecting magnets associated with any one level in two or more cross bar switches connected in multiple. One of these selecting magnets may be controlled by the start relay in the all-trunks-busy circuit disclosed in the copending application of W. V. K. Large et al., Serial No. 462,966, supra. However, the cross bar switch selecting magnets 3SM—0 to 3SM—9 are shown with their armatures and contacts arranged to close an operating circuit for relay 13D which operates at this time. Relay 13H, upon operating as hereinbefore described, connects ground at its No. 5 armature and contact to conductor 1305 which extends over two parallel paths, one over conductor 1212 to an unoperated armature of relay 4SL and the other over conductor 1213 to an unoperated contact at the inner left-hand armature of trunk advance relay 12AD. Also, relay 13H, upon operating, connects ground at its armatures Nos. 2, 3 and 4 to paths similar to that of conductor 1305 extending to individual trunk circuits other than that shown herein in detail. At its armature No. 6 relay 13H, upon operating, connects ground to a path extending to the all-trunks-busy circuit, and at armature No. 7 connects ground to a path including conductor 1306 which serves as a shunt for resistance 1307 of relatively high value.

Relay 13D, upon operating, (1) furnishes at its No. 1 or left-hand armature and front contact an additional ground for holding relay 11GD operated; (2) closes at its No. 2 armature and contact an operating circuit for connection lamp 1308 which lights thereby indicating to the attendant at the small switching center that the line of the calling subscriber station 202 has been connected to an idle trunk; and (3) connects ground at its No. 3 armature and contact to a circuit traceable through resistance 1301, conductors 1302 and 1103, contact and outermost upper armature of relay 11U2, conductor 1109, through armature No. 3 and contact of relay 11SC1, conductor 311', through the winding of "hold" magnet 3H2, to grounded battery. "Hold" magnet 3H2 operates to complete the connection of the calling subscriber line to the first idle trunk. "Hold" magnet 3H2, upon operating, opens at its normally closed make-before-break contacts the operating circuit for calling-in, or lamp, relay 3L2 which releases to extinguish lamp 306. Relay 3L2, upon releasing, first removes ground at its inner lower armature and contact from the locking circuit of relay 11SA1 and relay 11SA1 releases; (2) removes ground at its outer lower armature and contact to open the locking circuit for selecting relay 11U2 which also releases; relay 11SA1, upon releasing, releases relay 11SC1 which, upon releasing, removes ground from its armatures Nos. 3, 4 and 8. Relays 11GB, 13LS1, 13H and 11GC release. Relay 11GB, upon releasing, connects ground at its right-hand armature and contact to a circuit traceable over conductors 1115 and 414, contact and armature No. 9 of start relay 4ST, conductors 415, 416 and 1214, through the winding of relay 12AD, to grounded battery and relay 12AD operates. A trunk advance relay, such as relay 12AD, is individual to each trunk circuit provided, assuming as in this case, that there are ten trunks provided on the cross bar switch in the link circuit, and that there is a trunk sequence circuit provided for each trunk circuit. The trunk sequence circuit shown in detail in Figs. 11 and 12 includes in addition to relay 12AD, relays 12DL, 12BO and 12DC together with the common selecting relays 11U1 to 11U5 and the gate, or G relays, such as relay 11G shown in Fig. 11. The last trunk sequence circuit of the chain may be connected with the all-trunks-busy circuit which may be connected, as hereinbefore stated, to two of the levels of the cross bar switch in the link circuit.

Relay 12AD, upon operating, (1) locks to ground in a circuit traceable over its inner left-hand armature and contact to ground at the lower armature and contact of relay 4SL, which is operated in series with "hold" magnet 3H2 after relay 11SC1 in the sequence circuit is released; (2) closes at its contact No. 5 one completing point in the operating path of a relay in the all-trunks-busy circuit, the circuit being traceable over conductor 1208, No. 5 contact of relay 12AD, conductor 1215, through the contact No. 5 of each of the relays corresponding to relay 12AD, to ground connection 1207 in the last trunk sequence circuit; (3) transfers conductor 1304 from the back contact of the outer right-hand armature of relay 12AD to the front contact so that should the trunk shown in Figs. 4 and 5 be busy the next call will be routed over conductor 1217, through the winding of the start relay, corresponding to relay 4ST, in the next idle trunk, the circuit over which the next call will be routed being extended over the outer right-hand armature and back contact of the "AD" relay in the trunk sequence circuit associated with the next idle trunk; (4) open at the back contact and outer right-hand armature and the contact and outer left-hand armature both the operating and the locking circuits, respectively, for start relay 4ST which at this time has already completed the initiation of the connection between the calling subscriber line and the selected trunk circuit as will be hereinafter further described. Relay 4ST releases.

Supervisory features

The supervisory features provided by the all-trunks-busy circuit, subscriber's line circuit and sequence miscellaneous alarms are described in a copending application of W. V. K. Large et al., Serial No. 462,966, supra.

Calling subscriber line circuit is connected to an idle trunk circuit

As hereinbefore stated, when a subscriber originates a call by operating the station power switch, the subscriber station terminating equipment makes use of the sequence circuit to secure connection to the first idle trunk. Relay 4ST, when it operated, (1) closed at its No. 4 armature and contact an operating circuit for relay STR which operated; (2) at its No. 6 armature and contact closed an operating circuit for relay 4RC which operated; (3) at its No. 7 armature and contact closed an operating circuit for relay 4STR which operated; (4) at its No. 2 armature and contact closed an operating circuit for relay 4—ON which operated; and (5) at its No. 3 armature and contact closed an operating circuit for relay 4W which operated as hereinbefore stated; and (6) closed at its No. 9 armature and contact an operating circuit for relay 12AD which operated to light busy lamp 418. Relay 5TR, upon operating, transfers at its outer lower armature trunk circuit 501 from one path which extends through resistance 531 of high value, and the winding of relay 5L, over conductors 541 and 503, to ground at the central office, to another path which extends over conductor 534 to the trunk side of the repeater, that is, the left-hand side of winding No. 3 of receive relay 5R. Relay 4STR, upon operating, added another ground to the operating circuit of relay 5TR and thereby increases the release time of relay 5TR after relay 4ST releases. This insures registration at the central office even though the call is quickly abandoned. Relay 4—ON, upon operating, (1) locks to a normal ground at the back contact and inner lower armature of relay 4D1 and (2) connects ground at its armature Nos. 1 and 2 to the winding of repeater relays whereby such windings are energized, armature No. 1 serving to energize the artificial line windings Nos. 2 and 5 of relay 5R and armature No. 2 serving to energize the lower or biasing line windings of both relays 5BK and 5S; (3) at its No. 5 armature completes the filament circuit for vacuum tube 419; and (4) connects at its No. 3 armature an additional ground to the operating circuit for relay 4SL.

Relay 4SL in an operated position, connected ground at its lower armature to conductor 1212 and at its upper armature closes an operating circuit for relay 4SL1 which operated.

"Hold" magnet 3H2, in an operated position, opens the operating circuit for calling-in relay 3L2 in the subscriber line circuit which dismissed the sequence circuit. The release of the sequence circuit connected ground at the right-hand armature of relay 11GB to a circuit traceable over conductors 1115 and 414, contacts and No. 9 armature of relay 4ST (before relay 4ST was released), conductors 415 and 416, through the winding of relay 12AD to grounded battery. The trunk advance relay 12AD operated to advance the next call to the next idle trunk and opened both the operating and the locking circuit for start relay 4ST which released, as hereinbefore stated.

The calling subscriber line circuit is now complete and ground on the winding of relay 4SP, normally closed contacts at tip spring of jack 436B, conductors 422 and 358, operated ring contact of set 355, conductor 359, outer left-hand armature and front contact of hold magnet 3H2, conductor 310, normally closed contacts at spring member of jack 308B, ring conductor R2 of the calling subscriber line, station circuit, back over the tip conductor T2, tip spring and its normally closed contacts of jack 307A, conductor 309, right-hand armature and front contact of hold magnet 3H2, conductor 367, operated tip contacts of set 355, conductors 365 and 366, normally closed contacts at the tip spring of jack 435A, conductor 423, outer upper armature and back contact of relay 4R3, conductor 424, through the upper windings, in series, of relays 5BK and 5S, armature and marking contact of receive relay 5R, conductor 535, to grounded battery 536. This places a marking condition on the trunk looking toward the large switching center because both relays 5BK and 5S are maintained in their marking positions, send relay 5S being effective to transmit the marking condition toward the large switching center. Relay 4SP operates and closes at its armature and contact an operating circuit for relay 4SP1, the circuit extending to ground on armature No. 3 of relay 4—ON. Relay 4SP1, upon operating, operates in turn relays 4SP2 and 4RC. Relay 4SP2, upon operating, furnishes at its outer upper armature and contact a ground to hold relay 5TR operated even though start relay 4SP is released, relay 4SP2 being held operated by slow-to-release relay 4SP1.

At the large switching center the end of the trunk which terminates at that point the marking condition applied by relay 5S results in the operation of relays 6P and 6C as will be hereinafter described in more detail.

The release of start relay 4ST effected the release of relay 4W which in turn effected the release of its corresponding selecting magnets. The selecting magnets, upon releasing, remove ground from the operating circuit of relay 13D, and relay 13D releases thereby extinguishing lamp 1308. Relay 11GE reoperated following the release of relay 11GD and 11GA. Thus all relays in Figs. 11, 12 and 13 are in their normal condition with the exception of relay 12AD and the sequence circuit is now ready to route a new call.

An outward call received at the large switching center

The call is received at the large switching center from a subscriber station through the small switching center.

As hereinbefore stated, a call originating at a subscriber station through the small switching center is effective at the large switching center to operate relay 6C in a circuit traceable over tip conductor 501, normally closed contacts at tip spring of jack 608, conductor 610, upper armature and back contact of relay 6E, resistance 611 through winding No. 1 of relay 6P, through winding No. 2 of relay 6R, resistance 612, retardation coil 613, through the upper winding of relay 6C, outer upper armature and back contact of relay 6C1 to ground. Relay 6C operates and closes at its upper armature a circuit traceable from grounded battery 1405, resistance 1406, conductor 1407, resistance 1416, conductors 1417 and 624, contact and armature of relay 6C, conductor 625, resistance 1429, through the winding of relay 14H, conductor 1419, to the marking, or right-hand, contact and armature of relay 6P to ground, and relay 14H operates. Relay 14H, upon operating, closes at its armature and contact an obvious operating circuit for relay 6C1 which operates. Relay 6C1, upon operating, (1) closes at its outer upper armature and front contact the transmission circuit to ground through resistance

626 at the marking, or right-hand, contact of relay 6S; (2) closes at its front contact and inner upper armature an obvious operating circuit for relays 6SA and 6DR; and (3) closes at its inner lower armature and contact an obvious operating circuit for relay 6CL. Relays 6CL, 6SA and 6DR operate. Relay 6SA, upon operating, (1) closes at its lower armature and contact an operating circuit for relay 14L, the circuit being traceable from ground, over conductor 627, No. 4 armature and back contact of relay 6SL, conductor 628, through the winding of relay 14L, to grounded battery and relay 14L operates to light call lamp 1413 and to place a ground on start conductor 1415 to the sequence circuit at the large switching center, and (2) applies at its upper armature and contact grounded battery 629 of positive 130 volts to a circuit extending over the normally closed contacts of the tip spring of jack 631B, ring conductor 632 to the link circuit at the large switching center. The operating circuit for call lamp 1413 may be traced from ground at the upper armature and contact of relay 14TS, contact and outer upper armature of relay 14L, through the lamp 1413, conductor 1418, through the winding of relay 18E, to grounded battery, relay 18E being in the master control circuit of the sequence circuit at the large switching center. Relay 6CL, upon operating, (1) locks up in a circuit extending to the No. 1 armature and contact of relay 14D2; (2) transfers the grid of vacuum tube 1419 from ground at the unoperated No. 5 armature and contact of relay 14D2 to ground at the outer lower armature and contact of relay 6CI; and (3) closed at its outermost upper armature and contact an operating circuit for relay 14BY, the circuit being traceable over conductors 633 and 1420 through the winding of relay 14BY to grounded battery. Relay 14BY upon operating (1) closes a circuit for energizing the vacuum tubes 1419 and 1421, (2) closes an operating circuit for relay 14AD and relay 14AD operates so that calls for the small switching center subscribers will be routed to the next idle trunk, and (3) applies negative potential from the grounded battery 1422 to a circuit extending over conductor 1423 to the sleeve of the make-busy jack 609MB associated with the trunk shown in Figs. 6 and 14 and located at the attendant test-board.

Sequence circuit at the large switching center secures an idle trunk extending to the central office

The connection of ground to conductor 1415 causes start relay 15ST—1 to operate. Relay 15ST—1, upon operating, closes an operating circuit for relay 15AL—1, the circuit for the latter relay being traceable from ground at the inner lower armature of relay 15AL1—G0, back contacts and armatures of relay 15ST—0, front contacts and armatures of relay 15ST—1, through the winding of relay 15AL—1, normally closed make-before-break contacts of relay 15AL—9 to grounded battery 1501. Relay 15AL—1, upon operating, locks in a circuit traceable from grounded battery 1501, make-before-break contact of relay 15AL—9, through the winding of relay 15AL—1, front contact and uper armature and lower armature and front contact of relay 15ST—1 to ground at the innermost upper armature and front contact of relay 15AL—1. Relays 15ST—1 and 15AL—1 are both individual to the line trunk shown in Figs. 6 and 14. Likewise relays 15ST—0 and 15AL—0 are both individual to another line trunk circuit extending to the small switching center or to a subscriber's line connected directly to the large concentrating unit switching center, such as subscriber station 634 or 635 shown in diagrammatic form. Likewise, relay 15ST—9 and 15AL—9 are both individual to a trunk extending to the small switching center or to another subscriber line local to the large switching center. Relay 15ST—1, upon operating, removes the chain ground from all the higher numbered ST relays, such as relay 15ST—9, and since conductor 1502 is receiving ground from the inner lower armature and contact of relay 15AL1—G0 and since all other ST relays of the particular subgroup are normal, or if the particular ST relay, such as relay 15ST—1 happens to be in a preferential position, the operation of an ST relay also causes its associated AL relay to operate, provided no other AL relay of that subgroup is operated. Therefore, since 15ST—1 is in a preferential position and is operated then relay 15AL—1 operates. The operation of relay 15AL—1 removes the chain battery 1501 from all lower numbered AL relays, such as relay 15AL—0 when relay 15AL—1 is operated. Thus when the ST and AL relays associated with the line trunk shown in Figs. 6 and 14 are operated, ground and grounded battery chain circuits of the subscriber line sequence circuit have been broken, preventing the operation of any other AL relay in that group. Relay 15AL—1 upon operating, in addition to locking under control of relay 15ST—1 connects grounded battery 1501 to a circuit traceable over the normally closed make-before-break contacts of relay 15AL—9, inner lower armature and front contact of relay 15AL—1, through the winding of 15ST1—G0 to ground at the normally closed contact of relay 15BO—G0. Relay 15AL—1, upon operating, also connects conductors 636 and 1423 of the trunk line terminating equipment shown in Figs. 6 and 14 to the subscriber group sequence circuit. If the particular group has not been removed from service, grounded battery on start conductor 1503 causes the operation of the associated relay 15ST1—G0. Here also, if no other ST—1 relay is operated, or if the particular ST—1 relay, such as relay 15ST1—G0, is in a preferential position, and if no AL relay in either the subscriber group sequence circuit, such as relay 15AL—G0, or trunk sequence circuit, such as relay 16AL—0 or relay 16AL—1, is in an operated position, the associated AL relay, that is, relay 15AL—G0, will function in a manner similar to the one described above for relay 15AL—1. When relay 15ST1—G0 and 15AL—G0 of the group associated with the trunk circuit equipment shown in Figs. 6 and 14, having operated, permission to route the outward call to the large switching center has been received. The circuit for operating relay 15AL—G0 may be traced from grounded battery at the armatures and back contact of relay 25SU, conductor 2506, through the winding of relay 15AL—G0, front contact and lower armature of relay 15ST1—G0, through the back contact and lower armature of each of relays 15ST1—G0 to 15ST1—G9, inclusive, conductor 1505, back contact and lower armature of each of relays 16ST2—0 to 16ST2—9 and 17ST2—10 to 17ST2—19, conductor 1701, outer lower armature and back contact of relay 25D, back contact and inner upper armature of relay 25CS to ground and relay 15AL—G0 operates. Relay 15AL—G0, upon operating, causes the operation of relay 15AL1—G0, in an obvious operating circuit. The operation of relay 15AL—G0 also closes a circuit

extending from grounded battery at the lower armature and contact of relay 25SU in the miscellaneous alarm circuit, over conductor 2506, upper armature and front contact of relay 15AL—G0, conductor 1506, outer lower armature and front contact of relay 15AL—1, conductor 1507, through the winding of relay 18LS—1, to ground and relay 18LS—1 operates. Relays 18LS—1 and 18LS1—1 are provided for a single outlet of a group of trunks extending to one central office whereas relays 18LS—2, 18LS1—2 and 18TR are provided for a double outlet, that is, for a second group of trunks which extend to a second central office. The line trunk described herein as extending from the small switching center is arranged for connection to the single, or first, outlet of a group of trunks extending to the first central office.

Should an inward call and an outward call be received in the sequence circuit simultaneously, the inward call, that is the call coming from a central office would have preference of selection in the sequence circuit. It will be noted, therefore, that when the subscriber group sequence circuit is operated, the ST2 relay of each main trunk must be in an idle condition as hereinbefore described in tracing the circuit that included the lower armature and back contact of relay 16ST2—0. Relay 15AL—G0, upon operating to close the operating circuit for relay 18LS—1, closes a locking circuit for itself extending to ground at the inner upper armature and contact of relay 15ST1—G0. Relay 15AL1—G0, upon operating, (1) removes ground at its inner lower armature and contact from the operating circuit of relay 15AL—1 of the associated subscriber line sequence circuit connected to the calling trunk, (2) connects at its outer lower armature and contact the winding of "busy out" relay 15BO—G0 for future operation and (3) connects at its outer upper armature and contact, conductor 1508 which extends over the outermost upper armature and contact of relay 15AL—1, to the busy back conductor 1423 connected to grounded battery, through the winding of relay 14BB, and (4) connects at its inner upper armature and contact, conductor 1507 which extends over the middle upper armature and contact of relay 15AL—1 to the holding conductor 636.

Relay 18LS—1, upon operating, connects ground at its outer left-hand armature to the operating circuit of relays 18H—0, 18H—1, 18H—2, etc. These H relays, upon operating, in turn place individual ground for each group of trunk relays, the ground being furnished to the chain and advance circuit composed of an AD and a CH relay of each group, such as relay 16AD—0 and 16CH—0 of the first trunk holding that circuit in a fixed condition during the entire interval that an outward call is being routed through the concentrating unit, or in other words, for the duration of the call. In addition, in the case where a double outlet of trunks is employed, for instance, where one group of trunks extend to one central office and another group of trunks extend to a different central office, relay 18LS—2 being associated with the second trunk group in the unit, the operation of relay 18LS—2 will cause the operation of the associated transfer relay 18TR, if provided. Relay 18TR, when provided, is designed to alter the chain circuit to permit the selection of trunks first in the preferred trunk group and to seek selection of trunks in the other subgroup of trunks only if all trunks in the preferred group are busy.

Therefore, not only is the trunk chain circuit placed in a fixed condition by the operation of relays 18H—0, 18H—1 and 18H—2, etc., but if the order of selection was to have been changed, relay 18TR has accomplished this function before the start conductor to the trunk chain and advance circuit is called into use. The operation of relay 18H permits the operation of the LS—1 relay associated with the particular LS relay, for example, relay 18LS1—1 associated with relay 18LS—1 and relay 18LS1—2 associated with relay 18LS—2, which causes the operation of relays 18H—0, 18H—1, 18H—2, etc. The LS—1 relay operated, places ground on the start conductor, say conductor 1801, at a place in the trunk chain and advance circuit where there is available the first numbered trunk of the group of trunks associated with either relay 18LS—1 or relay 18LS—2. The operation of an LS—1 relay also results in the operation of start relay 25ST and finally in the operation of the common start relay 25CS in the miscellaneous alarm circuit, and furnishes a locking ground for relays 18H—0, 18H—1, 18H—2, etc., to insure that the trunk chain and advance circuit will be kept in a fixed condition until the routing of the call has been completed. Relay 25CS of the miscellaneous alarm circuit, when operated, removes the main chain ground on conductor 1701 from both the trunk sequence and subscriber group sequence circuit.

Establishing connection at the large switching center of a call from a subscriber station connected to the small switching center

Relay 18LS1—1, upon operating, connects its operating ground to the start conductor 1801 at such a place in this trunk chain as to permit selection of the first idle trunk in the trunk group desired. Should another trunk group be desired such as that which is provided in a double outlet system ground would be connected to a conductor of the trunk at such a place in the trunk circuit as to permit selection of the first idle trunk in the trunk group of the second outlet. This ground on the start conductor, say start conductor 1801, will be connected by means of the back contact of the first CH relay in the trunk chain to the associated idle trunk circuit, for example, should the trunk shown in Figs. 8 and 9 be the first idle trunk of the group desired, grounded start conductor 1801 would be extended over the inner lower armature and back contact of relay 16CH—0, conductor 1601, through the winding of trunk start relay 8ST to grounded battery and the trunk circuit shown in Figs. 8 and 9 will begin to function. A "mark" signal will be sent to the central office and an automatic ringing current signal will be returned from the central office as a verification that the "mark" signal has been received, and to make a preliminary test for trunk conductor failure. Thereafter the trunk circuit will function in conjunction with the link circuit and miscellaneous alarm circuit.

A brief review of the foregoing with additions to clarify the description of the operation will now be given. A calling subscriber at station 202, upon originating a call, causes ground to be connected to the winding of the ST relay, such as relay 15ST—1 individual to the calling line trunk extending from the small switching center. Ten ST relays, together with their respectively associated AL relays, form a subscriber line or line trunk sequence group, relays 15ST—1 and 15AL—1 are individual to a calling line trunk extending

to the small switching center. The number of groups that are provided depend upon the size of the office. Each subscriber line sequence group is associated with an ST—1 and an AL relay in the subscriber group sequence circuit. For example, in the first group of subscriber lines there is associated relays 15ST1—G0 and 15AL—G0. Ground from the group sequence circuit is connected to the armature of an ST relay associated with the lowest numbered subscriber line of the group, and is then connected in series with the other ST relays of the group. Grounded battery, such as battery 1501 for the first group of subscribers' lines, is connected to the winding and armature of the AL relay associated with the last line of the group and is then connected in series to the other AL relays of the group. This arrangement of the ground gives the preference of placing a call to the lowest numbered line of the group, while the arrangement of grounded battery permits the operation of only one AL relay at a time, thus preventing the routing of more than one call from the group at a time. Operation of relay 15ST—1, provided no lower numbered ST relay is operated, results in the operation of its associated relay 15AL—1, provided no higher numbered AL relay is operated. Relay 15AL—1 locks to relay 15ST—1, causing the operation of relay 15ST1—G0 of the subscriber group sequence circuit and preventing the subsequent operation of any lower numbered AL relay even though its associated ST relay operates in response to placing a call. The busy-back conductor 1423 and the hold conductor 636 from the calling line are connected through the subscriber line sequence circuit on the contacts and armatures of relay 15AL—1 and thence to the subscriber group sequence circuit. Grounded battery and ground from the miscellaneous alarm circuit are carried through the ST—1 and AL relays of the subscribers' group sequence circuit and the ST—2 and AL relays of the trunk sequence circuit in the same manner as outlined above for the subscriber line sequence circuit, thus giving the preference of placing a call to the lowest numbered trunk, and after all trunks to the group of subscribers' lines in the order of their appearance in the group sequence circuit. Operation of an ST—1 relay of the subscriber group sequence circuit, if no ST relay, or lower numbered ST—1 relay is operated, results in the operation of its associated AL relay, if no higher numbered AL relay is operated. Relay AL locks to relay ST—1 and causes the operation of relay LS in Fig. 18. Relay AL operates an auxiliary relay, such as relay 15AL1—G0 of the first subscriber line group sequence circuit, which relay extends conductors 1423 and 636 through the group sequence circuit to the all-trunks-busy circuit and miscellaneous alarm circuit, respectively. The purpose of conductor 1423 is to permit the operation of busy-back relay 14BB if all trunks are busy. The operation of either relays 18LS—1 or 18LS—2 connects ground to the armature of a CH relay in each trunk sequence group, thus permitting the release of any previously operated CH and AD relays while this call is being routed. Either of relays 18LS—1 and 18LS—2 also connects ground to the start conductor extending to the first idle trunk which is marked by non-operated CH and AD relays, operating the ST relay of the idle trunk circuit. This causes a marking signal to be sent from relay S of the first idle trunk, such as relay 8S for the trunk shown in Figs. 8 and 9, to the central office where it operates an RS relay, such as relay 10—RS in the trunk shown in Fig. 10, to its marking position.

When the start relay 8ST of the first idle trunk is operated as hereinbefore described it (1) causes relays 8L and 8S of the repeater to operate to their marking or right-hand, positions in a circuit traceable from ground at its No. 4 armature and contact, conductor 808, through the lower windings in series of relays 8S and 8L, transmission conductor 809, normally closed make-before-break contacts of relay 9TR, to grounded positive battery 901, (2) operates the off-normal relay 8—ON in a circuit traceable from ground at its No. 7 armature and contact, conductors 810 and 811 through the winding of relay 8—ON to grounded battery, (3) locks up at its No. 5 armature and contact in a circuit traceable from conductor 812, back contact and inner upper armature of relay 16AD—0, conductor 1610, contact and No. 7 armature of relay 8ST to ground, (4) lights the trunk-busy lamp 813 in a circuit traceable over conductor 814, No. 6 armature and contact, conductor 815, back contact of inner lower armature of relay 16BO—0 to grounded battery, and (5) after relay 8—ON operates places a ground located at the contact and No. 4 armature of relay 8—ON in a circuit traceable over conductor 816, outer lower armature and back contact of relay 8SL—1, outer lower armature and back contact of relay 8R2, contact and No. 1 armature of relay 8ST to conductor 801 which extends to the miscellaneous alarm circuit to warn the latter circuit that verification ringing has been requested from the central office. Relay 25TK responds to this warning.

Relay 8—ON upon operating (1) energizes the filament of the vacuum tubes 902 to 906, inclusive, in a circuit traceable from ground at its No. 6 armature and front contact, conductor 817, through the filament of vacuum tubes 902 to 906, in series, conductor 907 to grounded battery 908, (2) connects power to the loop repeater in a circuit traceable from ground at the contact and No. 5 armature of relay 8—ON, conductors 818 and 909, through the upper windings, in series, of relays 8S and 8L, conductor 809, normally closed make-before-break contacts of relay 9TR, to grounded battery 901 and in a second circuit traceable from ground at the No. 2 armature and contact of relay 8—ON, conductor 819, through the lower winding of relay 9R, inner upper armature and back contact of relay 9TR, conductor 910 to grounded battery 820, (3) connects ground at its No. 1 armature and contact to a circuit traceable over conductor 821, and through the winding of relay 8SL for future operation, (4) transmits the "mark" signal created by relay 8S to the central office in a circuit traceable over its contact and No. 3 armature, and (5) supplies the ground for conductor 801 extending to the miscellaneous alarm circuit as hereinbefore referred to in describing the function of start relay 8ST. The reception of a mark current at the central office as a calling-in signal causes that end of the trunk circuit to function to send to the large switching center a 20-cycle ringing current signal.

The vibration of the armature of relay 9TL in response to the 20-cycle ringing signal received from the central office, has no effect upon the vacuum tube circuit but the vibration of the armature of relay 9R causes the operation of relay 8R—1 in a circuit traceable from the armature of relay 9R, conductor 912, innermost lower armature and contact of relay 9TR, conductor

913, condenser 822, through the winding of alternating current relay 8R—1 to ground. Relay 8R—1, upon operating, closes a circuit extending from ground at the No. 3 armature and contact of relay 8ST, conductors 823 and 824, contact and armature of relay 8R—1, through the winding of relay 8R—2 to grounded battery and relay 8R—2 operates. Relay 8R—2, upon operating, (1) removes the ground from conductor 801 which is hereinbefore stated as extending through the miscellaneous alarm circuit, the removal of ground giving an indication that verification ringing current has been received, (2) causes the operation of relay 8M in a circuit traceable from ground at the contacts and No. 4 armature of relay 8—ON, conductor 816, outer lower armature and back contact of relay 8SL—1, outer lower armature and front contact of relay 8R—2, conductors 825 and 826, lower normally closed contacts of jack 802, through the winding of relay 8M, to grounded battery. Relay 8M, upon operating, causes all the selecting magnets located on different cross bar switches and associated with this first idle trunk to operate. Selecting magnet 7SM—1, upon operating, prepares this first idle trunk with which it is associated for a connection with the calling line, or line trunk, as the case may be. The selecting magnets connect ground to a circuit traceable over conductor 701, through the winding of relay 25D in the miscellaneous alarm circuit to grounded battery and relay 25D operates. Relay 25D which is of the slow-acting type, upon operating, orders the sequence circuit to operate hold magnet 7H3 of the link circuit, hold magnet 7H3 being associated with the calling trunk. The operating circuit for hold magnet 7H3 may be traced from grounded battery, through the winding of magnet 7H3, conductors 702 and 636, contact, and middle upper armature of relay 15AL—1, conductor 1507, contacts and inner upper armature of relay 15AL—1—G0, conductor 1509, normally closed contacts of relay 25F through the winding of relay 25E, to ground at the contacts and inner lower armature of relay 25D.

In earlier designs of the cross bar switch, such as that used in the link circuit, the directing finger actuated by the selecting magnet, chatters considerably on being operated. To prevent the hold magnet from functioning while the directing finger is chattering, ground for the operation of the hold magnet is delayed for a short period. The operation of the selecting magnet of the cross bar switch places a ground on the off-normal conductor 701 which extends through the miscellaneous alarm circuit causing therein the slow operation of relay 25D, which is of the slow-acting type. Relay 25D, upon operating, closes at its inner lower armature and contact the operating circuit for hold magnet 7H3 and relay 25E; both relay 25E in the miscellaneous alarm circuit and hold magnet 7H3 in the link circuit operate. Relay 25D, upon operating, closes at its outermost upper armature and contact the operating circuit for connection lamp 2503 which becomes illuminated as an indication that the selecting magnets have operated. Relay 25E, upon operating, causes the slow-operating relay 25F to operate locking to ground on relay 25D. Relay 25F, upon operating, removes the shunt path around resistance 2508 which now becomes part of the operating circuit for hold magnet 7H3 and relay 25E. The hold magnet 7H3 meanwhile has closed its locking contact and therefore locks in series with relay 8SL of the trunk circuit. When the selecting magnets return to normal ground is removed from the off-normal conductor 701, relay 25D releases, releasing relay 25F and also relay 25E if it has not already released, extinguishing the connection lamp 2503.

Hold magnet 7H3, upon operating, connects the calling trunk to the first idle main trunk circuit shown in Figs. 8 and 9 and inasmuch as the hold magnet has locked in series with relay 8SL of the main trunk circuit which in turn caused the operation of relay 8SL—1 and the grounding of the hold chain conductor 827. Relay 8SL—1, upon operating, causes the release of relay 8M which, upon releasing, causes the selecting magnet, such as magnet 7SM—1 to release. Meanwhile grounded battery 629 which is connected to the ring conductor 632 has been applied to a path extending over conductor 703, ring contact of operated set 704, ring conductors 705 and 706, normally closed contact at tip spring of jack 803B through the upper winding of relay 8SP, to ground and relay 8SP operates which in turn operates relay 8SP—1. Relay 8SP—1, upon operating, (1) closes at its No. 5 armature and contact an obvious operating circuit for relay 8RC which operates, and locks up under control of relay 8R2, preventing the start of automatic ringing on the calling line, (2) furnishes at its No. 4 armature and contact an additional ground for holding relay 8—ON operated and (3) closes at its No. 1 armature and front contact a locking circuit for itself extending over conductor 828, outer lower armature and contact of relay 8SB—1 to ground at the No. 5 armature and contact of relay 8—ON. Relay 8RC, upon operating, opens at its upper armature and contact a circuit extending from interrupter 829, No. 6 armature and contact of relay 8A which at this time is in an unoperated position, contact and upper armature of relay 8RC, contact and outer upper armature of relay 8SL—1, back contact and inner lower armature of relay 8R2 which at this time is in its operated position, armature and back contact of relay 8BL—1, No. 2 armature and back contact of relay 8SP—1 which at this time is in its operated position, through the winding of relay 8R3, to grounded battery which circuit when completely closed permits relay 8R3 to operate under the influence of the interrupter 829.

In the meantime hold magnet 7H3, upon operating, connects ground at the inner right-hand armature and contact to a circuit traceable over conductor 707, and then over two parallel paths one extending through the winding of relay 6SL—1 and the other extending through the winding of relay 6SL to grounded battery and relays 6SL—1 and 6SL operate. Relay 6SL, upon operating, (1) releases line relay 14L to extinguish call lamp 1413 and to open the start circuit of relay 15ST—1 of the calling line sequence circuit, (2) closes at its No. 4 armature and front contact a circuit traceable over conductor 637, through the winding of relay 14C2 to grounded battery and relay 14C2 operates, (3) closes at its No. 1 armature and contact the transmission circuit to the tip conductor 638, normally closed contacts at tip spring of jack 630, conductor 639, tip contacts of the operated set 704 in the link circuit, tip conductor 708 of the first idle trunk, (4) connects grounded battery 1405 in a circuit traceable over conductor 1424, contact and No. 5 armature of relay 6SL, conductor 640, through the winding of relay 14F and

resistance 1425, and (5) provides ground at its No. 2 armature and contact for the locking circuit of relay 6DR. Relay 6SL1, upon operating, (1) removes one of the two ground connections from the grid of vacuum tube 1421, (2) connects ground to the grid element of vacuum tube 1419, the connection being established at its No. 1 armature and contact, (3) connects at its No. 5 armature and contact a ground connection to windings Nos. 1 and 2, in parallel, of relay 14TC, and (4) connects ground at its No. 1 armature and contact to a circuit traceable over the No. 5 armature and front contact of relay 6CL, back contact and lower armature of relay 6TA, through the winding of relay 14TB, to grounded battery and relay 14TB operates. Relay 14C2, upon operating, will (1) open at its lower normally closed make-before-break contacts the energizing circuit for winding No. 4 of receive relay 6R to permit the latter relay to operate to its marking contact under control of the marking line current received over conductor 501 from the small switching center, (2) connects at its outer upper armature and contact the biasing winding of relay 6S to resistance 641 to form the apex circuit, the biasing path of the apex circuit being traceable over conductor 642, outer upper armature and contact of relay 14C2, conductor 1409, through the biasing, or lower, windings, in series, of relays 6S and 6S1, to a point in a potentiometer extending at one end through resistance 619 to ground and at the other end through resistance 651 to grounded battery 652, (3) opens at its inner upper armature and contact the operating circuit of alternating current relay 14R1, and (4) closes at its inner lower armature and contact the alternating current operating circuit of relay 14H to hold the latter relay operated from the contacts of relay 6P, the alternating current operating circuit being traceable from grounded battery 1405, resistance 1406, conductor 1407, resistance 1416, contact and inner lower armature of relay 14C2, condenser 1425, resistance 1426, conductor 1427, resistance 1429, through the winding of relay 14H, conductor 1419, to the marking contact of relay 6P. Relay 14H is held operated in the following manner: during the interval when relay 6P is on its marking, or right-hand, contact and the contact of relay 6C is open, resistance 1428 and the right-hand terminal of the winding of relay 14H is grounded. Grounded battery permitting current to pass through resistance 1416 and the front contact and inner lower armature of relay 14C2, charges condenser 1425 and the current through resistances 1426 and 1429 and winding of relay 14H, to ground on the marking, or right-hand, contact of relay 6P, holds relay 14H operated. When relay 6P operates to its spacing, or left-hand, contact one side of condenser 1425 and resistance 1416 reverses and continues to hold relay 14H operated. During the long marking or spacing signal, relay 6C operates to hold relay 14H operated.

Grounded battery 629 of say positive 130 volts, flowing in a circuit extending over resistance 642, upper armature and contact of relay 6SA, normally closed contact of the tip spring of jack 631, ring conductor 632, will operate the "SP" system of relays, such as relays 8SP and 8SP1. This closure of the tip conductor 639 and ring conductor 632 will cause relays in the trunk circuit shown in Figs. 8 and 9 to send a call over the trunks extending to the distant central office. When the operator at the central office answers the circuit is complete and ready for transmission.

Relay 14L, upon releasing, opens at its inner upper armature and contact the operating circuit for start relay 15ST—1 which releases. Relay 15ST—1, upon releasing, opens at both its armatures the locking circuit for relay 15AL—1 which also releases. Relay 15AL—1, upon releasing, opens at its inner lower armature and front contact the operating circuit for 15ST1—G0 and the latter relay releases. Relay 15ST1—G0 opens at its lower armature and front contact the operating circuit for relay 15AL—G0 which also releases. Relay 15AL—G0, upon releasing, opens at its upper armature and front contact the operating circuit for relay 18LS—1 which releases and at its outer lower armature and front contact the operating circuit of relay 15AL1—G0 which also releases. Relay 15AL1—G0, upon releasing, opens at its outer upper armature and contact the circuit including the busy-back conductor 1508 and at its inner upper armature and contact the circuit including "hold" magnet conductor 1507. However, hold magnet 7H3 does not release because it is held operated in a circuit extending over the sleeve contact of operated set 704, conductor 701, through the winding of relay 8SL, conductor 821, to ground at armature No. 1 and contact of relay 8—ON. Relay 18LS—1, upon releasing, causes the release of the associated transfer relay 18TR, if used, returning the trunk chain to its originally predetermined order, at the same time closing the chain circuit on its back contact and left-hand armature to connect ground to trunk advance conductor 1803 which extends over armature No. 8 and contact of start relay 8ST, conductor 861, through the winding of relay 16CH—0 to grounded battery. Advance conductor 1803 is connected in multiple to all trunk circuits. In only one of these trunk circuits is this ground at the left-hand armature of relay 18LS—1 effective and that is the trunk circuit which has just been selected by the calling line. The extension of this ground over conductor 861 causes the operation of relay 16CH—0 which, upon operating, extends the ground through the winding of relay 16AD—0 to grounded battery and relay 16AD—0 operates; relay 16CH—0 and 16AD—0 are locked up in a circuit extending over conductor 827, to ground at the lower armature and contact of relay 8SL and are so locked for the duration of the call. Relays 16CH—0 and 16AD—0, upon operating, cause trunk chain conductor 1801 to be advanced to the next idle trunk, the trunk advance being effected at the lower armature of relay 16AD—0. Relay 16AD—0, upon operating, opens at its inner upper armature and contact the holding circuit for relay 8ST and closes at its outer upper armature and contact its own link in the link chain conductor 1602. If the link chain conductor 1602 associated with a group of trunks is completely closed ground is extended to the all-trunks-busy circuit shown in Fig. 22 over conductors causing the latter circuit to time the interval that the condition persists. In the all-trunks-busy circuit conductor 1602 terminates grounded battery, through the winding of relay 22A which operates and connects the 60IPM interrupter 1429 to the magnet 22NCA of the register for the first group of trunks therefore registering the number of seconds that all trunks of the group are busy, and at the same time closes at its right-hand armature its portion of the operating circuit of

relay 14L which, when operated, initiates the sending of "letters" signals over the calling line when all trunks in all groups are busy.

Relay 16CH—0, upon operating, (1) removes at its inner lower armature and contact the holding ground from the winding of relay 18LS1—1 and thereby causes its release, and (2) connects grounded battery in a circuit extending over the inner lower armature and back contact of relay 16BO—0, conductor 815, contact and outer lower armature of relay 16CH—0, conductor 814, trunk-busy lamp 813 to ground, which lamp now lights. Relay 18LS1—1, upon releasing, releases relays 18H—0, 18H—1, 18H—2, etc. The release of relays 18H—0, 18H—1, 18H—2 removes the individual holding grounds from the CH relays of all the trunk circuits, such as relay 16CH—0 for the first trunk, thus permitting any CH relay that was in position to do so to release, removing the "fixed" condition of the trunk chain circuit which had been in force throughout the entire routing of the call. The holding circuit for relay 16CH—0 extends over the front contact and upper armature of the relay, conductor 1604 to ground at the contact and outer left-hand armature of relay 18H—0. Relay 18LS1—1, upon releasing, also causes the release of relay 25CS in the miscellaneous alarm circuit through the release of relay 25ST also in the miscellaneous alarm circuit, the release of relay 25ST being effected at the right-hand armature and contact of relay 18LS1—1. Relay 25CS, upon releasing, replaces the ground connection on the entire chain of lines and trunks at the large switching center. The trunk sequence and subscriber or calling line sequence circuits have thus been returned to normal and to a condition that will permit the routing of another call in either direction. Upon the completion of the thus established call, the locking ground that holds relays 16CH—0 and 16AD—0 operated will be removed permitting their release providing an auxiliary path is not being temporarily furnished by relay 18H—0, 18H—1, 18H—2, etc. Upon removal of any such temporary holding path relays 16CH—0 and 16AD—0 release returning the entire sequence circuit to normal.

In single outlet switching centers when the AD and CH relays, such as relays 16AD—0 and 16CH—0 for the first trunk, are operated, ground produced by an LS1 relay, such as relay 18LS1—1 representing a single outlet of trunks, is connected by means of the trunk chain to conductor 1804 of the all-trunks-busy circuit, the trunk chain being traceable from grounded battery, through the winding of relay 22ST in the all-trunks-busy circuit, conductor 1804, back contact and left-hand armature of relay 18TR, conductor 1703, contact and lower armature of each of the AD relays, in series, of the tenth to the nineteenth trunks, inclusive (represented in Fig. 17), conductor 1802, back contact and right-hand armature of relay 18TR, conductor 1605, contact and lower armature of each of the AD relays, in series, of the zero to the ninth trunk, inclusive (represented in Fig. 16), conductors 1801 and 1808, inner left-hand armature and contact of relay 18LS1—1 which when operated extends the circuit over the contact and right-hand armature of relay 18LS1—1 to ground at the inner right-hand armature and contact of relay 18H—0. The grounded trunk chain is also produced in a double outlet switching center arranged to permit overflow of calls from one outlet to another. In the double outlet non-overflow switching center the LS—1 relay associated with one outlet connects ground to the trunk chain conductor 1804 of the all-trunks-busy circuit associated with that outlet as soon as all AD and CH relays in the trunk sequence circuit associated with that outlet are operated. The all-trunks-busy circuit functions to produce a special typewriter character signal such as "letters" and transmits that signal to the line circuit of the particular subscriber calling, the character being recorded on the typewriter at the subscriber's station. The calling line circuit meanwhile operates to disconnect ground from the start conductor 1415, as hereinbefore stated, causing the release of the subscriber line sequence circuit, the group sequence circuit and all other relays that were operated as a result of this call. The all-trunks-busy circuit meanwhile continues to produce the teletypewriter character and continues to be connected to the subscriber line circuit until the subscriber releases.

Sequence circuit to all-trunks-busy circuit

If the sequence circuit finds that there are no trunks available as when ground is connected to trunk chain conductor 1804 to operate relay 22ST in the all-trunks-busy circuit, the ground connected at the right-hand armature and contact of relay 22ST is extended over busy-back conductor 2202, outer upper armature and contact of relay 15AL1—G0, conductor 1508, outermost upper armature and contact of relay 15AL—1, conductor 1423, through the winding of relay 14BB to grounded battery and relay 14BB operates. Relay 14BB, upon operating, (1) locks at its inner upper armature and front contact in a circuit extending over the inner upper armature and front contact of relay 14L, to ground at the upper armature and contact of relay 14TS, (2) closes at its outer lower armature and contact an operating circuit for relay 14C2, (3) closes at its outer upper armature and contact the transmission circuit to the all-trunks-busy circuit through resistance 1430, and (4) applies at its inner lower armature and contact grounded battery to conductor 1431 which extends to the winding of relay 22C to ground. Relay 22C operates to start the all-trunks-busy circuit which generates a busy signal and will transmit this busy signal over conductor 2203 of the transmission circuit, contact and outer upper armature of relay 14BB, conductor 1432, through the upper windings, in series, of relays 6S1 and 6S, armature and marking, contact of relay 6R to ground and relay 6S repeats this busy signal to trunk conductor 501 for transmission to the calling subscriber station connected to the small switching center. The calling subscriber will disconnect when the busy signal is received and the disconnection causes relays 6C, 14H, 6C1, 6DR, 6SA, 14L, 14C2, and 14BB to release to restore the trunk circuit equipment of the trunk extending to the small concentrating switching center to the normal idle condition.

Idle trunk available

Should the trunk shown in Figs. 8 and 9 be idle at the time of an incoming call over trunk conductor 501 and is therefore selected for the purpose of completing the connection to the central office, the following relays would have operated in response to the selection: Relays 8—ON, 8R1, 8R2, 8SL, 8SL—1, 8SP, 8SP—1, 8S and 8L. Relays 8SP—1, 8S and 8L are operated to their marking, or right-hand, positions under control

of the calling line, relays 9TL and 9R following the ringing current which is being received from the central office while a steady marking is being sent to the central office.

Call received at the central office from the large switching center

In establishing a connection at the large switching center in response to a call from a subscriber station connected to the small switching center a marking signal is impressed on trunk transmission conductor 914 as hereinbefore stated. However, when the trunk extending from the large switching center to the central office is in its idle, or spacing, condition relay 10—RS is in its spacing, or right-hand, position and keeps condenser 1001 discharged. When the marking signal is impressed on the trunk transmission conductor 914 condenser 1001 becomes charged and the filaments of vacuum tubes 1002 to 1006, inclusive, will become energized. When a marking signal in excess of one-half second is received as a result of a call, condenser 1001 will charge sufficiently to cause vacuum tube 1003 to become active, or conductive, that is, draw plate current and operate relay 10—C which in turn will operate relay 10—CT. The circuit for energizing condenser 1001 is traceable from grounded battery 1008, resistance 1021, conductors 1009 and 1010, resistances 1011 and 1012, condenser 1001 to ground. The charge at condenser 1001 is effective over conductor 1013 and the grid element of vacuum tube 1003 to cause current to flow through the winding relay 10—C from grounded positive battery 1008, through the filament of vacuum tube 1004, outermost upper armature and back contact of relay 10—E1, to ground at the marking contact and armature of relay 10—RS. Relay 10—CT, upon operating, opens at its outer lower armature and contact the spacing contact circuit of relay 10—RS so that when relay 10—RS returns to its spacing condition vacuum tube 1003 will remain conductive. Also relay 10—CT, upon operating, removes at its outer upper armature and contact the shunt circuit around the upper winding of relay 10—R so that relay 10—R is conditioned to follow signals received over conductor 914 of the outward transmission path. Relay 10—CT, upon operating, closes a circuit extending from grounded battery 1014, contact and inner lower armature of relay 10—CT, conductor 1015, through the winding of relay 10—TR, to ground and relay 10—TR operates. Relay 10—TR, upon operating, will lock and operate relay 10—ON which, upon operating, applies power to the repeater and operates relay 10—BY. Relay 10—BY, upon operating, closes at its outermost lower armature and contact an operating circuit for busy lamp 1016 at each of the appearances of the trunk at the operator's switchboard. Also relay 10—BY, upon operating, closes at its upper armature and contact a ground connection whereby the filaments of vacuum tubes 1002 and 1002 are energized independently of the marking contact and armature of relay 10—RS, and at its middle lower armature and contact applies a grounded potential to the sleeve of jack 1007 which affords the means for making the trunk circuit busy. Meanwhile, the vacuum tube filaments being energized, vacuum tube 1002 functions because of a potential on condenser 1017 after relay 10—RS moves over to spacing contact, the potential being applied over a circuit traceable from grounded positive battery 1008, resistance 1021, conductors 1009 and 1010, resistance 1034, conductor 1035, condenser 1017 to ground. Vacuum tube 1002 became conductive prior to the operation of relay 10—ON. The conductivity of vacuum tube 1002 causes relay 10—A to operate which relay, upon operating, causes the operation of relay 10—A1 and the source 1018 of 20-cycle alternating current to become connected to conductor 915 of the inward transmission path through the joint operation of relays 10—ON and 10—A1. Relay 10—ON, upon operating, locks through the back contact and innermost upper armature of relay 10—E1 and transfers at its No. 6 armature, condenser 1019 from ground to a high resistance charging path extending through resistances 1020 and 1021 to ground battery 1008. When condenser 1019 has charged for a period of one-half second, vacuum tube 1006 will become conductive to operate relay 10—E which, upon operating, will operate relay 10—E1. Relay 10—E1 upon operating closes a circuit at its middle upper armature and front contact for operating relay 10—L, the circuit being traceable from ground at the innermost lower armature and back contact of relay 10—SL, conductor 1022, lower armature and contact of relay 10—A1, inner upper armature and contact of relay 10—CT, contact and middle upper armature of relay 10—E1, through the winding of relay 10—L, to grounded battery. Lamp relay 10L, (1) operates to light line lamp 1023 at each appearance of the trunk in the operator's switchboard, (2) closes a circuit for operating the night alarm 1024, and (3) places a grounded potential on the tip spring of make-busy jack 1007.

Subscriber abandons the call

If the subscriber abandons the call before the operator answers, the outward path comprising conductor 914 will be returned to spacing and relay 10—RS will operate to its spacing, or right-hand, contact under the influence of the current flowing in its lower winding. Relay 10—RS, upon moving from its marking position, removes ground from the grid elements of vacuum tubes 1004 and 1005 and the grounded potential of battery 1008 will be impressed on a circuit traceable over resistance 1021, conductors 1009, 1010 and 1025, resistance 1026, outermost lower armature and contact of relay 10—SL, conductor 1027, condenser 1028, resistance 1029, conductor 1030, front contact and upper armature of relay 10—BY, to ground and condenser 1028 after one-third second accumulates a sufficient potential to make vacuum tube 1004 conductive to carry the grid element of vacuum tube 1003 to a potential which is negative with respect to its associated filament so as to make vacuum tube 1003 non-conductive. Vacuum tube 1003, upon becoming non-conductive, causes the release of relays 10—C, 10—CT, and 10—L and line lamp 1023 is extinguished. Relay 10—L, upon releasing, causes, due to resistance 1037, condenser 1028 to be charged at slower rate. After four seconds, vacuum tube 1005 will become conductive to operate relay 10—D which will, upon operating, short-circuit the holding circuit of relay 10—TR. Relay 10—TR will release and thereby cause the release of relay 10—ON. Relay 10—ON, upon re-

leasing, will return the inward path comprising conductor 915 to its grounded condition and will remove power from the repeater. Relay 10—ON, upon releasing, will also transfer condenser 1019 to a discharging path extending to ground connection 1031. After one and one-half seconds vacuum tube 1006 will become non-conductive and thereby cause the release of relays 10—E, 10—E1, and 10—BY and the circuit will thus be returned to its normal or idle condition. The four-second delay in the removal of source 1018 of 20-cycle dot impulse current from the inward path after the subscriber abandons the call as hereinbefore described, is utilized at the large switching center to hold the connection in case the subscriber recalls before the operator answers the call.

Operator answers

When the operator answers a call by connecting a cord circuit to the line jack 1032 with which line lamp 1023 is associated, relay 10SL operates in a circuit connected to grounded battery in the selected cord circuit. Relay 10SL, upon operating, opens at its innermost lower armature and back contact the operating circuit for relay 10—L which releases to extinguish the line lamps, such as lamp 1023. Relay 10—SL, upon operating, will change the timing for operating vacuum tube 1005 so that it will operate relay 10—D on subsequent spacing conditions of the outward path of one-second duration, the change being effected by closing a path at the outermost lower armature and contact of relay 10—SL to shunt resistance element 1026.

Transmission

With relay 10R of the repeater in its marking, or left-hand, position a biasing current will flow in the lower winding, in series, of relays 10—S and 10—SS. Relays 10—S and 10—SS will follow all signals sent from the operator's cord circuit. Relay 10—S will repeat the signals to the inward transmission path and relay 10—SS will apply ground to discharge condenser 1017 during all marking periods. When relay 10—R is operated to spacing by the outward path, the spacing signal will be repeated to the cord circuit and the biasing current in the lower windings of relays 10—S and 10—SS will be reversed to hold the latter relays to marking.

With relay 10—S in its marking, or left-hand, position a biasing current will flow in the lower winding of relay 10—R to operate it to its spacing or right-hand position when no current is flowing through the upper winding of relay 10—R to the outward transmission path. The loop current which flows in the outward transmission path during marking condition will operate relay 10—R to marking against this biasing current. When a spacing signal is sent from the cord circuit, relay 10—S will reverse the current in the lower winding of relay 10—R to hold relay 10—R to its marking position regardless of the condition of the outward transmission path which includes conductor 1033. It is by this action that the "break" feature of the repeater is accomplished.

The system is now in condition for transmission in either direction in response to the call originated by the subscriber whose station is connected to the small switching center.

Subscriber sends a "break" signal

When the subscriber whose station is located near and connected to the small switching center, operates the station "break" key, the local current is reduced from 20 milliamperes to 5 milliamperes. This current is sufficient to hold relay 4SP operated but permits relay 4S to place a spacing condition on trunk conductor 501 which extends to the large switching center. At the large switching center the spacing condition permits relay 6C to hold relay 14H and its associated relays operated, but relays 6P and 6R are operated to their spacing position and the transmission path which includes the upper windings, in series, of relays 6S and 6S1, conductors 605, 638 and 639, tip contact of operated set 704, conductor 708, the lower windings, in series, of relays 8S and 8L, conductor 809, and grounded positive battery 901, operates send relay 8S to its spacing condition whereby the spacing condition is repeated over a transmission path including conductors 831, 832 and 833, No. 3 armature and front contact of relay 8—ON, conductor 834, normally closed contacts at tip spring of jack 804-send, trunk conductor 914, extending to the central office. At the time relay 8S operated to its spacing position, relay 8L also operated to its spacing position thereby removing ground from a path including conductors 835 and 836, No. 5 armature and contact of relay 8A, conductors 837 and 907, and grounded battery 908, and permits condenser 838 to become charged in a path including grounded battery 908, conductors 907 and 837, contacts and No. 5 armature of relay 8A, conductors 836, 835 and 839, condenser 838 to ground. Condenser 838 receives sufficient potential after two-thirds of a second to cause vacuum tube 904 to become conductive and operate relay 9SB. Relay 9SB, upon operating, closes an operating circuit for relay 8SB1. Relay 8SB1, upon operating, causes relay 8B to operate. Relay 8B operates to connect source 830 of 20-cycle dots, or ringing current, in a circuit extending over the contact and middle upper armature of relay 8B, upper armature and contact of relay 8SB1, transmission conductor 833, contact and armature No. 3 of relay 8—ON, conductor 834, normally closed contact at the tip spring of jack 804, trunk conductor 914 to the central office. The reception of a limited space signal followed by ringing current at the central office is interpreted thereat as the transmission of a break signal. The transmission of ringing current to the central office end continues as long as the subscriber's break signal continues. When the subscriber break signal is terminated by a mark signal, relays 8S and 8L return to their marking positions and ground at the armature of relay 8L is connected to the grid element of vacuum tube 904 and relays 9SB, 8SB1, and 8B release. Relay 8SB1, upon releasing, together with the release of relay 8B, causes a mark signal to be sent to the central office thus returning the trunk circuit to the condition it was before the reception of a break signal from the subscriber. The break signal is, therefore, converted to 20-cycle dots at the large switching center after two-thirds of a second. At the central office when the break signal is first received, relay 10—RS is operated to its spacing position to allow condenser 1028 to charge. After one-third of a second, vacuum tube 1004 will become conductive and will carry the grid element of vacuum tube 1003 to a potential negative with respect to the filament of tube 1003. This will cause tube 1003 to release relays 10—C and 10—CT. Relay 10—CT upon releasing returns the control of vacuum tube 1003 grid network to the spacing contact of relay 10—RS. When the 20-cycle dots are received, condenser 1028 will be

discharged so that vacuum tube 1006 will not become conductive. The marking intervals in the 20-cycle dot signals are not of sufficient duration to make vacuum tube 1003 conductive. At the end of the break signal, when the outward path returns to marking, condenser 1001 would charge sufficiently to cause vacuum tube 1003 to again operate relays 10—C and 10—CT. During the time that the 20-cycle dot signals are received, relay 10—CT will be released. Relay 10—CT, when released, forces relay 10—R to spacing regardless of the line or trunk condition so that the 20-cycle dots will not be repeated to the cord circuit. Relay 10—CT, because of the operating time of vacuum tube 1003, requires .04 second to operate and its operation removes the short-circuit from the upper winding of 10—R thereby causing relay 10—R to operate to its marking position terminating the break signal sent to the cord circuit.

Operator at central office sends a "break" signal

When a break signal is sent from the cord circuit, relay 10—SS operates to its spacing condition and allows condenser 1017 to become charged under the influence of grounded battery 1008 in a circuit traceable over conductors 1009, 1010, resistance 1034, conductor 1036, through condenser 1017, to ground. After two-thirds of a second, condenser 1017 acquires a potential sufficient to operate vacuum tube 1002 and the plate current thereof operates relay 10—A which, in turn, operates relay 10—A1. Relay 10—A1 upon operating will supplant the spacing condition which has been placed on the inward path at the beginning of the break signal by a continuous 20-cycle ringing current from source 1018. This ringing current will cause the terminal repeater to transmit dot signals at 20-cycle frequency to the large concentrating unit switching center. When the break is ended, relay 10—SS will cause vacuum tube 1002 to release relays 10—A and 10—A1 and to return the inward path to the repeater. At the large concentrating unit switching center this break signal received from the central office is in the form of a limited space signal followed by a ringing current. Immediately, relays 9TL and 9R operate to their spacing positions, relay 9R transmitting the space signal to the small switching center. Relay 9TL, upon operating to its spacing position, removes ground from the grid element of vacuum tube 902 in a circuit traceable over conductors 915 and 916. The removal of ground from the grid element of the operator's break vacuum tube 902 causes condensers 917 to accumulate a charge in a circuit traceable from grounded battery 908, conductor 907, resistance 918, conductor 919, condenser 917, conductor 817, front contact and No. 6 armature of relay 8—ON to ground. After approximately one-third of a second, the potential on condenser 917 becomes of sufficient value to make vacuum tube 902 conductive and the resulting plate current flowing in vacuum tube 902 is effective to discharge condenser 920 which is normally charged in a circuit extending from grounded battery 908, conductor 907, resistances 921 and 922, conductor 923, condenser 920 to ground. The discharge of condenser 920 causes the grid element of cut-through vacuum tube 903 to become negative with respect to its filament thereby the plate current of vacuum tube 903 is discontinued to cause the release of relay 9CT. Relay 9CT, upon releasing, releases relay 9CT1. Relay 9CT1, upon releasing, again puts the grid element of vacuum tube 903 under control of relay 9TL and at the same time results in the operation of relay 9CT2. Relay 9CT2, upon operating, (1) removes ground from the grid element of the break limiting vacuum tube 905 and (2) places the line, or upper, winding of relay 9R under control of relay 8BL1 which, being unoperated at the time, continues to keep relay 9R in its spacing position. After two-thirds of a second of space signal, ringing current is received from the central office in time to prevent the operation of disconnect vacuum tube 906 and still keep vacuum tube 903 from operating, all of which results from the vibration of the armature of relay 9TL under the influence of the received ringing current. A space, therefore, is continuously sent to the small switching center. Since the condition at this small unit switching center cannot be determined while a space signal is being sent to such switching center, the break must be limited. Therefore, after approximately five seconds, vacuum tube 905, which lost the ground on its grid element because relay 9CT2 operated, functions to operate relay 9BL and, in turn, relay 8BL1, the latter under the influence of interrupter 829. The circuit for operating relay 8BL1 may be traced from grounded battery through the winding of the relay, conductor 839, contact and armature of relay 9BL, conductor 924, armature No. 6 and front contact of relay 8SP1 to ground at interrupter 829. Each operation of the relay 8BL1 causes a mark to be sent to the small switching center at which time a break, a recall, or a disconnect signal from the subscriber station connected to the small switching center will cause the circuit to act as outlined above in the section entitled "Subscriber sends a 'Break' Signal." At the conclusion of the break signal the ringing current received from the central office is replaced by a continuous mark signal which in approximately .050 second, causes the vacuum tube 903 to operate relays 9CT and 9CT1 in turn, causing the release of relay 9CT2 and again restoring the inward transmission path to normal. If vacuum tube 905 has functioned relay 9CT2 again connects ground to its grid element causing the release of relays 9BL and 8BL1. With the inward transmission path established, steady mark is again sent to the small switching center and the circuit has returned to the regular half-duplex transmission condition.

The operation of relay 9R under the influence of interrupter 829, causes a series of mark signals to be repeated through the large switching center to operate relay 6S in the trunk circuit extending to the small switching center and the series of mark signals are repeated by relay 6S to the small switching center. The repeated series of mark signals operate relay 6C which continues to hold relay 14H and its associated relays operated. If the break signal exceeds six seconds a set of relays, such as 9BL and 8BL1, in conjunction with interrupter 829 alternately place a four-second marking and two-second spacing condition on the repeater relay 9R and then in turn on repeater 6S and eventually on the calling line extending to the small switching center. At the small switching center, the ordinary break signal from the central office is received as a spacing condition and relay 5R operates to its spacing contact and the calling subscriber loop current is reduced to zero. This will release relay 4SP which would tend to release relay 4SP1 and thus relay 4SP2. However, relay 5—OB operates to its left-hand contact to furnish ground potential to a circuit

extending through the winding of relay 4SP1 to hold the latter relay operated. If the break signal from the central office exceeds six seconds, the trunk terminating equipment in Figs. 8 and 9 at the large switching center will send a marking condition to intervals, as hereinbefore stated, over the trunk to the small switching center to permit the calling subscriber to register a recall or a disconnect signal.

"Recall" signals from subscriber

The subscriber originates a recall signal by operating the subset power switch, such as start key 210 at subscriber station 202, to the "off" position and then again operating it to the "on" position. This is in effect a disconnect followed by a new call. When the switch is in the "off" position, relays 4SP, 4SP1 and 4SP2 release. Relay 4SP2, upon releasing, causes relay 5TR to release which transfers conductors 540 and 541 from the repeater relay to the loop condition which includes high resistance ground (resistance element 531). The high resistance ground condition on the trunk extending toward the large switching center causes relay 6C to release and in turn relays 14H, 6C1, 6SA and 14C2 release. Relay 6C1 upon releasing, (1) releases relay 6SA which indicates a disconnect condition to the terminating equipment at the large switching center; (2) transfers the transmission circuit to the small switching center from the armature of relay 6S to ground on the back contact of relay 6C1. Relay 6SA, when released, will also release relay 14C2 to operate relay 6S to its marking contact and relay 6R to its spacing contact, the circuit for operating relay 6S being traceable from grounded battery 1405, resistance 1406, conductor 1407, resistance 1408, upper make-before-break contacts of relay 14C2, conductor 1409, through the lower windings, in series, of relays 6S and 6S1, resistance 619 to ground, and the circuit for operating relay 6R to its spacing contact may be traced from grounded battery 1401, resistances 1402 and 1403, lower normally closed make-before-break contacts of relay 14C2, conductor 1404, through winding No. 4 of relay 6R, to ground. Relay 6R in its spacing position sends a spacing signal to operate relays 8S and 8L to their spacing positions. Relay 8S, upon operating, to its spacing position transmits a spacing signal over trunk conductor 914, through the upper windings of relays 10—RS and 10—R at the central office. Relay 8L, upon operating to its spacing position, directly removes ground from the grid element of vacuum tube 904. On reoperation of the power switch at the calling subscriber station, say switch 210 at station 202, relay 8S again sends a marking signal to the central office and relay 8L again connects ground to the grid element of vacuum tube 904. On very slow flashes, in approximately three seconds, the charge on condenser 338 and, therefore, on the grid element of vacuum tube 904 has become sufficiently positive with respect to its associated filament circuit to cause a plate current to flow to thereby operate relay 9SB which in turn operates relay 8SB1. Relay 8SB1, upon operating, releases relay 8SP1 which again grounds the grid of vacuum tube 904, causing the release of relays 9SB and 8SB1. In the meantime, a continuous space has been sent to the central office. When the switch at the calling subscriber's station is again turned on, relay 8S sends a marking signal to the central office and at the same time relay 8L applies ground to the grid of vacuum tube 904 which becomes non-conductive and thereby releases relays 9SB and 8SB1 if they have not already released, or prevents them from operating if they have not operated. The potential on ring conductor 706 again operates relay 8SP and in turn relay 8SP1 which again locks under the control of 8SB1. The space and mark signals sent to the central office are used to flash the line lamp at the switchboard.

The operation of relay 10—RS to its spacing position will cause relays 10—C, 10—CT and 10—TR to release as hereinbefore described under the section entitled "Subscriber sends a 'Break' signal." The new call portion of the recall signal will reoperate relays 10—C, 10—CT and 10—TR to remove the ground from ring conductor 1035. The momentary grounding of the ring circuit to the cord circuit as a result of a subscriber's recall signal will cause the relay in the cord circuit to flash the supervisory lamp. Each time that the power switch at the subscriber's station is operated to its "on" position, a marking condition will be placed on the transmission trunk and the relays will assume their respective positions that they usually assume when the transmission trunk is prepared for transmission, such as relays 6C, 14H, 6C1, 6SA, 14C2 will be operated.

Subscriber sends a "disconnect" signal

When the subscriber at station 202 sends a disconnect signal the subscriber's loop is open and relays 4SP, 4SP1, and 4SP2 release. Relay 4SP2, upon releasing, causes relay 5TR to release which transfers the trunk from the repeater relays to the high resistance ground or loop condition including resistance element 531 of relatively high value. The connection of resistance 531 which may have a value of 18,000 ohms at the small switching center causes relay 6C at the large switching center to release which in turn releases relay 14H and the release of relay 14H releases relay 6C1. Relay 6C1, upon releasing, (1) releases relay 6SA which indicates a disconnect condition to the equipment at the large switching center resulting in a lighted supervisory lamp at the distant central office, (2) transfers the transmission circuit to the small switching center from the armature of relay 6S to ground on the back contact of relay 6C1. Relay 6SA, when released, will also release relay 14C2 to operate relay 6S to its marking contact and relay 6R to its spacing contact. The circuit for operating relay 6S to its marking contact may be traced from grounded battery 1405, resistance 1406, conductor 1407, resistance 1408, normally closed upper make-before-break contacts of relay 14C2, conductor 1409, through the lower windings, in series, of relays 6S and 6S1, resistance 619 to ground. The circuit for operating relay 6R to its spacing contact may be traced from grounded battery 1401, resistances 1402 and 1403, normally closed lower make-before-break contacts of relay 14C2, conductor 1404 through the No. 4 winding of relay 6R to ground. The transmission of a space signal from relay 6R operates relays 8S and 8L to their spacing positions. Relay 8L upon operating to its spacing position removes ground from the grid element of vacuum tube 904 which with relay 8A operated now requires two-thirds of a second to draw sufficient plate current to operate relays 9SB and 8SB1. The circuit for making vacuum tube 904 conductive may be traced from grounded battery 908, conductors 907 and 837, resistance 840, contact and No. 5 armature of relay 8A, conductor 836,

then over parallel paths one extending through condenser 838 to ground and the other continuing along conductor 839 to the grid element of vacuum tube 904. From this point on, the trunk terminating circuit acts differently if the space were the result of a subscriber sending a break, a flash, or a disconnect signal and the three will be discussed separately. In the case of a subscriber sending a disconnect signal relay 8SP being in a spacing position, allows relay 8SP1 to release which, in turn, causes the release of relay 9TR and the application of ground to the grid of vacuum tube 904, the action of the tube changing to a non-conductive condition causing the release of relays 9SB and 8SB1. Relay 9TR, upon releasing, returns the circuit to effective full-duplex transmission. The trunk sends a continuous space to the central office where it is interpreted as a disconnect signal and the circuit awaits appropriate action of the switchboard operator.

Relay 8S, upon operating to its spacing condition and sending a spacing signal to the central office, causes relay 10RS at the central office to operate to its spacing position. After one-third second, vacuum tube 1004 will be conductive as hereinbefore described in the section entitled "Subscriber sends a 'Break' signal" to cause the release of relays 10—C and 10—CT, and one second after the beginning of the spacing signal, vacuum tube 1005 will become conductive and relay 10—D operates. Relay 10—D upon operating, closes at its armature and contact a shunt path around the winding of relay 10—TR and relay 10—TR releases. Relay 10TR, upon releasing, applies ground to the ring conductor 1035 and to the ring conductor of the cord circuit to light the supervisory lamp, not shown, but well known in the art. The operator at the central office switchboard may dismiss the connection at this time by disconnecting the cord circuit from the trunk jack. If this is done, relay 10—SL will release and open at its front contact and innermost lower armature the operating circuit for relay 10—ON which also releases. Relay 10—ON, upon releasing, applies ground or a spacing condition to the inward path including conductor 915, and connects ground at connection 1031 over its back contact and No. 6 armature to discharge condenser 1019. After one and one-half seconds vacuum tube 1006 will become non-conductive and thereby release relays 10—E, 10—E1 and 10—BY. The circuit will then be restored to the normal idle condition.

When the operator at the distant central office removes the cord circuit plug from the trunk jack, "hold" magnet 7H3 releases removing ground from conductor 707 whereby relays 6SL, 6SL1 and 6DR release and condenser 1433 thus accumulating a potential via resistances 1434 and 1435. After approximately 2 seconds the vacuum tube 1419 becomes conductive thereby operating relay 14D1 which operates relay 14D2. Relay 14D2, upon operating, will (1) complete the charge of condensers 1433, (2) operate relay 6E and connect negative 130-volt grounded battery to conductor 601 of the outgoing trunk to release the trunk terminating equipment at the small switching center; (3) connects ground through resistance 1436 to condenser 1433; (4) opens the ground connection in the locking circuit of relay 6CL to release that relay, and (5) supply a holding ground for relay 14BY. Relay 6CL, upon releasing (1) opens the charging circuit for condenser 1433 which then starts to discharge through resistance 1436. After approximately 2 seconds, the plate current in vacuum tube 1419 is reduced by the decreased grid element potential to a point where relay 14D1 releases. Relay 14D1, upon releasing, releases relay 14D2 which in turn, upon releasing, releases relay 14BY and the circuit is then restored to normal idle condition.

If the operator at the operator's office wishes to re-ring the subscriber station, ringing current applied to the distant end of the trunk circuit causes relay 5R1 to operate, in turn operating relay 5R5 which operates relay 5R4. Relay 5R4, upon operating, causes the release of relay 5R5. Relay 5R5, upon releasing, causes relay 4R2 to operate in turn operating relay 4R3. The operation of relay 4R3 (1) connects ground to the ring conductor 422 of the transmission path, the connection being made at the link circuit side of relay 4SP; (2) operates relay 4B and transfers tip conductor 366 of the transmission path from the link circuit side of the repeater relay to source 440 of 20-cycle ringing current which operates the subscriber's station ringer, or bell. When the operator releases the ringing key, relays 5R1, 4R2, 4R3 and 5R4 release to remove the link circut side from the ringing source 440. Relay 4B which also connects ground to conductor 422 of the transmission path, releases after an interval sufficient to allow the loop and link circuit capacity to become discharged. If the circuit is arranged for automatic ringing, relay 4R3 will thereafter be operated by interrupted ground pulses from interrupter 431 to apply ringing current through the link circuit to the loop at regular intervals.

If the switchboard operator at the central office disconnects, the disconnect from the subscriber's station locally connected to the small switching center having been registered as above described, by removing the cord plug from the trunk jack, the trunk terminating equipment at the large switching center times out a 2-second interval and then applies negative grounded battery to the trunk for 2 seconds. Relay 5L operates to open its normally closed contacts for the duration of the negative battery pulse, removing ground from the grid condenser 425. Condenser 425 is then charged through resistance 434 so that in one second the grid element potential is of a value that sufficient plate current flows in vacuum tube 419 to operate relay 4D in turn operating relay 4D1. The operation of relay 4D1 releases relays 4—ON and 4RC, connects ground to conductor 430 which extends to the sequence circuit to operate relay 12DL and in turn causes disconnect lamp 1201 to light. Relay 12DL and disconnect lamp 1201 are employed only when the attendant's teletypewriter machine is plugged into jacks 435A and 436B. The release of relay 4—ON opens the filament circuit of vacuum tube 419, releasing relays 4D and 4D1 and the circuit is again in normal idle condition.

If the operator at the central office disconnects from the selected trunk on an uncompleted inward call or after the subscriber has disconnected, the trunk circuit at the large switching center receives a steady space signal from the central office. As outlined above under section entitled "Operator at central office sends a 'Break' signal," the trunk circuit terminating equipment at the large switching center allows vacuum tube 902 to function to ground, the grid element of vacuum tube 903 resulting in the release of relays 9CT and 9CT1 and the operation of relay 9CT2. Though the 9R relay operates

to its spacing position it has no effect upon the subscriber line. After another ⅔-second has elapsed, disconnect vacuum tube **906** functions to operate relay 9D which in turn causes the release of relay 8A. Relay 8A, upon releasing, causes the release of relays 9CT2 and 8—ON. Relay 8—ON, upon releasing, removes grounded battery from the vacuum tubes **902** to **906** and the repeater relay at the large switching center, releasing relay 9D, and removes ground from relay 8SL, causing it and the hold magnet 7H3 locked in series with it, to release. The release of the hold magnet 7H3 removes the subscriber line from the trunk. Relay 8SL, upon releasing, causes relay 8SL1 to release and removes ground from conductor **827**, releasing the associated chain relay, such as relay 16CH—0 of the sequence circuit, thus removing the trunk-busy condition to other calling subscribers and extinguishing the trunk-busy lamp **813**, returning the circuit to normal.

Call from the central office

The operator at the central office will originate a call by connecting a cord circuit to the selected trunk jack. Relay 10SL will operate and close at its innermost lower armature and front contact an operating circuit for relay 10—ON which operates. Relay 10—ON, upon operating, closes at its No. 1 armature and front contact the inward transmission path comprising conductor **915** for extending to the large switching center a marking condition produced by relay 10—S when the operator inserts the plug of the selected cord circuit into jack **1036** and the terminating circuit at the large switching center is prepared for teledirection. Ground at the outer upper armature and back contact of relay 10—TR will be extended over ring conductor **1035** to light the cord circuit supervisory lamp, not shown, until a marking condition is placed on the outward transmission path by the terminating equipment at the large switching center as an indication that it is prepared for teledirection. The marking condition on the outward transmission path which includes conductor **914** will result in the operation of relay 10—TR to extinguish the cord circuit supervisory lamp to indicate the condition to the operator at the central office, who will then transmit the teledirection character signals. If the number called is busy, out-or-order busy, or unassigned, distinctive teletypewriter signals will be returned by the terminating equipment at the large switching center to indicate the condition to the operator. If the line or line trunk is idle, connection will be established to it by the terminating equipment of the selected trunk at the large concentrating unit switching center. Since in this case the called subscriber line or line trunk is idle, the equivalent of a disconnect condition will exist and the outward transmission path will return to spacing to relight the cord circuit supervisory lamp by the release of relay 10—TR during the time the subscriber station is being rung or ringing current is being applied to the idle line trunk. When the subscriber answers, the outward transmission path will again be changed to marking and the resultant extinguishing of the cord circuit supervisory lamp will indicate the answer of the call to the operator.

The reception of a continuous mark signal at the large switching center operates relay 9TL to its marking, or left-hand, position, thereby removing ground at the spacing contact of relay 9TL from condenser **920** which begins to assume a charge over a circuit extending from grounded battery **908**, resistances **921** and **922**, conductor **923**, condenser **920** to ground. After approximately ½-second, condenser **920** assumes a charge having a value sufficient to cause vacuum tube **903** to become conductive thereby causing the operation of cut-through relay 9CT and in turn the operation of relays 9CT1 and 8A successively. Relay 9CT1, upon operating removes relay 9TL from the control of the grid element of vacuum tube **903**. Relays 9CT and 9CT1 remain operated, and prepares at its outer lower armature and contact an operating circuit for start relay 16ST2—0 in the trunk sequence circuit corresponding to the trunk selected by the operator at the central office. Relay 8A, upon operating, (1) closes at its No. 4 armature and contact an operating circuit for relay 8—ON which upon operating connects power to the loop repeater and ground on the winding of relay 8SL; (2) removes at its No. 1 armature and contact the ground connection from conductor **841**; (3) locks up under control of relay 9D, which, upon operating, closes a shunting circuit traceable from grounded battery **925**, contact and armature of relay 9D, contact and middle lower armature of relay 9TR, contact and its own armature No. 7 directly to ground; (4) connects ground at its No. 8 armature and contact to conductor **842** which is extended over conductor **831**, through the winding of relay 16CH—0 to grounded battery and relay 16CH—0 operates among the chain relays of the sequence circuit to make this trunk test busy to calling subscribers and also to light the trunk busy lamp **813**. Relay 8—ON, upon operating, completes the circuit previously prepared at the outer lower armature and contact of relay 9CT so that such prepared circuit may now be traced from ground, the contact and No. 5 armature of relay 8—ON, outer lower armature and contact of relay 8SB1, No. 1 armature and back contact of relay 8SP1, outer lower armature and contact of relay 9CT1, inner lower armature and contact of relay 8SL1, conductor **843**, through the winding of start relay 16ST2—0, conductor **815**, back contact and innermost lower armature of relay 16BO—0 to grounded battery. Relay 16ST2—0 operates whereby the sequence circuit is ordered to connect a director circuit to the selected trunk for the purpose of receiving teledirecting pulses. The sequence circuit when it attaches a director circuit to the selected trunk circuit connects ground at the innermost lower armature and contact of relay 16AL1—0, as will be hereinafter described, to conductor **1607** which is extended over the normally closed contacts associated with the ring spring of jack 802A, through the winding of relay 8M to grounded battery. Relay 8M, upon operating, closes a plurality of circuits each extending through the winding of one of the selecting magnets 7SM—1 of the cross bar switches connected in multiple, which form part of the link circuit.

When start relays 16ST2—0 and 16CH—0 operate, an operating circuit for relay 16AD—0 is closed through the auxiliary contact of relay 16CH—0 to grounded conductor **861**. Relay 16AD—0 operates to connect ground at its outer upper armature and contact to conductor **1602** which serves as a trunk chain circuit and is therefore immediately advanced and if this trunk chain circuit of the trunk group is complete, that is a group is represented by the three vertical rows of relays shown in Fig. 16, ground is sent to the all-trunks-busy circuit shown in Fig. 22, causing it

to time the interval that the all-trunks-busy condition persists. Relay 16ST2—0, upon operating, (1) connects ground at its middle upper armature and contact to conductor 1611 which extends through one or more trunk sequence groups to a director circuit wherein it is connected over the inner right-hand armature and back contact of relay 23T5, to conductor 2307 which is used to keep in speed the distributor motor associated with the director distributor circuit; (2) connects ground at its outermost upper armature and contact to a circuit extending through call-disconnect lamp 1612, conductor 1418, through the winding of relay 18E, to grounded battery, to light the call lamp 1612; and (3) closes at its lower armature and front contact, assuming that no other ST2 relay in either of the trunk sequence groups shown in Figs. 16 and 17 is operated, a circuit extending from ground at the lower armature and back contact of relay 25CS in the miscellaneous alarm circuit, conductor 2507, contact and lower armature of relay 25D, conductor 1701, lower armature and back contacts of each of relays 17ST2—19 to 17ST2—10, and each of relays 16ST2—9 to 16ST2—1, lower armature and front contact of relay 16ST2—0, through the winding of relay 16AL—0, conductor 1624, back contact and upper armature of each of relays 15AL—G9 to 15AL—G0, conductor 2506, back contacts and armatures of relay 25SU in the miscellaneous alarm circuit, to grounded battery. Relay 16AL—0 operates provided no other AL relay in either of the trunk sequence groups shown in Figs. 16 and 17 is in an operated position. If these conditions are not met, the particular AL relay, such as relay 16AL—0 in the particular case at hand, will be delayed in operating until it has received a preference accorded to it by the sequence circuit. Relay 16AL—0, upon operating, (1) locks under control of its associated start relay 16ST2—0; (2) causes relays 25ST and 25CS in the miscellaneous alarm circuit to operate successively; and (3) closes at its lower armature and front contact an operating circuit for relay 16AL1—0 which also operates, the circuit being traceable from ground, through the winding of relay 16AL1—0, front contact and lower armature of relay 16AL—0, conductor 1624, back contact and upper armature of each of relays 16AL—G9 to 16AL—G0, conductor 2506 to grounded battery at the contact and lower armature of relay 25SU in the miscellaneous alarm circuit. Relay 16AL1—0, upon operating, (1) connects at its outermost upper armature and contact a ground connection to conductor 1615, inner left-hand armature and back contact of relay 23T5, conductors 2308 and 2602, through the winding of start relay 26A, to grounded battery in the director circuit; (2) connects the two transmission conductors 808 and 913 respectively, at its middle upper armature and contact and at its innermost upper armature and contact to conductors 1616 and 1617, and thereby connects the selected idle trunk circuit shown in Figs. 8 and 9 to the director circuit; (3) connects ground at its innermost lower armature and contact to conductor 1607 which extends over conductor 826, normally closed contacts associated with ring spring of jack 802, through the winding of relay 8M to grounded battery to energize the selecting magnet 7SM—1 and corresponding magnets on other crossbar switches connected in multiple with that shown in Fig. 7 in the link circuit; and (4) connects the winding of relays 16BO—0 and 16BO1—0 over its two lowermost armatures and front contacts to conductors 1618 and 1619 respectively, conductors 1618 and 1619 being the common busy-out conductors extending to the miscellaneous alarm circuit. The operation of relay 25CS in the miscellaneous alarm circuit removes ground from conductor 1701 of the entire office sequence circuit chain.

When the trunk circuit at the large switching center receives permission to route the call through the center, the sequence circuit, as has just been described, connects the director circuit to the particular trunk. The inward transmission path from the trunk circuit is in a marking condition and is connected to conductors 913 and 808. Conductor 913 is extended over conductor 1616, back contact and outer left-hand armature of relay 23T4, conductor 2309, through the lower winding of a gate relay 26G to ground, and conductor 808 is extended over conductor 1617, back contact and outer right-hand armature of relay 23T5, conductor 2310, outer left-hand armature and back contact of relay 26A4, conductor 2603, normally closed make-before-break contacts of relay 26U, normally closed make-before-break contacts of relay 26N3, conductor 2604, through the left-hand winding of relay 26C2, to the front contact and outer left-hand armature of relay 26A4, but relay 26A4 being unoperated at this time, the latter traced circuit is open. The terminations of both of these circuits just traced are in the director circuit. The sequence circuit, upon seizing the director, places ground on conductor 1615 which causes the operation of relay 26A in the director circuit. The operation of relay 26A is the first function of the director circuit. Relay 26A, upon operating, (1) closes at its inner left-hand armature and contact an operating circuit for relay 26A1 which operates; (2) closes at its outer left-hand armature and contact an operating circuit for relay 26A2 which operates, the operating circuit for relay 26A2 extending to ground at the outer right-hand armature and contact of relay 26C1 which at this time is unoperated; (3) applies telegraph ground at its right-hand armature and contact (*a*) to a path extending over conductor 2605, armature and back contact of relay 26C, conductor 2606, back contact and right-hand armature of relay 26AL, conductors 2607 and 2702, to the receiving contacts 2703 to 2707 inclusive, of the motor driven distributor, the grounded conductor 2607 also serving to energize and operate start magnet 2701 which upon operating permits rapid acceleration of the motor 2708 by eliminating clutch drag, (*b*) to the upper winding of the receiving relay 26G in a circuit extending over resistance 2608, to grounded battery 2609, the circuit through the upper winding of relay 26G serving to bias the relay armature to its spacing, or left-hand, contact, (*c*) to the "stop" pulse contact 2709 of the motor driven distributor, the circuit being traceable over conductor 2610, normally opened contacts 2709 which are open at this time, right-hand armature and front contact of relay 26A2, to the armature of relay 26B which is now unoperated, (*d*) to the primary, or left-hand, winding of relay 26A3 in a circuit traceable over the back contact and outer left-hand armature of relay 26C1, armature and marking contact of relay 26G to grounded battery 2609, causing relay 26A3 to operate, providing relay 26G is operated to its right-hand or marking contact in response to a marking signal being received from the loop repeater over conductor 2309, (*e*) to the potentiometer formed by resistances 2711 and 2712 which is later used in operating the registering relays 27R1

to 27R5 inclusive, the circuit being traced as hereinbefore described over conductor 2610 to conductor 2713, resistances 2711 and 2712 to grounded battery 2714, (f) to the primary or upper winding of relay 27R6, resistance 2715 to grounded battery 2714 which circuit biases relay 27R6 to its spacing or left-hand contact, and (g) to the inner left-hand armature of relay 26C1 which armature, when engaged to its associated front contact, is used to start the "director-ready" signal. Relay 26A1, upon operating, closes at its left-hand armature and contact a circuit extending from grounded battery, conductor 2611, series winding 2716 of motor 2708, resistances 2717 and 2718 to ground. The motor governor contacts 2719 disclosed in U. S. Patent 1,860,556, granted to J. H. Sole, May 31, 1932, are closed in the motor operating circuit, while the motor is coming up to speed. Relay 26A1 which therefore starts the distributor motor, locks to ground in a circuit which extends over its contact and outer right-hand armature, conductor 2307, back contact and inner right-hand armature of relay 23T5, conductor 1611, to ground at the middle upper armature and contact of relay 16ST2—0 in the trunk sequence group circuit, and the motor is kept running under control of the sequence circuit as long as an incoming call is awaiting completion. Relay 26A1, upon operating, also supplies ground to the armatures of relays 27R1 to 27R5 inclusive, which permits these relays to lock in either direction in which they may be operated, the circuit being traceable from ground at the inner right-hand armature and contact of relay 26A1, conductor 2612, to the armatures in parallel of relays 27R1 to 27R5. While the distributor motor 2708 is attaining speed, the distributor cams are successively operating, causing brief closures of each receiving contact of contacts 2703 to 2707, in turn. Relays 27R1 to 27R5 will, therefore, operate and lock in the spacing position or direction, due to these closures of telegraph ground at relay 26A. The spacing locking paths of relays 27R1 and 27R2 extend through resistances 2727 and 2728 respectively, through the winding of relay 27J to grounded battery.

Likewise, the spacing locking paths of relays 27R4 and 27R5 extend through resistances 2729 and 2730 respectively, and through the winding of relay 27J. Therefore, relay 27J will operate as soon as any one of the relays 27R1, 27R2, 27R4 or 27R5 operate to spacing position. This operation of relay 27J opens the operating path of relay 26F preventing its premature operation. Meanwhile relay 26A2, upon operating, has in effect, placed the sensitive 26B relay across the governor contacts 2719, has prepared in advance a path for operating the fast operating relay 26C and has operated the relay 26A4. Relay 26A4, upon operating, (1) prepares a path for sending the "director-ready" signal out over conductor 2310 and through the lower windings, in series, of relays 8S and 8L to the transmission conductor 809, (2) operates relay 26A5 and (3) prepares a path for lighting lamp 2601 in case the director circuit is timed out in this condition. Relay 26A5, upon operating, (1) closes at its outer left-hand armature and contact a circuit extending from ground at the inner left-hand armature and contact of relay 26A4, outer left-hand armature and contact of relay 26A5, conductor 2613, back contact and right-hand armature of relay 23T6, conductor 2303, through the lower winding of relay 25AB to grounded battery, and relay 25AB operates; (2) closes at its inner right-hand armature and contact a circuit traceable from ground, outer left-hand armature and back contact of relay 26AL, conductor 2614, outer right-hand armature and back contact of relay 23T4, conductor 2301, through the lower winding of 25K1 to grounded battery, and relay 25K1 operates (relays 25AB and 25K1 are in the miscelleaneous alarm circuit and operate as an indication that the director circuit has been moved off normal and conductor 2613 furnishes the miscellaneous alarm circuit with information as to the satisfactory condition of the associated trunk circuit); (3) prepares to lock over its left-hand winding and inner left-hand armature and contact to ground at the right-hand armature of relay 26C1; (4) prepares a path toward the tell-tale lamps 2615, 2616 and 2617; and (5) provides a locking path for relay 26A3. Relay 26A3 being operated at this time prepares to connect conductors 2618 and 2619 to ground as soon as the "director-ready" signal has operated relays 26C2. Relay 26A3 also prepares to light lamp 2617 in case of trouble to indicate that the incoming marking signal has been registered.

While the distributor motor 2708 is accelerating, relays 26A, 26A1, 26A2, 26A3, 26A4 and 26A5 are operated. When full speed is reached the governor contacts 2719 (U. S. Patent 1,860,556, supra) open momentarily, removing the short-circuit from resistance 2717, which has a value of approximately 1000 ohms and allowing relay 26B to operate through resistances 2731 and 2620. Relay 26B is slow releasing and with the help of condenser 2621 holds over the closures of governor contacts 2719 thus operating relay 26C as soon as the "stop pulse" contacts 2709 close.

Relay 26C, upon operating, (1) removes telegraph ground at its back contact from the receiving contacts 2703 to 2707 and the start magnet 2701, thereby latching the clutch 2732 and preventing further operation of the receiving contacts; and (2) locks through the winding of relay 26C1 which operates. Relay 26C1, upon operating, applies telegraph ground at its inner left-hand armature and contact to send the "director-ready" signal out over conductor 2310 to the loop repeaters comprising relays 8S and 8L, the circuit being traced from ground at the right-hand armature and contact of relay 26A, conductor 2605, inner left-hand armature and contact of relay 26C1, through the left-hand winding of relay 26C2, front contact and outer left-hand armature of relay 26A4, conductor 2310, outer right-hand armature and back contact of relay 23T5, conductor 1617, contact and innermost upper armature of relay 16AL1—0, conductor 808, through the lower winding, in series, of relays 8S and 8L, transmission conductor 809, normally closed make-before-break contacts of relay 9TR to grounded positive battery 901. Relay 26C2 operates through current in its left-hand or secondary winding providing its operating circuit comprising conductors 2310, 1617, 808 and 809 is not in trouble. Relay 26C1, upon operating, also (1) transfers the armature of gate relay 26G from the winding of relay 26A3 to magnet 2701, the transfer being effected at the outer left-hand armature and front contact of relay 26C1 to close a new circuit extending over conductor 2606, back contact and left-hand armature of relay 26AL, conductor 2607, through the winding of distributor motor start magnet 2701 to grounded battery, conductor 2607 also serving to furnish incoming character pulses over conductor

2702 to the selecting receiving contacts 2703 to 2707 inclusive, of the distributor motor cam shaft; (2) opens at its outer right-hand armature and back contact the operating circuit for relay 26A2 which releases; and (3) provides at its right-hand armatures and front contacts an off-normal ground to a large part of the director circuit including the locking ground for relay 26A5 and ground on the armature of relay 27R6, the circuit for the latter ground being traced over conductors 2622 and 2623, right-hand armature and back contact of relay 26R, conductor 2624 to the armature of relay 27R6. Relay 26C2, upon operating, (1) prepares at its left-hand armature and front contact a path to light lamp 2616 instead of lamp 2615 in case of trouble to indicate that the "director-ready" signal has been sent; (2) locks at its right-hand armature and contact to ground at the inner right-hand armature and contact of relay 26C1; and (3) connects ground at the inner right-hand armature and contact of relay 26C1 over its right-hand armature and contact to the left-hand armatures and contacts of relay 26A3 to conductors 2618 and 2619 which extend to the miscellaneous alarm circuit to indicate that in case of trouble the director should not be taken out of service. Relay 26A2, upon releasing, removes relay 26B from the governor contacts 2719, releases relay 26A4 and transfers the stop pulse contacts 2709 from the left-hand winding of relay 26C to conductor 2626 which extends through the operating or lower winding of relay 27R6 preparatory to receiving pulses from the loop repeater. Relay 26A4, upon releasing, (1) discontinues the use of the secondary or left-hand winding of relay 26C2 in conductor 2310, and connects conductor 2310 to conductor 2603 which extends to the contacts of relays 26U and 26N3 for sending signals to indicate busy, out-of-order busy, or unassigned lines; (2) opens at its inner left-hand armature and contact the operating path of relay 26A5 which remains locked up by current in the left-hand winding of relay 26A5; and (3) transfers ground at its right-hand armature from the path for lighting lamp 2601 to a path for lighting lamps 2616 and 2617. After the "director signal" is sent the following relays are held operated; 26A, 26A1, 26A3, 26A5, 26C, 26C1, 26C2, 27J, 26G to their marking or left-hand positions and relays 27R1, 27R2, 27R3, 27R4, 27R5, 27R6 are operated to their spacing or left-hand positions. The circuit is now prepared to receive pulses from the master office.

Reception of the "figures" character at the large switching center

Telegraph pulses received over the inward transmission path are repeated by gate relay 26G which is normally held to its marking or right-hand contact. The distributor motor is running but the receiving contacts of the distributor cams 2720 to 2726 inclusive, are not operated because start magnet 2701 is released, thereby latching the clutch 2732. As soon as the character is received, the start pulse of the character sends the relay 26G to its spacing position to close the operating circuit for start magnet 2701 which operates, allowing cams 2720 to 2726 to rotate and to successively operate their respectively associated contacts. The motor speed and receiving contacts 2703 to 2707 are adjusted so that at the time the first selecting pulse of the character is received, the secondary, or No. 3 winding of relay 27R1 is momentarily connected to the armature of relay 26G. If the first pulse is marking, relay 27R1 will operate and lock to its marking or right-hand contact. Similarly relay 27R2 will be left either spacing or marking depending on the character of the second pulse. The reception of the "figures" character then proceeds as follows:

Dot element	26G	Register relay	Fan relay operated
1	Marking	27R1 (marking)	Relay 27D1.
2	do	27R2 (marking)	Relay 27D2.
3	Spacing	27R3 (spacing)	
4	Marking	27R4 (marking)	Relay 27D4.
5	do	27R5 (marking)	Relay 27D5.

With relays 27R1 to 27R5 operated as above-mentioned, it will be noted that none of the locking paths of these relays pass through the winding of relay 27J but if any one is operated in the reverse direction, relay 27J will be energized. Relay 27J will, therefore, release only when a "figures" character is received. The succeeding stop pulse is marking which causes start magnet 2701 to release. The momentary closure of telegraph ground by the stop pulse distributor contact 2709 causes relay 27R6 to operate to its marking or right-hand contact overcoming the effect of its bias to its spacing contact. The timing condenser 2733 causes relay 27R6 to remain on its marking contact for .030 second after the stop pulse distributor contacts 2709 open. This allows time for the operation of relay 26F which locks to ground in a circuit traceable over conductors 2628 and 2629 to ground at the inner right-hand armature and contact of relay 26C1, and prepares a path for operating relay 26K when relay 27R6 returns to its spacing contact. In this way relay 26K operates and locks to ground over conductors 2628 and 2629 to ground at the inner right-hand armature and contact of relay 26C1, and transfers the marking contact of relay 27R6 along to succeeding counting relays in preparation for the registration of the next two digits as in the case where one hundred subscriber lines or less are provided for the large switching center.

The reception of "figures" has therefore set up a combination of relays 27R1 to 27R5, locking direct to grounded battery instead of through the winding of relay 27J thereby releasing relay 27J and allowing the next characters to be registered. Therefore "hits" on the line are harmless until the operator has sent a preliminary "figures." After the "figures" character has been received the following relays are operated; 26A, 26A1, 26A3, 26A5, 26C, 26C1, 26C2, 27D1, 27D2, 27D4, 27D5, 27E1, 27E2, 26F, 26K, 26G, 27R1, 27R2, 27R4 and 27R5 are in marking position; and 27R3 and 27R6 are in spacing position. The operation of relays 27D1, 27D2, 27D4, 27D5, 27E1 and 27E2 perform no useful function at this time.

Reception and deciphering of the first digit at the large switching center

The first digit of the called subscriber number will be repeated by relay 26G, broken up pulse by pulse of the distributor contacts and recorded by relays 27R1 to 27R5 in much the same way as the "figures" character was received. Relay 27R1 is operated in accordance with the position of the armature of relay 26G at the middle of the first pulse received in the windings of relay 26G, relay 27R2 according to the second pulse, etc. In each case the operating or No. 3 winding can quickly overcome the holding winding No. 1 or No. 2 but otherwise the relays hold in whichever directions they are

operated under control of motor start relay 26A1. The following table indicates the condition of relays 27R1 to 27R5 resulting from transmission of numerical characters. "M" indicates marking; "S" indicates spacing:

Character		Relay condition				
Lower case	Upper case	27R1	27R2	27R3	27R4	27R5
"Figures"	"Figures"	M	M	S	M	M
P	0	S	M	M	S	M
Q	1	M	M	M	S	M
W	2	M	M	S	S	M
E	3	M	S	S	S	S
R	4	S	M	S	M	S
T	5	S	S	S	S	M
Y	6	M	S	M	S	M
U	7	M	M	M	S	S
I	8	S	M	M	S	S
O	9	S	S	S	M	M

It will be noted that relay 27R1 in its marking position operates relays 27D1 and 27E1 in the fanning-out circuit. Similarly, each of the other fan relays is operated when its associated register relay is in its marking position. Also relay 27J will be operated during the reception of the first digit but performs no useful function after the "figures" character has been received. At the conclusion of the reception of the dot element of the particular character transmitted, relay 27R6 again operates to its marking position and is again held for an additional period of .030 second. Relay 27R6, upon operating to its marking, or right-hand, position causes the operation of relay 26L in a circuit traceable from grounded battery through its primary, or left-hand, winding of relay 26L, back contact and right-hand armature of relay 26M, front contact and right-hand armature of relay 26K, conductor 2630, marking contact and armature of relay 27R6, conductor 2624, back contact and right-hand armature of relay 26R, conductors 2623 and 2622, to ground at the inner right-hand armature and contact of relay 26C1. Relay 26L, upon operating, locks to ground also furnished at the right-hand armature and contact of relay 26C1 but in a circuit traceable over conductors 2628 and 2629. Relay 27R6, upon operating, to its marking contact furnishes ground at the right-hand armature and contact of relay 26C1 to a circuit traceable over conductors 2622 and 2623, right-hand armature and back contact of relay 26R, conductor 2624, armature and marking contact of relay 27R6, conductor 2630, right-hand armature and front contact of relay 26K, right-hand armature and back contact of relay 26M, back contact and armature of relay 26N1, back contact and outer left-hand armature of relay 26R, left-hand armature and contact of relay 26LU, conductor 2631, through the armature of relay 27D5. From the armature of relay 27D5 the path just traced is fanned out by means of the operated or non-operated fanning-out relays to one of ten conductors designated by Nos. 0 to 9 and included in group 2735 which eventually cause the operation of a relay such as relays 24H—0 to 24H—9 represented on the drawings by relays 24H—0, 24H—4 and 24H—9, the relay selected being that which is associated with the particular conductor of those designated by Nos. 0 to 9. The H relay selected corresponds to the tens group of the particular called local subscriber line or line trunk extending to the small switching center. The selected H relay, upon operating, locks in series with relay 24K0 in a circuit traceable over conductor 2401, back contact and outer right-hand armature of relay 23T3, conductors 2628 and 2629 to ground at the right-hand armature and contact of relay 26C1. Relay 24K0, upon operating, (1) removes grounded battery from the operating windings of all H relays, such as relays 24H—0, 24H—4 and 24H—9, preventing the operation of another H relay on this call; (2) causes the operation of relays 24K—1 and 24K—2 which definitely remove any H relays from their associated conductors, Nos. 0 to 9 of the fanning-out circuit; and (3) closes at its right-hand armature and contact a connection between conductor 2402 extending to the miscellaneous alarm circuit and conductor 2403, a ground connection in the miscellaneous alarm circuit later serving to operate the "hold" magnet of the link circuit in case the called line or line trunk is idle. Relay 26L, upon operating, prepares a path at its left-hand armature and front contact for the operation of relay 26M. When relay 27R6 returns to its spacing, or left-hand, contact after .030 second, relay 26M will operate and ground connection will be supplied to a contact on a particular H relay operated, causing the operation of the H1 and H2 relays associated with the particular tens group of the called lines or line trunks, say relays 23H1—0 and 23H2—0, or 24H1—4 and 24H2—4, or 24H1—9 and 24H2—9 or any intervening pair of H1 and H2 relays. The particular pair of H1 and H2 relays selected, upon operating, connect the fanning-out conductors, Nos. 0 to 9 of group 2735 to the corresponding conductors, Nos. 0 to 9 of the particular tens group of called lines. Relay 26M, upon operating, (1) locks to ground at the armature and contact of relay 26C1; (2) opens the operating path for relays 26L and the operated H relay, such as relays 24H—0, 24H—4 and 24H—9, and prepares a path for the operation of relay 26N; (3) connects ground at the release key 2632, over the outer right-hand armature and back contact of relay 26LU, contact and outer left-hand armature of relay 26M, conductor 2633 which extends to the sequence circuit where the connected ground is instrumental in fixing the trunk advance change and in preventing the release of any link circuit in use on an established call. After the first digit has been received the following relays are operated: 26A, 26A1, 26A3, 26A5, 26C, 26C1, 26C2, 26F, 26K, 26L, 26M, one H relay such as 24H—0, 24K0, 24K1, and 24K2, and one pair of H1 and H2 relays. Relay 26G is in its marking position, relay 27R6 is in its spacing position, relays 27R1 to 27R5 and 27D1 to 27D5 and 27E1 and 27E2 are operated according to the character signal just received, as shown in the table set forth above.

Reception and deciphering of second digit at the large switching center

The second digit of the called line or trunk is received, registered and made to operate the fanning-out relays in the same way as the first digit. Relay 27R6 operates to its marking contact while the stop contacts 2709 are closed and thereby causes the operation of relay 26N, the operating circuit for relay 26N being traceable from grounded battery, through the winding of relay 26N, front contact and right-hand armature of relay 26M, front contact and right-hand armature of relay 26K, conductor 2630, marking contact and

armature of relay 27R6, conductor 2624, back contact and right-hand armature of relay 26R, conductors 2623 and 2622, to ground at the inner right-hand armature and contact of relay 26C1. Relay 26N, upon operating, (1) connects grounded positive battery 2634, through a high resistance 2635, say of 5,000 ohms, to a circuit traceable over the contact and outer left-hand armature of relay 26N, conductor 2636, through the lower winding of relay 26G to ground to prevent any additional incoming pulses from being registered; (2) locks over its inner left-hand armature and contact to grounded conductor 2622; and (3) opens at its right-hand armature and back contact the operating path of relay 26M, the operated pair of relays H1 and H2, and prepares a path for the operation of relay 26N1.

When relay 27R6 returns to its spacing, or left-hand, contact, it causes the operation of relay 26N1 in a circuit traceable from grounded conductor 2624, armature and spacing contact of relay 27R6, conductor 2734, left-hand armature and contact of relay 26F, left-hand armature and front contact of relay 26L, right-hand armature and front contact of relay 26N, through the winding of relay 26N1 to grounded battery. Relay 26N1, upon operating, (1) closes at its armature and front contact a circuit extending from grounded battery, through the windings, in series, of relays 26—OO and 26—BY, front contact and armature of relay 26N1, back contact and outer left-hand armature of relay 26R, left-hand armature and contact of relay 26LU, conductor 2631, through the fanning-out circuit closed by the operated combination of relays 27D1 to 27D5 and 27E1 and 27E2, particular conductor of those designated Nos. 0 to 9 of group 2735, through a normally closed contact and an armature on relay 23T1 or 23T2 or 23T3, and particular conductor of those designated Nos. 0 to 9 in groups 2312, over the closed contacts of one of the operated armatures of one of the relays H1 or H2 of the desired pair to a conductor extending to the desired, or called, line trunk extending to the small switching center, such as conductor 2313 in the case shown and described herein which extends over the normally closed make-before-break contacts of relay 14AD, through the winding of relay 14HH, to grounded battery. Relay 26N1, upon operating, also causes the operation of the slow-acting relay 26N2. It will be noted that as usual the registration remains locked in the direction in which it was last operated.

Testing at the large switching center of a line trunk to the small switching center

The connection of grounded battery through the windings, in series, of relays 26—OO and 26BY to the called trunk lines represented by conductor 2313 as hereinbefore described, ordinarily enables these two relays to determine if the conductor 2313 is terminated in a direct ground which causes the operation of both the relays 26—OO and 26BY, or a 1900-ohm out-of-order ground which results in the operation of relay 26—OO only. However, in a tandem system as herein described, relay 26BY only is required because of the automatic hunting arrangement available for selecting the first idle line trunk of a group as shown in Fig. 14 wherein conductor 2313 may be connected if all line trunks to the small switching center are busy, over the front contact and outer lower armature of an AD relay in each of the line trunks extending to the small switching center to ground.

This test takes place during the slow-operating time of relay 26N2 which begins to operate when relay 26N1 operates. As soon as relay 26N2 operates, relay 26N3 operates in a circuit traceable from ground at the inner right-hand armature and contact of relay 26C1 is connected over the armature and front contact of relay 26N2, the armature and front contact of relay 26—OO to grounded battery, through the winding of relay 26N3. Assuming that the trunk line extending to the small switching center, as shown in Figs. 6 and 14, is idle, in which case ground is not connected to conductor 2313, relay 26—OO will be non-operated and the ground connection at its armature and back contact will cause the operation of relay 26R. Relay 26R, upon operating, (1) removes relays 26—OO and 26BY from conductor 2313 and replaces them by relay 26S whose winding is included in a circuit traceable over conductor 2637, back contact and inner left-hand armature of relay 23T4, conductor 2403, right-hand armature and contact of relay 24K0, conductor 2402 and 1509 in the sequence circuit; (2) causes the release of relay 26N1 by removing at its right-hand armature and back contact, the ground connection at the inner right-hand armature and contact of relay 26C1; (3) prepares at its inner left-hand armature and front contact a path for operating relay 26U and (4) locks to ground at the inner right-hand armature and contact of relay 26C1. Relay 26N1, upon releasing, causes relay 26N2 to slowly release. During the time that relays 26N1 and 26N2 are releasing, ground at the inner lower armature and contact of relay 25D in the miscellaneous alarm circuit is connected in a low resistance path extending through the winding of relay 25E, normally closed contact of relay 25F, conductors 1509 and 2402, contact and right-hand armature of relay 24K0, conductor 2403, inner left-hand armature and back contact of relay 23T4, conductor 2637, through the winding of relay 26S, front contact and outer left-hand armature of relay 26R, inner left-hand armature and contact of relay 26LU, conductor 2631, through the fanning-out circuit to conductor 2313, normally closed make-before-break contacts of relay 14AD, through the winding of relay 14HH to grounded battery. Under the assumed condition that the called line trunk shown in Figs. 6 and 14 is idle, grounded battery permits relay 26S to operate but due to the high resistance of the circuit, relay 14HH remains unoperated. Relay 26S, upon operating, opens the operating path of relay 26U, and closes a path to operate relay 26S1 in a circuit traceable over the front contact and left-hand armature of relay 26S, back contact and armature of relay 26N2, conductors 2623, and 2622, to ground at the inner right-hand armature and contact of relay 26C1. When relay 26N2 releases, ground supplied by the inner right-hand armature and contact of relay 26C1 is connected to the armature and front contact of relay 26S, through the winding of relay 26S1 to grounded battery and relay 26S1 operates. Relay 26S1, upon operating, (1) locks to ground in a circuit traceable over the contact and left-hand armature, conductors 2628 and 2629, to ground at the right-hand armature and contact of relay 26C1; (2) short-circuits at its operated auxiliary contact, the winding or relay 26S and (3) holds open at its right-hand armature and contact, the operating path for relay 26U. With the winding of relay 26S short-circuited, resistance ground supplied by the miscellaneous alarm circuit, connected through the fanning-out

circuit to conductor 2313, will cause the operation of relay 14HH. Relay 14HH, upon operating, (1) operates relays 6SL and 6SL1; (2) disconnects the winding of relay 14BY from the No. 3 armature of relay 6SL1 and (3) connects ground via resistance 643, normally closed contacts associated with ring spring of jack 630A, conductor 702, through the winding of hold "magnet" 7H3, to grounded battery. Hold magnet 7H3 operates and thus connects this called line trunk circuit extending to the small switching center to the calling trunk at the large switching center. Operation of hold magnet 7H3 will cause the closure of the cross bar switch contacts of set 704 at the intersection of the selected trunk and the called line trunk. When hold magnet 7H3 operates, it locks in series with relay 8SL which in turn operates relay 8SL1. Relay 8SL1, upon operating, (1) opens at its inner lower armature and contact, the operating circuit for start relay 16ST2—0 in the trunk sequence group which releases to dismiss the director circuit and (2) permits relay 8R3 to operate intermittently in a circuit traceable from grounded battery, through the winding of relay 8R3, contact and No. 2 armature of relay 8SP1, contact and lower armature of relay 8BL1, inner lower armature and back contact of relay 8R2, outer upper armature and contact of relay 8SL1, upper armature and contact of relay 8RC, contact and No. 6 armature of relay 8A, to grounded interrupter 829. Relay 8R3, upon operating, (1) applies ringing current from source 830 to the transmission conductor 706, (2) operates relay 8B in a circuit traceable from grounded battery, through the winding of relay 8B, inner lower armature and back contact of relay 8SB1, contact and outer lower armature of relay 8R3, conductor 811 to ground at the No. 4 armature and contact of relay 8A and (3) connects ground at its inner lower armature and contact to a circuit extending over conductor 844, contact and No. 3 armature of relay 8SP1, conductor 845, to the ring conductor 706 thereby short-circuiting the line circuit winding of relay 8SP. Relay 8R3, upon operating, and releasing, alternately, under the influence of grounded interrupter 829, therefore connects automatic ringing to the transmission conductor 708. Each time relay 8R3 releases it again sends a steady mark to the transmission conductor 708 and causes the slow-releasing relay 8B to release, resulting in the removal of the short-circuiting ground from the line winding of relay 8SP. Should the circuit be not arranged for automatic ringing, the attachment of the called trunk line to the calling trunk and the consequential release of the director circuit causes the transmission of a space signal to the central office where it is employed to inform the operator to start ringing. The ringing signal received in this trunk and transmitted by the operator causes the operation of relays 8R, 8R1 and 8R2 resulting in the operation of relay 8R3 which in turn acts upon relays 8SP and 8B exactly as if operated from grounded interrupter 829 and the called line is rung in accordance with the ringing received from the central office.

Release of sequence circuit and director circuit at the large switching center

Immediately after the first digit of the called number of the desired line trunk extending to the small switching center, is received by the director circuit at the large switching center, a circuit is closed extending from ground at the release key 2632, outer right-hand armature and contact of relay 26LU, front contact and outer left-hand armature of relay 26M, conductor 2633, through the windings, in parallel, of relays 18H—0, 18H—1 and 18H—2, to grounded battery and relays 18H—0, 18H—1 and 18H2 operate. After the link circuit shown in Fig. 7 has completed the connection of the calling trunk to the called line trunk and relay 8SL and relay 8SL1 have operated, ground is disconnected from the operating circuit of the start relay in the trunk sequence group such as relay 16ST2—0 of the first trunk of the first trunk sequence group causing the release of relay, say, relay 16ST2—0. Relay 16ST2—0, upon releasing, causes the subsequent release of relay 16AL1—0 and extinguishing the call disconnect lamp 1612. Relay 16ST2—0, upon releasing, (1) removes ground from a path including conductor 1611 which extends through the winding of relay 26A1, to grounded battery, the path serving as a locking circuit for the latter relay, provided conductor 1611 is not grounded by another ST2 relay, such as relays 16ST2—1 or 16ST2—9, or 17ST—10; (2) causes the release of the associated relays 16AL—0 and 16AL1—0. Relay 16AL1—0, upon releasing, (1) removes ground from conductor 1615 which extends through the winding of relay 26A to grounded battery and relay 26A releases permitting the director circuit to return to normal; (2) opens the two transmission conductors 808 and 913 thereby disconnecting the trunk circuit from the director circuit; and (3) removes relays 16BO—0 and 16BO1—0 from the trunk circuit, the operating circuits for relay 16BO—0 and 16BO1—0 having been respectively extended over conductors 1618 and 1619 to the miscellaneous alarm circuit. Relay 16AL—0, upon releasing, removes grounded battery from conductor 1622 which extends to the miscellaneous alarm circuit. Relay 25CS of the miscellaneous alarm circuit does not release until the director circuit has returned to normal and upon its release reconnects ground to the circuit (including conductors 2507 and 1701) which extends to the sequence circuit to enable the sequence circuit to handle a new call. The director circuit on returning to normal removes ground at the release key 2632 by the release of relay 26M of the operating circuit of relay 18H—0, 18H—1 and 18H—2 which now is released. Upon the completion of a call, the trunk circuit functions to permit the release of relays 16CH—0 and 16AD—0 which, if the relays 18H—0, 18H—1 and 18H—2 are not operated, release and return to normal. If the chain is held in a fixed condition by the operated 18H—0, 18H—1 and 18H—2, the particular CH and AD relays will remain operated until the fixed condition is removed and then returns this circuit to normal.

As hereinbefore stated, the subscriber's station will be connected to the line trunk circuit which will function to release the sequence circuit. The sequence circuit in turn will function to remove the ground from conductor 1615 and relay 26A therefore releases removing off-normal telegraph ground from the various parts of the circuit including relays 26C and 26C1 and releasing relay 26A1 unless the circuit including conductors 2307 and 1611 is held grounded indicating that another inward call is awaiting completion. Relay 26C1, upon releasing, removes off-normal locking ground from a considerable part of the director circuit. If relay 26A1 releases the distributor motor will be stopped and all remaining parts of the circuit will be deenergized. If, however, relay 26A1 is held operated, the distributor motor is

kept running and the relays 27R1 to 27R5 and the associated fanning-out relays 27D1 to 27D5 and 27E1 and 27E5 are locked in the condition in which they were operated by the last digit. When the next call comes in, the operation will be described as hereinbefore described except as follows: Relay 26B now operates immediately since the motor is running at full speed and relays 26C and 26C1 follow at once upon receiving a closure of the stop pulse contacts 2709 of the distributor. Before this stop pulse is reached, relays 27R1 to 27R5 may be operated to a spacing position through a back contact of relay 26C but in any case the circuit waits to receive "figures" before proceeding with the call. The operation continues as hereinbefore described.

The operation of relay 6SL1, as hereinbefore stated, operates relay 14D in a circuit traceable from ground at the No. 1 armature and contact of relay 6SL1, conductor 644, armature No. 5 and back contact of relay 6CL, conductors 645 and 646 through the winding of relay 14D, to grounded battery. Relay 14D, upon operating, closes at its lower armature and contact an operating circuit for relay 6E and relay 6E operates applying ringing current from source 1437, to a circuit extending over the front contact and upper armature of relay 14D, back contact and No. 6 armature of relay 14D2, conductor 1438, front contact and upper armature of relay 6E, conductor 610, normally closed contacts associated with ring spring of jack 608, conductor 501 of the called line trunk extending to the small switching center. In the case of two-wire operation, the operation of relay 6E also transfers the neutralizing conductor 503 from resistance 615 to ground, providing a metallic circuit for ringing. Relay 6SL1, upon operating, (1) removes ground from the grid element of vacuum tube 1421, permitting condenser 1439 to charge in a circuit traceable from grounded positive battery 1405, conductor 1424, contact and No. 5 armature of relay 6SL, conductor 640, resistance 1425, condenser 1439 to ground, (2) energizes the filaments of vacuum tubes 1419 and 1421 and (3) connects ground at its No. 1 armature and contact to a circuit traceable over conductors 644 and 647, through condenser 1433, to ground at the No. 4 armature and contact of relay 6SL1. Relay 6SL, upon operating, (1) completes the transmission circuit from conductor 638 which now extends to the repeater of Fig. 8 to conductor 605 through the upper windings of supervisory relay 6S1 and send relay 6S, to ground at the armature and contact of relay 5R; (2) completes at its No. 5 armature and contact the circuit extended from grounded positive battery 1405 as hereinbefore traced through the winding of relay 14F, to the plate of vacuum tube 1421; and (3) supplies ground at its No. 3 armature and contact to a circuit extending through the upper winding of relay 14AD. Should it be desired to arrange the line trunks extending to the small switching center on a line hunting basis as well known in machine switching telephony, two additional or upper, armatures may be provided for the AD relay in each line trunk such as relay 14AD for the trunks shown in Figs. 6 and 14. One of these armatures would have a normally closed contact connected through the resistance to a grounded negative battery, such armature being connected to ground, through a normally opened contact and armature, not shown, on relay 25D in the miscellaneous alarm circuit. The other armature of such pair is likewise connected to the normally opened contact and armature of relay 25D and its associated normally opened contacts connected to a similar arrangement of armatures on the AD relay in the succeeding trunk of the group or directly to ground. Therefore, during the time that the sequence circuit is in use and the line trunks to the small switching center are arranged on a hunting basis, ground is placed on the conductor, not shown, extending to an armature on relay 25D in the miscellaneous alarm circuit. Thus the operating ground for relay 14AD supplied by relay 6SL is not effected until ground is removed from the conductor extending to an armature on relay 25D. The originating ground for the circuit including conductors 2507 and 1701 is supplied from the same relay, that is, relay 25D in the miscellaneous alarm circuit. When relay 14AD operates, therefore, no ground is connected to the conductor extending to the next trunk in the group. After approximately one second vacuum tube 1421 becomes conductive to operate relay 14F which in turn operates relay 6CL which locks to a contact at armature No. 1 of relay 14D2. The operation of relay 6CL applies ground to condenser 1439 to cause the vacuum tube 1421 to become non-conducting and in turn release relay 14F. Relay 6CL, upon operating, closes at its No. 1 armature and contact, an operating circuit for relay 14BY which operates to lock relay 14AD operated for the duration of the call. Relay 6CL, upon operating, releases relay 14D which replaces the ringing current on the called line trunk conductor 501 with ground through resistance 1440 to discharge trunk conductors 501 and 503 which are now connected in a loop extending through the small switching center. Relay 6E is released from relay 14D and transfers the line conductors to the main trunk circuit extending back to the central office.

At the small switching center the reception of the ringing current has conditioned the line trunk terminating equipment for the reception of the call and has established connection to its director circuit which places a negative marking potential on the line trunk at the small switching center.

The call from the operator's office is received at the small switching center as a one second interval of twenty-cycle ringing current. Relay 5R1 operates, operating relay 5R5 which operates relay 5R4. The operation of relay 5R4 causes relay 5R5 to release. With relay 5R4 operated and relay 5R5 released, a circuit is completed to operate relay 4R2. Relay 4R2 operates relay 4—ON and relay 4—OC, both of which lock to a back contact and inner lower armature of relay 4D1. Relay 4—ON, upon operating, (1) connects telegraph ground at its Nos. 1 and 2 armatures to the repeater relay 5R, 5S, and 5BK to energize their windings; (2) completes at its No. 5 armature and contact the energizing circuit for the filament of vacuum tube 419, the energizing circuit extending to grounded positive battery 412; (3) connects ground at its No. 3 armature to a circuit for effecting future operation of relay 4SL and (4) completes at its No. 6 armature and contact a circuit extending from ground, contact and inner upper armature of relay 4R2, No. 6 armature and contact of relay 4—ON, inner lower armature and contact of relay 4RC, contact and middle lower armature of relay 4SL1, conductor 433, the right-hand armature and back contact of relay 12BO, and then over two parallel paths, one extending over the back contact and left-hand armature of relay 12DL, through the call-disconnect lamp 1201, conductor 1209, through the

winding of relay 13E to grounded battery and the other path extending over conductor 1221, resistance 1222, through the winding of relay 12ST2, to grounded battery. Call disconnect lamp 1201 lights, relay 13E operates and relay 12ST2 operates. Relay 13E, upon operating, operates relay 13F which, upon operating, causes buzzer magnet 13D—MGT to give an audible alarm during night service. Relay 13E, upon operating, also causes the lighting of a night alarm lamp 1309. Night alarm lamp 1309 and buzzer 13D—MGT may be released during day service by operating night alarm cut-out key 1303.

Relay 4—OC, upon operating, connects ground at its outer lower armature and contact to conductor 416 to operate relay 12AD which operates to remove this line trunk shown in Figs. 4 and 5 from the sequence circuit chain. At the end of the ringing period, relays 5R1, 5R4, 4R2 release and ground at the back contact and inner upper armature of relay 4R2 is now effective to operate relay 12ST2 in the sequence circuit as hereinbefore described and to seize the director circuit for use in establishing the connection to the desired subscriber's station. Relay 12ST2, upon operating, connects ground at its armature and contact in a circuit traceable over conductor 1223, No. 1 armature and contact of relay 11G, conductor 1121, contact and outer left armature of relay 12BOX, through the winding of relay 12TA to grounded battery and relay 12TA operates and locks up through its inner right-hand armature and contact directly to ground at relay 12ST2. Relay 12TA, upon operating, (1) opens at its inner left-hand armature and back contact, the operating circuit for relay 11SC which is traceable from grounded battery and winding of relay 11SC, front contact and outer right-hand armature of relay 11SA, conductor 1199, through the all-trunks-busy circuit, shown diagrammatically, conductor 1299, back contact and inner left-hand armature of relay 12TA, conductor 1211, to ground at the lower spring member on manual service key 1101; (2) closes at its front contact and inner left-hand armature the operating circuit for relay 12TC which is traceable from ground at the lower spring member of manual service key 1101, conductor 1211 to the left-hand armature and front contact of relay 12TA, through the winding of relay 12TC, to grounded battery; (3) connects at its outer right-hand armature and contact a ground connection, through a conductor 2008 to the director circuit to supply a locking path for the motor start relay 20—A1, the operation of which will be hereinafter described.

Relay 12TC, upon operating, extends two conductors of each trunk circuit of a group of five to one of the "U" relays of the five "U" relays shown in Fig. 11. Assume that the trunk selected by the operator at the central office is trunk No. 1 of its particular group of five, then armatures Nos. 1 and 2 of relay 12TC will respectively extend conductors 1221 and 1224 to conductors 1225 and 1226. The ground on conductor 433 as hereinbefore described when relay 4R2 released, is now extended over conductor 1221, contact and armature No. 1 of relay 12TC, conductors 1225 and 1122 in series, contact and No. 1 armature of relay 11GA, conductor 1123, through the winding of relay 11U1 to grounded battery and relay 11U1 operates. Relay 11U1, upon operating, closes at its front contact and inner lower armature a locking circuit for itself, the circuit extending over conductor 1110, armature, back contact and right-hand winding of relay 11GB through the winding of relay 11GF, conductor 1124, to ground at the back contact and left-hand armature of relay 13D. Relay 11GB now operates under the influence of the current in its left-hand winding. Relay 11GB, upon operating, operates relay 11GC in a circuit traceable from grounded battery, through the winding of relay 11GC, front contact and armature of relay 11GB, inner lower armature and front contact of relay 11U1, conductor 1123 to the grounded conductor 433. Relay 11GC, upon operating, operates relay 11GA. Relay 11GB, upon operating, causes the release of relays 11GF and 11GE, successively. Relay 11GE, upon releasing, causes lamp 1125 to light, indicating that the sequence circuit is busy. The release of relay 11GE also causes slow-to-release relay 11GD to operate. Relay 11GD, upon operating, connects ground at its right-hand armature and contact to a circuit traceable over conductors 1117 and 1118, contacts and middle upper armature of relay 11U1, conductor 1226, No. 2 armature and contact of relay 12TC, conductor 1224, through the winding of director circuit relay 12DC to grounded battery and relay 12DC operates. Also relay 11GD, upon operating closes at its outer left-hand armature and contact, a point in the operating circuit of relay 13LS1 but inasmuch as relay 11SC is unoperated at the time, relay 13LS1 does not operate and consequently relay 13H does not operate on a call originating at the central office.

Relay 12DC, upon operating, (1) places ground at its contact and outermost left-hand armature on conductor 1204 for operating director circuit start relay 20—A and relay 20—A operates; (2) connects transmission conductors 1202 and 1203 to conductors 411, and 413, respectively, of the trunk circuit; (3) connects at its innermost left-hand armature and contact, the left-hand winding of relay 12BO to a circuit extending in parallel paths over conductor 2024 and alarm conductor 1225 respectively; (4) connects at its innermost right-hand armature and contact, a ground connection to a path which extends over conductor 1226, contact 434 through the winding of relay 4W to grounded battery relay 4W operating for a purpose to be hereinafter described; (5) connects at its middle left-hand armature and contact, an additional ground for locking relay 11GD. Ground connected to conductor 1226 which leads to the line trunk circuit causes, through the operation of relay 4W, the operation of selecting magnets 3SM—0 to 3SM—9 of the cross bar switch of the link circuit shown in Fig. 3. The operation of the selecting magnets 3SM—0 to 3SM—9 connects ground at the armature and contact of these magnets to conductor 366 which extends to grounded battery through the winding of relay 13D and relay 13D operates. In this case relay 13D, upon operating, causes connection lamp 1308 to light and supplies an additional holding ground for relay 11GD.

Director circuit at the small switching center

When the called line trunk at the small switching center receives permission to route the call through such switching center, the sequence circuit connects the director circuit to the particular, or called line, trunk. The inward transmission path from the line trunk circuit is in marking condition and by means of the contact and armature of gate relay 4G, is connected to conductor 411 which extends over the contact and

outermost right-hand armature of relay 12DC, conductor 1202, normally closed contact of jack 2001, conductor 2002, through the upper winding of relay 20—G to ground. The outward transmission path through the line trunk circuit includes conductor 1203, middle right-hand armature and contact of relay 12DC, conductor 413, upper windings, in series, of relays 4G and 4G1, to grounded battery 412. The sequence circuit, upon seizing the director circuit, placed ground, as hereinbefore stated, on conductor 1204 which causes the operation of relay 20—A. Relay 20—A, upon operating, (1) operates relay 20—A1; (2) removes at its outer lower armature and back contact the ground connection from the grid element of vacuum tube 2017; (3) closes at its outer upper armature and contact an operating circuit for relay 20—A2 and relay 20—A2 operates; (4) supplies at its inner upper armature and contact, a ground for the locking circuit of relay 20—T1, which will be hereinafter described; (5) applies telegraph ground (*a*) through the back contact and armature of relay 20—C to ground the receiving selecting contacts 1905 to 1909 of the start-stop distributor and to operate start magnet 1901 which when operated permits rapid acceleration of the motor by eliminating clutch drag; (*b*) to the lower winding of relay 20—G to grounded battery 2028, current in the lower winding tending to bias relay 20—G to its spacing, or left-hand, position; (*c*) over conductor 2029 to the "stop" pulse contact 1910 of the start-stop distributor; (*d*) over conductors 2029 and 1943 to the potentiometer formed by resistances 1936 and 1935 which is later used in operating the register relays 19R1 to 19R5; (*e*) to the upper winding of relay 19R6 which biases this relay to its spacing, or left-hand, contact and (*f*) to a front contact of relay 20—C1 which is later used to start the "director-ready" signal since relay 20—A1, when operated, closes at its inner lower armature and contact an operating circuit for the distributor motor, the circuit being traceable from grounded battery 2036, resistance 2004, inner lower armature and contact of relay 20—A1, conductor 2031, motor series winding 1930 of motor 1931, resistances 1903 and 1932 to ground and the governor contacts 1933 (U. S. Patent 1,860,556, supra) which are closed while the motor is coming up to speed. Relay 20—A1, upon operating, performs other functions, namely, (1) closes a locking circuit for itself extending over its upper armature and contact, conductor 2008, to ground at the outer right-hand armature of relay 12TA and therefore the motor is kept running under control of the sequence circuit as long as an incoming call is awaiting completion; (2) supplies ground at its outer lower armature and contact, over conductor 2032 to the armature of relays 19R1 to 19R5 to permit these relays to lock in either direction in which they may be operated. While the motor is attaining speed the distributor cams 1923 to 1929 are operating, the receiving-selecting cams 1925 to 1929 successively causing brief closures of each receiving contact, in turn, the contacts being designated 1905 to 1909, respectively. Relays 19R1 to 19R5 will therefore operate and lock in the spacing, or right-hand, direction due to these closures to ground. The spacing locking circuit of relays 19R1 to 19R5 extends through the respective No. 3 windings of the relays and through the winding of relay 19J. Therefore relay 19J will operate as soon as any one of relays 19R1 to 19R5 operate to spacing position. Relay 19J, upon operating, opens the operating path of relay 19F preventing its premature operation. Meanwhile, relay 20—A2, upon operating, has in effect placed the sensitive slow-release relay 20—B across the governor contacts 1933, prepares in advance a circuit for operating the fast-operate relay 20—C, and has opened at its outer lower armature and contact a future operating circuit extending from the armature of relay 20—G to the distributor stop contacts.

When full speed is reached, the governor contacts open momentarily, removing the short circuit around resistance 1903 of relatively high value and allowing relay 20—B to operate through resistances 1904 and 2005. Relay 20—B being of the slow-release type, with the help of condenser 2006 holds over governor contact closures thus operating relay 20—C as soon as the "stop" pulse contacts 1910 close at the end of each character signal received.

Relay 20—C, upon operating, removes ground from the receiving contacts 1905 to 1909 and start contacts 1911 whereby a start magnet 1901 releases, latching the clutch and preventing further operation of the contact cams. Relay 20—C, upon operating, locks in a circuit traceable from grounded conductor 2037, armature, front contact and lower winding of relay 20—C, through the winding of relay 20—C1, conductor 2033, to grounded battery 2038 and relay 20—C1 operates. Relay 20—C1, upon operating, closes at its lower armature and contact the circuit for sending the "director" ready signal to the distant central office, the circuit being traceable from ground on conductor 2037, contact and lower armature of relay 20—C1, normally closed make-before-break contacts of relay 20—N3, conductor 1203, middle right-hand armature and contact of relay 12DC, conductor 413, through the upper winding, in series, of relays 4G and 4G1 to grounded battery 412. Relays 4G and 4G1 operate, relay 4G sending the "director" ready signal to the loop repeater which in turn transmits the "director ready" signal to the operator at the distant central office. Also, relay 20—C1, upon operating, (1) connects at its inner upper armature and contact, the armature of relay 20—G to a circuit extending over the distributor receiving contacts 1905 to 1909 and start contacts 1911 which circuit is open at the outer lower armature and contact of relay 20—A2, preparatory to receiving the pulses of the loop repeater; (2) opens at its outer upper armature and back contact the operating circuit for relay 20—A2 which releases; and (3) provides at its outer upper armature and front contact off-normal ground to a large part of the director circuit including ground on the armature of relay 19R6. Relay 20—A2, upon releasing, removes relay 20—B from the governor contacts 1933, completes the circuit from the armature of relay 20—G to the receiving contacts 1905 to 1909 and starting contacts 1911, and transfers the stop pulse contacts 1910 from the upper winding of relay 20—C to the operating, or lower, winding of relay 19R6 preparatory to receiving pulses from the loop repeater. After the "director" ready signal is sent, the following relays are held operated: 20—A, 20—A1, 20—C, 20—C1, 19J, 20G to its marking, or right-hand, position and relays 19R1 to 19R5 to their spacing, or right-hand, positions. The circuit is now prepared to receive pulses from the central office.

Receipt of director ready signal at the large switching center

The "director ready" signal is repeated at the large switching center to the central office. The "director ready" signal, that is, a negative potential, or marking condition, is received over line trunk conductor **501** at the large switching center to operate relay 6C. Relay 6C, upon operating, closes an operating circuit for relay **14H**, the circuit being traceable from grounded battery **1405**, resistance **1406**, conductor **1407**, resistance **1416**, conductor **1417**, contact and armature of relay 6C, conductor **625**, resistance **1429**, through the winding of alternating current relay **14H**, conductor **1419**, to ground at the marking contact and armature of relay 6P and relay **14H** operates. Relay **14H**, upon operating, closes at its armature and contact, an operating circuit for relay **6C1** which operates. Relay **6C1**, upon operating, (1) closes at its front contact and inner upper armature an operating circuit for relays 6SA and 6DR which operate; (2) connects ground at its inner lower armature and contact to the operating circuit of relay 6CL which operates; (3) connects at its outer lower armature and contact a ground connection to a circuit traceable over conductor **648**, front contact and No. 6 armature of relay 6CL, conductor **647** to the condenser **1433** and (4) transfers at its outer upper armature the transmission circuit comprising the upper winding of relay 6C from ground to the armature of relay 6S. Relay 6SA, upon operating, (1) closes at its lower armature and contact an operating circuit extending from ground, conductor **627**, armature No. 4 and front contact of relay 6SL, conductor **637**, through the winding of relay **14C2**, to grounded battery and relay **14C2** operates and (2) connects at its upper armature and contact, grounded positive battery **629**, through resistance **642**, to the normally closed contacts of the tip spring of jack **631**, ring conductor **632**, contact and outer right-hand armature of hold magnet **7H3**, ring conductor **703**, operated ring contacts of set **704**, conductor **706**, normally closed contacts at the tip spring of jack **803**—B, through the upper winding of relay 8SP, to ground and relay 8SP operates to effect a marking condition toward the main trunk conductor **914** extending to the central office. Relay 8SP, upon operating, closes an operating circuit for relay **8SP1**, the circuit extending from ground at the No. 1 armature and contact of relay 8—ON, conductor **821**, armature and spacing, or left-hand, contacts of relay 8SP, through the winding of relay **8SP1**, to grounded battery and relay **8SP1**, operates. Relay **8SP1**, upon operating, (1) causes the operations of relay 8RC which locks under control of relay **8R2** preventing the start of automatic ringing at the subscriber's station, (2) furnishes an additional ground for holding relay 8—ON operated, the circuit being traceable from ground over its No. 4 armature and contact, conductor **810** and **811**, through the winding of relay 8—ON to grounded battery and (3) locks up under control of relay **8SB1**, the circuit being traceable from grounded battery, through its winding, front contact and its No. 1 armature, conductor **828**, back contact and outer lower armature of relay **8SB1**, to ground at the No. 5 armature and contact of relay 8—ON.

In response to the marking condition received from the small switching center, relay 6R is operated to its marking, or right-hand, position to extend the marking condition through the upper winding, in series, of relays 6S and **6S1**, No. 1 armature and contact of relay 6SL, normally closed contact at tip spring of jack **630**—A, conductor **639**, operated tip contacts of set **704**, conductor **708**, normally closed contacts of tip spring of jack **802A**, upper armature and back contact of relay **8R3**, through the lower winding, in series, of relays 8S and 8L, conductor **809**, to grounded positive battery **901**, and relay 8S remains in its marking, or right-hand, position. Relay 8S in its right-hand position extends the marking condition toward the central office over conductors **831** and **832**, normally closed make-before-break contact of relay **8SB1**, conductor **833**, front contact and No. 3 armature of relay 8—ON which is locked in its operated position by relay **8SP1**, conductor **834**, normally closed contact and tip spring of jack **804** send, main trunk conductor **914**, through the upper windings, in series, of relays **10**—RS and **10**—R, to grounded positive battery. Relay **10**—R does not operate because relay **10**—CT is released. Relay **10**—RS, upon operating to its marking, or left-hand position, removes ground from condenser **1001** and condenser **1001** becomes charged in a circuit extending from grounded positive battery **1008**, resistance **1021**, conductors **1009** and **1010**, resistances **1011** and **1012**, condenser **1001** to ground. When the marking signal is in excess of one-half second, condenser **1001** will charge sufficiently to cause vacuum tube **1003** to become conductive and plate current will flow to operate relay **10**—C. Relay **10**—C, upon operating, operates relay **10**—CT. Relay **10**—CT, upon operating, closes a circuit from grounded battery **1014**, contact and inner lower armature of relay **10**—CT, to the winding of relay **10**—TR to ground and relay **10**—TR operates to remove ground from the ring spring of jack **1032** and ring conductor of the selected cord whereby the supervisory lamp in the operator's cord circuit and controlled by the ring conductor thereof, is extinguished, thereby giving an indication to the operator that the trunk is prepared for teledirection signals. The operator will then transmit the teledirection signals corresponding to the number of the desired subscriber's station. The operator then sends pulses representing, first, "figures" and then the code number of the desired subscriber's station. The listed code number is used in cases where the operator desires a direct connection to a subscriber's station and the unlisted code number of the desired station is used when the operator wishes to connect the called subscriber in a conference circuit. However the conference circuit is not discussed herein and the description which immediately follows, applies to a direct connection and therefore the subscriber's station number will be identified as the listed number.

Receipt of code pulses at the small switching center

The operator at the central office sends pulses representing the preliminary signal "figures" followed by the two digits of the called subscriber's station listed number. The listed number may be that of a single subscriber's line or one of a group of lines; any one of such group being arranged to be automatically selected and if such selected one line of a group is busy hunting facilities are provided whereby the next higher numbered line of the group, that is idle, is selected for the connection. First, the method of establishing a connection to a single subscriber's line will be described, and then, that of establishing a connection to one of a group of lines for which

line hunting facilities are provided will be described.

The pulses representing "figures" are received over the transmission conductor 501 of the line trunk circuit normally closed contacts at the tip spring of jack 538, conductor 539, normally closed contacts at the tip spring of jack 560, conductor 540, outer lower armature and front contact of relay 5TR, through the No. 3 winding of relay 5R, to grounded negative battery 532 at the marking contact and armature of relay 5S. Relay 5R, upon operating, repeats the incoming pulses over conductor 424, armature and contact of relay 4G, conductor 411, outermost right-hand armature and contact of relay 12DC, conductor 1202, normally closed contact and tip spring of jack 2001, conductor 2002 through the upper winding of relay 20—G to ground. The director circuit in conjunction with the sequence circuit decodes the pulses received from the central office and prepares to make connection to the required subscriber's station loop, making a test, however, to determine that this subscriber loop is not busy, out of order, or unassigned. If any one of the above conditions is encountered, characters indicative of the condition are impressed on conductor 413 and therefore repeated by relays 4G and 4G1 and then by relay 5S of the repeater to the transmission conductor 501 of the trunk circuit and eventually appear on the operator's teletypewriter at the central office. Relay 4G1 follows these pulses but relay 5TR which is controlled by relay 4G1 has sufficiently slow-release characteristics to remain unoperated.

For a call to a single subscriber station, the receipt of incoming code pulses in the director circuit at the small switching center

In the case of the call being to a single subscriber station the incoming code pulses received over transmission conductor 501 of the line trunk are repeated by a gate relay 20—G which is normally held to marking, or right-hand, contacts. The distributor motor (Fig. 19) is running but the receiving contacts 1905 to 1909 are not operated because the stop magnet 1901 is in a released position, latching the clutch.

The first character "figures" consists of a start pulse which is always spacing followed by the five selecting pulses, namely, marking, marking, spacing, marking, and marking and these are followed by the stop pulse which is always marking. The start pulse operates relay 20—G to its spacing, or left-hand position thereby closing a circuit extending from grounded battery, through the winding of start magnet 1901, conductor 1922, normally closed start contacts 1911, conductor 2026, outermost lower armature and contact of relay 20—LU, conductor 2025, contact and outer lower armature of relay 20—A2, inner upper armature and front contact of relay 20—CL, conductor 2034, armature and spacing contact of relay 20—G, conductor 2035, contact and outer upper armature of relay 21N, conductor 2115, front contact and outer lower armature of relay 20—A to ground and start magnet 1901 operates and therefore the cams 1923 to 1929 begin rotating under the control of the distributor motor. The motor speed and receiving contacts 1905 to 1909 are adjusted so that at the time the first selecting pulse, say "marking," of the character is received from relay 20—G, contacts 1905 are closed to complete a circuit extending from contact point 1934 in the potentiometer comprising resistances 1935 and 1936, and grounded negative battery 1939, conductor 1937, through winding No 1 of relay 19R1, conductor 1938, closed contact 1905, conductor 2026, outermost lower armature and contact of relay 20—LU, conductor 2025, contact and outer lower armature of relay 20—A2, inner upper armature and contact of relay 20—C1, conductor 2034, to the armature of relay 20—G to which grounded positive battery 2028 is connected. Assuming as stated above that the first selecting pulse is marking, relay 19R1 will operate and lock in its marking, or left-hand, position. Similarly, relay 19R2 will be left either spacing or marking depending on the character of the second pulse. The reception of the "figures" character then proceeds as follows:

Dot element	Relay 20G	Registered relay	Fan relay operated
1	Marking	19R1 (marking)	Relay 19D1.
2	do	19R2 (marking)	Relay 19D2.
3	Spacing	19R3 (spacing)	
4	Marking	19R4 (marking)	Relay 19D4.
5	do	19R5 (marking)	Relay 19D5.

With relays 19R1 to 19R5 operated as above, it will be noted that none of the locking paths of these relays pass through the winding of relay 19J, but if any one is operated, in the reverse direction, relay 19J will be energized. Relay 19J will therefore release only when a "figures" character is received. The succeeding stop pulse which is marking for each character is received at a time when contacts 1910 are momentarily closed by cam 1924 and start contacts 1911 are momentarily opened by cam 1923. When start contacts 1911 are opened, start magnet 1901 releases. A momentary closure of contacts 1910 at the time the stop pulse is received by relay 20—G, a circuit is closed from grounded battery 1939, resistances 1940 and 1941, through the lower winding of relay 19R6, conductor 1942, back contact and outer upper armature of relay 20—A2, conductor 2036, closed contacts 1910, conductors 2029 and 2037, front contact and outer lower armature of relay 20—A to ground and relay 19R6 operates to its marking, or right-hand, position, overcoming the effect of the biasing current flowing in the upper winding. The charge on timing condenser 1912 causes relay 19R6 to remain in its marking, or right-hand, position 4.030 seconds after the stop pulse contact 1910 opens, the discharge circuit extending to ground at the outer lower armature and front contact of relay 20—A in a path including conductors 2037, 2029 and 1943, the upper and lower windings in series, of relays 19R6 and condenser 1912 to ground. This allows time for the operation of relay 19F in a circuit which is traceable from grounded battery, through the winding of relay 19F, armature and contact of relay 19J, back contact and upper armature of relay 19K, marking contact and armature of relay 19R6, conductor 1913, back contact and upper armature of relay 21R, conductor 2102, front contact and outer upper armature of relay 20—C1 to ground. Relay 19F operates and locks to ground over conductors 1944 and 1918, to ground at the front contact and outer upper armature of relay 20—C1. Relay 19F, upon operating, prepares a path for operating relay 19K when relay 19R6 returns to its spacing, or left-hand, contact. In this way relay 19K operates and locks to ground over conductor 1918 to ground at the front contact and

outer upper armature of relay 20—C1 and transfers the marking contact of relay 19R6 from the contact and armature of relay 19J to conductor 2122 which is connected for the succeeding counting or fanning-out relays in preparation for the registration of the next two digits, that is, the two digits of the called subscriber's station listed number.

The reception of "figures" can therefore set up a combination of relays 19R1 to 19R5 locking direct to grounded battery instead of through the winding of relay 19J, thereby releasing relay 19J and allowing the next two characters to be registered. Therefore, "hits" on the line are harmless until the operator has set a preliminary "figures." After the "figures" character has been received, the following relays are operated Relays 20—A, 20—A1, 20—C, 20—C1, 19D1, 19D2, 19D4, 19D5, 19F, 19K; relays 20—G, 19R1, 19R2, 19R4, 19R5 are in their respective marking positions; relays 19R3 and 19R6 are in their respective spacing positions. The operation of relays 19D1, 19D2, 19D4, and 19D5 perform no useful function at this time.

Reception and deciphering of the first and second digits at the small switching center

The first digit of the called subscriber's listed number will be repeated by relay 20—G, broken up pulse by pulse by the distributor contacts and recorded by relays 19R1 to 19R5 in much the same manner as the "figures" character was received. Relay 19R1 is operated in accordance with the position of relay 20—G at the middle of the first pulse, relays 19R2 according to the second pulse, etc. In each case the operating or No. 1 winding of each of relays 19R1 to 19R5, can quickly overcome its associated holding windings Nos. 2 and 3, but otherwise these relays hold in whichever direction they are operated under control of motor start relay 20—A1.

Assume that the listed number of the call subscriber's station is No. 12, the operation resulting from the reception of No. 1 will be herein described first and the order of received pulses constituting the character No. 1 are marking, marking, marking, spacing and marking. In accordance with the description hereinbefore given, relay 19R1 will be in its marking, or left-hand, position. Relays 19R2 and 19R3 will also be in their respective marking, or left-hand, positions. Relay 19R4 will be in its spacing, or right-hand, position and relay 19R5 will be in its marking, or left-hand, position. With relay 19R1 in its marking position, a circuit is closed from ground at the outer lower armature and contact of relay 20—A1, conductor 2032, armature and marking contact of relay 19R1, through the winding of relay 19D1 to grounded battery and relay 19D1 operates. In a similar manner relay 19D2, 19D3 and 19D5 are operated. Relay 19R4 is operated to its spacing, or right-hand, contacts in response to the fourth pulse of the No. 1 digit. A circuit is closed at the time for operating relay 19J, but, as hereinbefore stated, performs no useful function after the "figures" character has been received. At the conclusion of the reception of the dot elements of the particular character transmitted, relay 19R6 again operates to its marking position and is again held for an additional period of .030 second. Relay 19R6, upon operating, to its marking contact, causes the operation of relay 21L in a circuit traceable from grounded battery 2101, through the lower winding of relay 21L, back contact and lower armature of relay 21M, conductor 2122, front contact and upper armature of relay 19K, marking, or right-hand, contact and armature of relay 19R6, conductor 1913, back contact and upper armature of relay 21R, conductor 2102, to ground at the outer upper armature and front contact of relay 20—C1. Relay 21L operates and locks up to ground furnished by relay 20—C1. Relay 19R6 also furnishes ground over the normal contacts of relays 21M, 21N1, 21R and 20—LU to an armature of relay 19D5. From the armature of relay 19D5, the grounded circuit is fanned out by means of the combination of operated and/or unoperated fanning-out relays 19D1 to 19D5 to one of ten conductors designated Nos. 0 to 9 of group 2735. Each of the conductors Nos. 0 to 9 is arranged by means of cross-connecting blocks 1914 and 1915 to operate a relay such as relay 19HA, representing the tens group in which the desired subscriber's station may be found. Relay 19HB represents another tens group of subscriber lines. The operating circuit for relay 19HA is traceable from grounded negative battery through the winding of the relay 19HA, armature and contact of relay 19K1, one of the conductors designated Nos. 0 to 9, for example, say conductor No. 1 which represents the tens groups in which the called subscriber's station No. 12 is located, front contact and armature No. 8 of relay 19D1, front contact and innermost upper armature of relay 19D2, front contact and inner lower armature of relay 19D3, back contact and inner lower armature of relay 19D4, front contact and lower armature of relay 19D5, conductor 1916, back contact and middle lower armature of relay 20—LU, conductor 2007, outer lower armature and back contact of relay 21R, lower armature and back contact of relay 21N1, back contact and lower armature of relay 21M, conductor 2122, front contact and upper armature of relay 19K, marking contact and armature of relay 19R6, conductor 1913, back contact and upper armature of relay 21R, conductor 2102, to ground at the front contact and outer upper armature of relay 20—C1. Thus relay 19HA, upon operating, indicates that the desired subscriber's station is one of those in the group of ten stations, say the second group. In this case the operated relay corresponds to the tens groups of the particular called subscriber's line which is line No. 12. Relay 19HA, upon operating, locks in a circuit traceable from its lower armature and contact, conductors 1917, 1944 and 1918, to ground at the outer upper armature and front contact of relay 20—C1. This locking circuit also serves to operate and lock relay 19K1. Relay 19K1, upon operating, definitely removes the other H relays, such as relays 19HB, 19HC (not shown), etc., in the other tens groups, from its associated conductor of conductors Nos. 0 to 9. Relay 21L, upon operating, prepares a path for the operation of relay 21M. When relay 19R6 returns to its spacing contact after 0.030 second, relay 21M will operate, close a circuit extending from ground, at the outer upper armature and front contact of relay 20—C1, conductor 2102, upper armature and front contact of relay 21M, conductor 2103, front contact and inner left-hand armature of relay 19K1, front contact and upper armature of relay 19HA, conductor 1948, through the winding of relay 19H1, to grounded battery. Relay 19H1 is associated with the particular tens group in which the desired, or called, subscriber line No. 12 is found. Relay 19H2 is associated with another tens group of subscriber lines, and relay 19H3 (not shown)

may be associated with still another group and so on. Relay 19H1, upon operating, connects the closed fanning-out conductor to the desired conductor of conductors Nos. 0 to 9 of the particular tens group of the called subscriber's station. The other relays 19H2, 19H3, etc., corresponding to relay 19H1 and respectively associated with the other tens groups, are through the operation of relay 19K1, prevented from operating during the time that one of the tens group relays, such as relay 19H1, is operated. Relay 21M, upon operating, (1) locks to ground on conductor 2102; (2) opens the operating paths of relays 21L and 19HA and prepares an operating path for relay 21N. Relays 21L and 19HA, however, remain operated over their locking circuit. After the first digit has been received, the following relays are operated: 20—A, 20—A1, 20—C, 20—C1, 19F, 19K, 21L, 21M, 19HA, 19K1, and 19H1. Relay 20—G is in its marking position and relay 19R6 is in its spacing position. Relays 19R1 to 19R5 and 19D1 to 19D5 are operated according to the character just received.

The second digit of the called subscriber's station listed number, say No. 2, is received, registered and made to operate the fanning-out relays in a distinctive combination in the same manner as the combination for the first digit. The order of received pulses constituting the character No. 2 is marking, marking, spacing, spacing and marking. The fanning-out relays 19D1, 19D2 and 19D5 operate in accordance with the combination set up on the register relays 19R1 to 19R5. Relay 19R6 operates to its marking position, while start magnet 1901 is operated thereby causing the operation of relay 21N. The circuit being traceable from grounded battery, through the winding of relay 21N, front contact and lower armature of relay 21M, conductor 2122, front contact and upper armature of relay 19K, marking contact and armature of relay 19R6, conductor 1913, back contact and upper armature of relay 21R, grounded conductor 2102. Relay 21N, upon operating, (1) opens the circuit of the spacing contact of relay 20—G to prevent any additional incoming pulses from being registered; (2) locks to the ground on conductor 2102; (3) opens the operating path of relays 21M and 19H1 and prepares a path for the operation of relay 21N1. When relay 19R6 returns to its spacing, or left-hand position, it causes the operation of relay 21N1. Relay 21N1, upon operating, closes a path extending from grounded battery, through the windings, in series, of out-of-order relay 21—OO and busy relay 21BY, front contact and lower armature of relay 21N1, back contact and outer lower armature of relay 21R, conductor 2007, middle lower armature and back contact of relay 20—LU, conductor 1916, lower armature and contact of relay 19D5, inner lower armature and back contact of relay 19D4, inner lower armature and back contact of relay 19D3, innermost lower armature and front contact of relay 19D2, No. 7 armature and contact of relay 19D1, to conductor No. 2 of the conductors Nos. 0 to 9, armature No. 2 and contact of relay 19H1 which remains operated in its locking circuit, conductor 1945, normally closed contact at the ring spring of jack 308A, conductor 311, through the winding of "hold" magnet 3H2, to grounded battery. The locking circuit for relay 19H1 may be traced over the upper armature and contact of relay 19HA, inner left armature and contact of relay 19K1, conductor 2103, front contact and upper armature of relay 21M to grounded conductor 2102. "Hold" magnet 3H2 corresponds to the line extending to the called subscriber's station 202, the listed number of which is assumed herein to be No. 12. Also relay 21N1, upon operating, closes at its upper armature and contact, the operating circuit of slow-acting relay 21N2, which operates. It will be noted that as usual the registration relays 19R1 to 19R5 remain locked in the direction in which they were last operated.

Testing the called subscriber line

The connection of grounded battery through relays 21—OO and 21—BY to the particular called subscriber line enables these two relays to determine if conductor 311 connected to conductor 311' and to the winding of the hold magnet of the called subscriber line is terminated in a direct ground which causes the operation of both relays 21—OO and 21—BY or in a high resistance out-of-order ground which may be connected to the ring spring of an out-of-order jack, patched to jack, say jack 308B, of the called subscriber line which results in the operation of relay 21—OO only. In case no ground is available neither of the relays 21—OO and 21—BY operates. This test takes place during the slow-operating time of relay 21—N2, which, as indicated above, begins to operate when relay 21—N1 operates. As soon as relay 21—N2 operates, the off-normal ground on the front contact and outer upper armature of relay 20—C1 is connected in a circuit extending over conductor 2102, armature and front contact of relay 21—N2, to the armature of relay 21—OO. Assume that the called subscriber line is idle, in which case ground is not connected to conductor 311, relay 21—OO will be unoperated and ground connected to its armature by the operation of relay 21—N2 will cause the operation of relay 21—R. Relay 21—R, upon operating, (1) removes relays 21—OO and 21—BY from conductor 311 of the called subscriber line and replaces them by relay 21—S; (2) causes the release of relay 21—N1 by removing ground, the ground being furnished over conductor 2102 which is connected to its upper armature; (3) prepares an operating circuit for relay 21—U; and (4) locks to grounded conductor 2102. Relay 21—N1, upon releasing, causes relay 21—N2 to slowly release. During the time that relays 21—N1 and 21—N2 are releasing, ground at the No. 3 armature and contact of relay 13D is connected to a circuit extending through high resistance 1301, conductors 1302 and 1205, outer left-hand armature and contact of relay 19K1, conductor 1921, through the winding of relay 21—S, front contact and outer lower armature of relay 21—R, conductor 2007, middle lower armature and contact of relay 20—LU, conductor 1916, lower armature and contact of relay 19D5, inner lower armature and back contact of relay 19D4, inner lower armature and back contact of relay 19D3, innermost lower armature and front contact of relay 19D2, No. 7 armature and front contact of relay 19D1, to conductor No. 2 of conductors Nos. 0 to 9, and as hereinbefore traced over conductor 311, through the winding of "hold" magnet 3H2 to grounded battery. Under the assumed condition of the called subscriber line being idle, grounded battery on the winding of "hold" magnet 3H2 of

the cross bar switch in the link circuit, permits relay 21—S to operate, but due to the high resistance 1301 in the circuit, the "hold" magnet 3H2 remains unoperated. Relay 21—S, upon operating, opens the operating circuit of relay 21—U, and closes an operating circuit for relay 21—S1 which operates in a circuit traceable over the armature and back contact of relay 21—N2. Relay 21—S1, upon operating, (1) locks over grounded conductor 2102, (2) short-circuits the winding of relay 21—S and (3) holds open the operating circuit of relay 21—U. With the winding of relay 21—S short-circuited, the ground at the No. 3 armature and contact of relay 13D which is connected to the circuits hereinbefore traced is now effective to cause the operation of hold magnet 3H2 which operates to move its vertical row of contact sets into engagement with their respectively associated sets of horizontal conductors, a set of horizontal conductors associated with the selected trunk 401 having already been moved into its operated position by the operation of selecting magnet 3SM—1, the called subscriber line will therefore be connected at contact set 355 to the trunk circuit 401 which will function to release the sequence circuit. The sequence circuit, in turn, will function to remove the ground from conductor 1204 to release relay 20—A. Relay 20—A, upon releasing, removes ground from the various parts of the circuit including relays 20—C and 20—C1 and releasing relay 20—A1 unless conductor 2008 is connected to ground at relay 12TA, indicating that another inward call is awaiting completion. Relay 20—C1, upon releasing, removes locking ground from a considerable part of the director circuit. If relay 20—A1 releases, the motor will be stopped and all remaining parts of the circuit will be deenergized. If, however, relay 20—A1 is held operated, the motor is kept running and relays 19R1 to 19R5 and the associated fanning-out relays 19D1 to 19D5 are locked in the condition at which they were operated by the last digit of the called subscriber line number. When the next call comes in, the operation will be as described above, except as follows: relay 20—B now operates immediately since the motor is running at full speed and relays 20—C and 20—C1 follow at once upon receiving a closure of the stop pulse contact 1910 of the start-stop distributor. Before the stop pulse is received, relays 19R1 to 19R5 may be operated to spacing through the back contacts of relay 20—C, but in any case the circuit awaits to receive "figures" before proceeding with the call. If the inward call is to a busy called subscriber line or an out-of-order line, the operation of the call is exactly the same as hereinbefore described up to the point where the operation of relay 20—N1 connects relay 21—OO and 21BY to conductor 311 of the called subscriber line circuit. At this time, however, conductor 311 terminates in direct ground (busy) or ground connected through a resistance to the ring spring of the out-of-order jack which is patched to a jack of the called subscriber's line, the jack corresponding to jack 308B of subscriber's line 302. The direct ground established by a busy condition may be traced over conductor 1945, normally closed contacts at the ring spring of jack 307A, conductors 311 and 354, operated sleeve contacts of set 355, conductors 357, and 420 through the winding of relay 4SL to ground at the No. 3 armature and contact of relay 4—ON. In either case of busy condition, relay 21—OO quickly operates but relay 21BY is marginal and operates only on direct ground. Relay 21—OO, upon operating, prevents relay 21R from operating and therefore, relay 21N1 remains operated keeping relays 21—OO and 21BY connected to conductors 311 and 354. Relay 21—OO therefore remains operated along with relays 21N, 21N1, and 21N2 and also operates relay 20—N3. Relay 20—N3, upon operating, (1) applies at its upper armature and contact, ground to start recording "K" or "Q" characters by producing the corresponding signals through the operation of relays 20—P and 20—P1; (2) connects the contacts of relay 20—P1 to the outward transmission path, the connection being established over its outer lower armature and front contact and extending over conductor 1203. Relay 20—P and 20—P1 operate in a condenser timed circuit to generate "K" and "Q" signals as follows: When the ground is applied to one end of the potentiometer, comprising resistances 2104, 2009, and 2010, relay 20—P will operate to its spacing, or left-hand, position, due to current flowing in its upper winding. When the armature of relay 20—P is in its left-hand position, the current in the upper winding of the relay is reversed but the discharging of condenser 2044 through the lower winding of the relay holds the relay to its spacing, or left-hand, position until the discharge current is so reduced that the upper winding of the relay regains control and operates the armature to its marking, or right-hand, position. Here the process is repeated, the upper winding of relay 20—P, tending to make the relay armature return to its spacing position while the conductor in charging holds it to its marking, or right-hand, position until their effect is overcome. The condenser and potentiometer resistances are so proportioned that relay 20—P will pulse at about 9 cycles per second if resistance 2009 is in the circuit or eleven cycles per second if resistance 2009 is shirt-circuited. As will be seen hereinafter, if the line were busy, relay 21BY, upon operating, would cause "K" signals to be sent; if out of order, the relay 21BY is released and "Q" signals will be sent.

When the ground is connected by relay 20—N3, relay 20—P1 will operate to its marking, or left-hand, position due to current in its upper winding. This maintains a marking signal over the outward transmission path which is hereinbefore traced as extending through the upper windings, in series, of relays 4G and 4G1. However, when relay 20—P opens it marking, or right-hand, contacts, condenser 2015 will charge through the lower winding of relay 20—P1 to cause relay 20—P1 to leave its marking, or left-hand, position for one pulse length (approximately .022 second), the charging originating in grounded battery 2109 and extending through the resistances 2110 and 2111, over conductor 2116. Relay 20—P1 then returns to its marking, or left-hand, position and after relay 20—P operates to its marking, or right-hand, position, condenser 2015 is discharged through resistance 2016. Since relay 20—P is pulsing continuously, relay 20—P1 will send out a spacing pulse of .022 second every time relay 20—P opens its marking, or right-hand contacts. In this way relay 20—P drives relay 20—P1 at either

9 or 11 cycles per second, sending "K" signals if the line is busy and "Q" signals if the line is out of order. These characters are transmitted over the line and printed on the operator's teletypewriter at the distant central office for a time interval of 1 second. The timing arrangement will be described hereinafter.

Connection to unassigned or impossible number

If an unassigned number or non-numerical code is received and registered, the circuit functions as described hereinbefore. When, however, relay 21S is connected to the circuit extending over conductor 1921, over outer left-hand armature and contact of relay 19K1, conductors 1205 and 1302 as hereinbefore traced, when testing a particular called subscriber line for an indle condition, grounded battery on the winding of hold magnet such as hold magnet 3H1 for a subscriber line station 201 is not available and relay 21S fails to operate. When, therefore, relay 21N2 releases, off-normal ground will be connected to the winding of relay 21U, causing relay 21U to operate. Relay 21U, upon operating, closes at its inner lower armature and front contact, an operating circuit for relay 20—N3, causing ground through the operation of relay 20—N3 to be connected to relays 20—P and 20—P1 and associated apparatus as hereinbefore described, and disconnects resistance 2113 which was in parallel connection with resistance 2114. Resistance 2114 is in the circuit inasmuch as the shunt around the outer lower armature and contact of relay 21U has been opened. Under these conditions relay 20—P operates at approximately 6 cycles per second. When relay 20—P operates to its spacing, or left-hand, position, relay 20—P1 is operated to its spacing, or right-hand, position for two pulse lengths, that is, 0.044 second, by a charging condenser 2015. Relay 2051, upon returning to its marking, or left-hand, position remains in that position until relay 20—P again operates to its spacing, or left-hand, position, thus a signal corresponding to a "V" or ⅜ character is generated and transmitted to the operator's teletypewriter at the distant central office.

When the director circuit at the small switching center times out

When the director circuit at the small switching center was first seized, the operation of relay 20—A removed at the outer lower armature and back contact of the relay a ground connection from the grid of vacuum tube 2017, thereby permitting condenser 2018 to start charging from grounded battery 2019, through resistances 2020, 2021 and 2022. If a call is not completed and the director circuit dismissed within a 10-second period, the charge on condenser 2018 and thus the voltage on the grid of vacuum tube 2017 is of such value that the plate current operates relay 20—T which, in turn, operates relay 20—T1. Relay 20—T1, upon operating, (1) transfers transmission conductor 2003 from its back contact and No. 5 armature to its front contact and No. 4 armature so that the transmission conductor is now connected to the marking, or right-hand, contact of relay 20—P instead of to the marking, or left-hand, contact of relay 20—P1; (2) operates relay 20—N3 and (3) removes the shunt from resistances 2009 and 2011. Relay 20—P with the resistance change in its upper winding operating circuit pulses at approximately 8 cycles per second rate, the charge and discharge on condenser 2044 holding the armature of relay 20—P on its marking, or right-hand, contacts 0.123 second and on spacing, or left-hand, contacts 0.110 second. Thus the signal generated by relay 20—P has a spacing period equivalent to a start pulse and four character pulses and a "T" or "5" character is generated and sent to the operator's teletypewriter at the distant central office for a period of 1 second.

Signal limiting feature at small switching center

Busy, or out-of-order, unassigned and director circuit timed-out signals are all limited to 1 second as mentioned above. The operation is as follows: When relay 20—N3 operates ground is connected through a winding of relay 20—TA which operates and locks to ground on the contact of relay 20—TB. Relay 20—TA, upon operating, (1) operates a relay 20—TB which locks directly to ground at the inner lower armature and contact of relay 20—N3; and (2) connects at its middle upper spring member, which is normally opened, a ground connection to the grid of vacuum tube 2017 to recycle the vacuum tube in case relay 20—T1 has operated. Relay 20—TB, upon operating, (1) opens the operating and locking circuits of relay 20—TA; (2) removes resistances 2022 from the charging circuit of condenser 2018; and (3) transfers the armature and contact of relay 20—T from the winding of relay 20—T1 to the contact at the outer lower armature of relay 20—TA. Relay 20—TA, upon releasing, completes a circuit extending over the contact and outer lower armature of relay 20—TA, conductors 2023 and 2024, innermost left-hand armature and contact of relay 12DC, through the left-hand winding of relay 12BO to grounded battery. At approximately 1 second, relay 20—T operates, connecting ground to grounded battery through the left-hand winding of relay 12BO. Relay 12BO, upon operating, locks the trunk out until released at the distant central office and immediately releasing the director circuit to restore all relays to normal.

With reference to the registering relays 19R1 to 19R5 being operated in different combinations in accordance with the pulse combinations received from the distant central office for the establishment of connections to local subscriber lines, the following table shows the relative positions of each of the relays for each character received. "M" indicates marking, "S" indicates spacing.

Characters	Characters	Relays	Relays	Relays	Relays	Relays
Lower case	Upper case	19R1	19R2	19R3	19R4	19R5
Figures	Figures	M	M	S	M	M
P	0	S	M	M	S	M
Q	1	M	M	M	S	M
W	2	M	M	S	S	M
E	3	M	S	S	S	S
R	4	S	M	S	M	S
T	5	S	S	S	S	M
Y	6	M	S	M	S	M
U	7	M	M	M	S	S
I	8	S	M	M	S	S
O	9	S	S	S	M	M

"All-trunks-busy" circuit operation at small switching center

For a description of the operation of the "all-trunks-busy" circuit, reference may be made to the copending application of W. V. K. Large and F. J. Singer, Serial No. 462,966, supra. The all-trunks-busy circuit describes the transmission of

letters to the subscriber's station during the call no-circuit period.

Test circuit at the small switching center

Reference to the test circuit at the small switching center may be made to the copending application of W. V. K. Large and F. J. Singer, Serial No. 462,966, supra.

Alarm features at the small switching center

The alarm features are shown in Fig. 13 as part of the sequence circuit for the equipment at the small switching center. Vacuum tube 1301 has a plate current which is normally flowing to maintain relay 13A operated. The grid element of vacuum tube 1301 normally has grounded positive battery 1310 normally connected in a circuit traceable through resistance 1311, over conductor 1312, contact and outermost left-hand armature of relay 11G, conductor 1112, No. 6 armature and contact of relay 11GA, contact and right-hand armature of relay 11GE, conductor 1119, and then in parallel paths, one path extending through condenser 1313 to ground and the other path extending to the grid element of vacuum tube 1301. Relay 13A in its normally operated condition holds relays 13A1, 13A2 and 13A3 also in an operated condition. Condensers 1313 and 1126 are in a charge condition normally because of this normally charged circuit. When a call, either incoming or outgoing at the small switching center, causes relay 11G, the main gate relay, to operate, grounded positive battery 1310 is, therefore, disconnected from the grid circuit of vacuum tube 1301 and condensers 1313 and 1126 start discharging through resistances 1314, 1315 and 1307. If a call should succeed in operating relay 11G and progress no further toward completion, the alarm circuit would function at the end of approximately 50 seconds. Should the call proceed to a point where relay 11GE is released and then fail to proceed, the alarm circuit would operate in approximately 15 seconds due to the removal of condensers 1126 from the grid circuit of vacuum tube 1301. In the case of an outgoing call, the operation may continue to include the operation of relays 13LS1 and 13H and then fail. Under these conditions the alarm circuit will operate in approximately 4 seconds due to the removal of resistance 1307 from the grid element circuit. When, under any of the above conditions, the charge on the grid condenser 1313 or condensers 1313 and 1126 drops to a point where the plate current will no longer hold relay 13A operated, that relay, in releasing, releases relay 13A1. The release of relay 13A1 (1) opens the operating circuit of relay 13A2; (2) opens a holding circuit for relay 13A3; (3) connects ground to the innermost left-hand armature and contact of relay 12DC.

In case the call is incoming, relay 12DC is operated and the ground supplied by relay 13A1 operates relay 12BO which (1) operates relay 12AD to advance the chain to the next idle trunk and (2) transfers the ground on conductor 433 from the call disconnect lamp 1201 and conductor 1221 to its own holding, or right-hand, winding. Relays 11GE, 11GF, 11GB, 11GC, 11GD and 11GA, the operated relay of relays 11U1 to 11U5, together with relays 12TC, 12TA, 12BOX and 12ST2 returned to their normal idle condition completing the circuit for restoring the positive potential from grounded battery 1310 to be grid element of vacuum tube 1301 as hereinbefore traced when the alarm relays resume their normally operated condition.

In case of an emergency, such as failure of the sequence circuit, in which the automatic features of the switching unit are in trouble, manual service key 1101 will be operated by the attendant. The manual service key 1101 when operated makes the trunk sequence ineffective so that a director cannot be attached to a trunk and the subscriber portion of the sequence circuit cannot complete its task of automatically selecting an idle trunk and connecting the subscriber to it. The operation of this key causes the manual service lamp 1102 to flash. An outward call will be indicated by the lighting of the call lamp, such as lamp 306 associated with the subscriber line of subscriber station 202.

An inward call will be indicated by a lighted call disconnect lamp associated with the trunk sequence circuit, such as lamp 1201 of the trunk sequence circuit associated with the trunks shown in Figs. 4 and 5. The attendant will connect a double plug patching cord between the jacks 435A and 436B of the line trunk circuit and the jacks of the subscriber line associated with the attendant's line of the test circuit, such as jacks 307A and 308B of the subscriber's line of station 202, making sure that the attendant's teletypewriter is connected. The operator types the calling number of the desired subscriber's station which appears on the attendant's teletypewriter. The attendant then makes a busy test of the required subscriber line by connecting a patching cord between the two jacks of the required line such as jacks 307A and 308B of the line of subscriber station 202 and the busy test circuit. If the line is busy the lamp of the busy test circuit lights and the attendant will then manually send "K" signals to the operator from his teletypewriter. If the line is idle, he will patch directly from the trunk jacks 435A and 436B to the line jack, say jacks 307A and 308B. A description of the test circuit may be had by referring to the copending application of W. V. K. Large and F. J. Singer, Serial No. 462,966, supra.

At the conclusion of the call when both subscriber and operator have disconnected, ground on conductor 1208 will operate relay 12DL, which will lock to ground on conductor 1209 and light call disconnect lamp 1201. When the cord is removed from the subscriber line jacks, say jacks 307A and 308B, relay 12DL releases extinguishing lamp 1201. The night alarm circuit involving relay 13F and 13E and buzzer 13D—MGT was hereinbefore described.

Alarm features at the large switching center

As described hereinbefore, during the routing of a call established by the subscriber or one established by the distant central office operator, relay 25ST is operated in the miscellaneous alarm circuit. The interval used in routing the call is timed to see that it does not exceed a certain specified limit and thus prevent the permanent disabling of the trunk and subscriber group sequence circuit. In case of an outward call the miscellaneous alarm circuit times out in 2 seconds and a ground is placed on conductor 946 if the indications are that the trunk is not in trouble. Since the AL1 relay associated with the particular subscriber group containing the calling subscriber line, say 15AL1—G0 for its associated group of subscriber lines, is operated. Ground on conductor 1618 will cause the operation of a BO relay in Fig. 15, such as relay

15BO—G0, which in turn will lock under the control of the associated subscriber group release key such as key 1510. The operation of the BO relay, say relay 15BO—G0, will cause the release of the associated relay 15ST1—G0 and 15AL—1 and light a lamp such as lamp 1511 indicating that the subscriber subgroup is in trouble. Relay 15BO—G0 prevents any subscriber of the particular subgroup from entering the subgroup sequence circuit, thus removing that particular group of subscribers' stations from outward service. The release of relay 15ST1—G0 permits the release of the associated relay 15AL—0. Relay 15AL—G0 released causes relay 18LS—1 or relay 18LS—2 to release, which sends a ground potential to the trunk advance chain. The trunk advance chain functions, causing the release of the associated LS1 relay such as relay 18LS1—1 or 18LS1—2. But if the trunk has not been connected to the calling line, the "advance" is not locked up. The release of the 18LS1 relay causes the release of the relays 18H—0, 18H—1 and 18H—2 as hereinbefore described. Relay 25CS of the miscellaneous alarm circuit is meanwhile held operated for approximately 1 second longer to permit all this action to be completed and upon release reconnects ground to the circuit including conductors 2507 and 1701 of the entire switching center chain. This reconnection of ground permits all other outward calls except those originated by the subscribers in the group out of service, to be routed through the switching center. An appropriate alarm is sounded by the miscellaneous alarm circuit and, together with the lamp indicating the group in trouble, gives an indication to the attendant of the existing type of trouble. The group subscriber station remains out of service until the attendant has removed the trouble and then operates the subscriber group release key 1510 associated with the illuminated lamp 1511. The operation of key 1511 causes the release of relay 15BO—G0, returning the busy-out feature to normal, extinguishing the trouble lamp and permitting the particular subscriber group access to the sequence circuit and in turn to calling service.

If the miscellaneous alarm circuit times out in 2 seconds on an outward call and the indications are that the trunk conductors, or some part of the trunk relay equipment, is at fault, ground is not placed on conductor 1618 but connected to conductor 846 which is included in a circuit traceable over the contact and No. 2 armature of relay 8ST, conductor 847, front contact and lower armature of relay 25TK, contact and outermost upper armature of relay 28TM1, contact and inner lower armature of relay 25TM, conductor 2514, to ground at the inner lower armature and contact of relay 25ST. It would be noted by referring to Fig. 18 that conductor 847 is multipled to all the trunk circuits. The particular trunk circuit preselected at the time by the outward call, say the trunk circuit shown in Figs. 8 and 9, is the only trunk circuit that is in a position to utilize the ground on the contact and inner lower armature of relay 25ST and this ground causes relay 16BO—G0 which is associated with the trunk circuit shown in Figs. 8 and 9 to operate. Relay 16BO1—0, upon operating, locks under control of its associated trunk release key 1620 and at its outer upper armature and contact connects ground to the upper winding of relay 16BO—0 which also operates. Relay 16BO—0, upon operating, (1) connects at its middle upper armature and contact a ground connection to conductor 831 which extends to grounded battery through the winding of relay 16CH—0 which operates and causes in turn the operation of relay 16AD—0; (2) locks at its outer lower armature and contact under control of any mark signal of the distant central office, the control being had by relay 9CT1 which is operated in response to a mark signal from the central office. The operation of relay 16BO1—0 also causes the associated trunk lamp 1621 to flash under the influence of interrupter 1704 as an indication that the trunks are in trouble. The operation of relay 16CH—0 and 16AD—0 removes the possibility of using that particular trunk on the outward call, but permits this outward call to be connected to the next idle trunk. Under this condition, therefore, the subscriber will receive service even though the connection of the distant central office is slightly delayed. If the path to the distant central office is in trouble, obviously no signal can be sent to it and trouble of such a nature will become apparent when the distant operator selects the trunk to originate an inward call. The miscellaneous alarm, therefore, has effectively removed the trunk from service on an outward call and may have given a trouble indication to the operator at the distant central office. When the trouble is cleared by the attendant the trunk may be put back into service by momentarily operating the key 1620 which causes the release of relay 16BO1—0. Relay 16BO1—0, upon releasing, removes ground from the secondary or upper winding of relay 16BO—0 at the same time changing the lamp 1621 from a flashing condition to a steady light condition. Relay 16BO—0 will, however, remain operated under control of a marked signal that might be received from the distant central office. At the conclusion of this mark signal, relay 16BO—0 releases. Relay 16BO—0, upon releasing, causes (1) the release of relays 16AD—0 and 16CH—0 and readmits the trunk circuit to the trunk advance chain making it available to a subscriber's originating outward call and (2) extinguishes the trunk lamp 1621.

On an inward call the miscellaneous alarm circuit permits three separate timing intervals, 2 seconds being allowed to place the director circuit in an off-normal condition, a total of 4 seconds being allowed for the director circuit to provide itself in a position to receive the teletypewriter characters typed by the operator at the distant central office and 10 seconds in which to completely fulfill its function. When the miscellaneous alarm circuit times out at the conclusion of the 10-second interval, it places ground on conductors 1618 and 1619, if it has been determined that the trouble causing the failure of the inward call to be routed through the switching center might possibly exist in the trunk sequence or trunk circuit, but grounds only conductor 1618 if it has been determined that a trouble does not exist in either of the two circuits. If conductors 1618 and 1619 are both grounded, relays 16BO—0 and 16B1—0 operate and are locked under control of both the trunk release key 1620 and any marked signal that may be received from the distant central office (controlled by relay 9CT1) causing the associated trunk lamp 1621 to flash and connecting a ground to the operating circuit of relays 16CH—0 and 16AD—0, operating both. When the interval is 10 seconds, the director circuit is arranged to send a 1-second series of "T" signals to the distant central office as a reorder signal. In addition, the operation of relay

16BO—0 removes battery from the operating winding of 16ST2—0 causing the release of relays 16ST2—0 and 16AL1—0. Relay 16ST—0, upon releasing, removes ground from conductor 1611 which extends to the outer right-hand armature of relay 26A1 in the director circuit and causes the release of relay 16AL—0 which releases relay 16AL1—0. Relay 16AL1—0, upon releasing, opens the operating circuit of relays 16BO—0 and 16BO1—0, disconnects the trunk circuit from the director circuit, removes the starting ground from conductor 1615 which extends through the winding of start relay 26A in the direct circuit, and removes ground from conductor 1607 which is employed in the operating circuit of relay 8M in the trunk circuit. Relay 16AL—0, upon releasing, removes grounded battery from conductor 1622 which extends to the miscellaneous alarm circuit over conductor 1807 to the winding of relay 25ST to ground permitting relay 25ST of the miscellaneous alarm circuit to release, if it is not held operated from some other source, and reconnects ground to conductor 1624, thus permitting the sequence circuit to handle a new call in either direction. The operation of the CH and AD relays, such as relays 16CH—0 and 16AD—0, removes the trunk circuit from the trunk chain as far as an outward call is concerned. After the trouble has been cleared, the attendant restores the trunk to service by momentarily operating the key associated with the flashing lamp 1621 and as indicated heretofore the relay 16BO—0 will remain operated until any marking signal that might be received from the distant central office is terminated. At the conclusion of any such marking signal, the trunk circuit is restored to service. If, however, it has been determined that neither the trunk sequence circuit nor the trunk circuit is in any way responsible for the failure of the inward call, conductor 1618 alone is grounded causing the operation of relay 16BO—0 which, as described hereinbefore, takes the trunk circuit out of service temporarily as long as a marking signal is received from the distant central office. At the conclusion of such a marking signal the trunk is restored to service.

Miscellaneous Alarm Circuits

Description of operation

When a subscriber originates an outward call and the sequence circuit is called into use, grounded battery is placed on conductor 1807 causing the operation of relay 25ST. Relay 25ST, upon operating, (1) removes ground from the director transfer key 2802 to prevent a manual transfer from one director circuit to the second director circuit; (2) causes the operation of relay 25CS; (3) furnishes a ground connection to supplement the one on the director transfer key 2802 to nullify the return to normal of that same key and to continue the particular director circuit in use during the routing of the call through the switching center. The operation of relay 25CS removes ground from conductor 1701 to the sequence circuit, preventing further use of the sequence circuit on a new call, connects locking ground for the time measuring relays and connects the 60—IPM interrupter 2518 supply to relay 28P which follows the ½-second open and ½-second closed 60—IPM interrupter. The first operation of relay 28P causes the operation of relay 28A1; upon the release of relay 28P, relay 28B1 operates. With the relays 28A1 and 28B1 operated, relay 28A2 operates. On the next closure of relay 28P, relay 28A1 releases causing the operation of relay 28B2. On the next open of relay 28P, relay 28B1 releases. After the third release of relay 28P (which would occur 2 to 2.5 seconds after relay 25ST had operated, if the relay 25ST remained operated), ground on the contact of relay 25CS is connected in a circuit extending over conductors 2509 and 2803, lower armature and back contact of relay 25K2, conductor 2511, outer upper armature and contact of relay 28B2, outer upper armature and contact of relay 28A1, outer upper armature and contact of relay 28B1, conductor 2804, through the winding of relay 25TM to grounded battery, and relay 25TM operates. Relay 25TM, upon operating, (1) closes the operating circuit for relay 28TM1, the circuit being traceable from grounded battery, through the upper winding of relay 28TM1, conductor 2805, contact and inner upper armature of relay 25TM, conductor 2512, inner upper armature and back contact of relay 25K5, to ground at the contact and outer upper armature of relay 25K2 and relay 28TM1 operates; (2) connects ground at the contact and inner lower armature of relay 25ST in a circuit traceable over conductors 2513 and 2514, inner lower armature and contact of relay 25TM, inner upper armature, contact and upper winding of relay 25TK, to grounded battery for holding relay 25TK operated; and (3) opens the operating path of relay 28TR, which path may be traced from grounded battery 2806, armature and contact of relay 28LT, through the lower winding of relay 28TR, back contact and outer upper armature of relay 28DA2, conductor 2807, contact and inner upper armature of relay 28K2, outer lower armature and contact of relay 25TM, conductor 2513, contact and inner lower armature of relay 25ST, to ground. Relays 25K5 and 25K2 being normal, relay 28TM1 operates immediately, locking under control of relays 28B1 and 25CS, placing a supplementary ground on relay 25CS, preparing a path for testing the subsequent release of the sequence circuit and connecting ground obtainable on the contact and inner lower armature of relay 25ST to other contacts on relay 25TK. During the routing of the outward call, the trunk circuit sends the calling-in signal to the central office and awaits the reception of ringing current sent automatically from the central office. If this calling-in signal was not received at the central office, due to a faulty conductor or if the calling-in signal fails to be registered at the central office, or if in any event the ringing current fails to be received in the large switching center, ground on conductor 801 would continue to keep relay 25TK operated causing it to lock the moment relay 25TM operates. Therefore, the ground furnished by relay 25ST and directed to the lower armature and front contact of relay 25TK by means of the inner lower armature and contact of relay 25TM and the outermost upper armature and contact of relay 28TM1, would be applied to conductor 847 which extends to the lower winding of relay 16BO1—0 in the sequence circuit and to the operating, or upper, winding of relay 25TKA in a circuit which may be traced over the grounded conductor 2514, inner lower armature and contact of relay 25TM, outer lower armature and back contact of relay 25K1, outer upper armature and front contact of relay 25TK, through the upper winding of relay 25TKA to grounded battery. Ground on conductor 847 causes relay 25SU to operate, which relay, upon operating, opens the sequence circuit chain and causes the trunk circuit in conjunction with the

sequence circuit to remove the particular trunk circuit from service. Relay 25TKA, upon operating, will light lamp 2515, bring in minor alarms 2808 and 2812 and lock under control of the release trunk key 2516. The removal of the trunk from service will permit the subscriber call to receive service over another trunk after the alarm circuit has tested and found the sequence circuit normal and when connected to the new trunk a sequence circuit will return to normal after the subscriber has received service and removes battery from conductor 1807, causing relay 25ST to release and, in turn, release relay 25CS. Relay 25CS will release all counting relays operated at that time, returning the circuit to normal except for locked-in alarms.

If the selected trunk has satisfactorily gone through its paces and registered the received ringing current, or if the trunk circuit was not even preselected, the relay 25TK will be normal when relay 25TM operated and ground available on the contact and inner lower armature of relay 25ST and directed to the contacts of relay 25TK by means of relays 25TM and 28TM1 would be applied to conductors 1618 and 1619 of the sequence circuit and would cause the operation of relay 25SA. Ground on conductor 1618 (conductor 1619 is ineffective on this type of call) to the sequence circuit will cause the latter circuit to function and remove from outward service the particular subgroup of subscribers' stations containing the calling subscriber's station. The operation of relay 25SA would bring in minor alarms 2808 and 2812, prior to the elimination of lamp 2501 and permits relay 25SA to lock under control of release key 2517. In either case after a ½ second has elapsed, relay 28P again operates causing the release of relay 28A1. Relay 28A1 released causes the release of relay 25TM and relay 25TM released connects the operating winding of relay 28SE to ground at the contact and armature of relay 25ST, the circuit being traceable from grounded conductor 2514, outer upper armature and back contact of relay 25TM, middle upper armature and contact of relay 28TM1, through the upper or operating winding of relay 28SE to grounded battery. If, therefore, in the ½ second that relay 28A1 and 28B1 were operated and in which relay 25TM and 28TM1 functioned to apply ground to the contacts of relay 25TK and in which an attempt was made to free the sequence circuit, relay 25ST did not release, ground on its front contact would cause the operation of relay 28SE, as soon as relay 25TM released. Relay 28SE operated would lock under control of the release sequence key 2810, light the sequence lamp 2501 and bring in major alarms 2809 and 2811 as an indication that the sequence circuit itself is in trouble. If, however, relay 25ST released during this interval, the miscellaneous alarm awaits for another ½ second until relay 28B1 releases which permits the release of relay 28TM1. The release of relay 28TM1 removes the ground from the winding of relay 25CS which, in releasing, removes the 60—IPM interrupter 2518 from the winding of relay 28P, removes the locking ground from the time measuring relays and reconnects ground to conductor 1701, extending to the sequence circuit, permitting the sequence circuit to handle a new call.

The removal of holding ground from the time measuring relays, and the disconnection of 60—IPM interrupter 2518 from the winding of relay 28P, causes release of relay 28P and all time counting relays, returning the miscellaneous alarm circuit to normal except for the locked-in trouble indication and thus permitting the alarm circuit to handle the timing of a new call. As indicated herein, relay 25TKA, 25SA or 28SE will remain operated depending upon the type of trouble that the miscellaneous alarm circuit discovers. The operation of a key associated with each of these relays and the associated annunciator circuit will permit the silencing of the audible alarm and will lock-in the lamp indicating the trouble brought in. Each of these relays also has associated with it a release key the operation of which, after the trouble has been cleared, eliminates the locked-in trouble indication. Restoring the release key associated with the relay and the annunciator alarm circuit extinguishes the trouble indicating lamp provided the locked-in trouble indicating relay has been released. With the trouble indicating lamp extinguished, the circuit has returned to normal.

Timing the interval used by the sequence circuit on an inward call if a director circuit has not been seized

When a trunk circuit on an inward call receives permission to use the sequence circuit, grounded battery applied to conductor 1807 causes the relay 25ST to operate. Relay 25ST, upon operating, results in the operation of relay 25CS as hereinbefore indicated. The operation of relay 25CS permits the time registering relays 28P, 28A1, 28B1, 28A2 and 28B2 to function as hereinbefore described and if, after approximately 2 seconds, relay 25K2 should still be non-operated, as a result of the failure of the sequence circuit to seize a director circuit, relay 25TM will operate as hereinbefore indicated followed by the operation of relay 28TM1. If relay 25ST is still operated at this particular time, ground on its inner lower armature and contact directed by means of the inner lower armature and contact of relay 25TM and the outermost upper armature and contact of relay 28TM1 to the lower armature and back contact of relay 25TK will be applied to the conductors 1618 and 1619 of the sequence circuit to remove the particular trunk used in originating the call from service and at the same time permits the operation of relay 25SA as hereinbefore indicated. From thereinafter the miscellaneous alarm circuit functions exactly as indicated hereinbefore under the condition when it timed out a period in excess of two circuits on an outward call in which the trunk circuit called into use was found unsatisfactory. In this case, therefore, the trunk will be removed from service as indicated by a flashing lamp 2519 and together with lamp 2501 and minor alarms 2808 and 2812 will serve to indicate the type of trouble.

Timing the interval used by the sequence circuit when conductor 2301, but not conductor 2302 to the miscellaneous alarm circuit, is grounded

As hereinbefore indicated when the sequence circuit is seized, relay 25ST of the miscellaneous alarm circuit operates causing, in turn, the operation of relay 25CS. As hereinbefore described, relay 25CS connects the 60—IPM interrupter 2518 to relays 28A1, 28B1, 28A2, 28B2, 28A3, 28B3, in combination for the purpose of counting the interval. Under the assumption that conductor 2301 has been grounded, relay 25K1 of the miscellaneous alarm circuit operates and (1) connects conductor 2530 to the contact and outer upper armature of relay 25TM; (2) places a supplementary holding path on the operating wind-

ing of relay 25CS; (3) locks under control of relay 25ST; (4) connects the operating path of relay 28DA1 or 28DA2 to contacts of relay 25TM, the selection of either of relays 28DA1 or 28DA2 being under the control of the lower armature of relay 28TR; (5) causes the operation of relay 25K2. Relay 25K2, upon operating, connects conductor 2521 to the contacts of relay 25TM, partially prepares the path for operating relay 28TR and locks under control of relay 25CS at the same time removing ground from the outer upper armature of relay 28B2. Relays 28A1, 28A2, 28B1 and 28B2 function and at the conclusion of a 2-second interval, relay 25K2, being operated, the miscellaneous alarm does not cause the operation of relay 25TM. At the conclusion of 4 seconds, however, relays 28B3, 28A1 and 28B1, being operated, ground furnished by relay 25CS through the operated contacts of relay 25K2 and normal contacts of relay 25K3 cause the operation of relay 25TM. Relay 25TM, upon operating, (1) connects ground to the conductor 2520 through the director circuit where it is instrumental in bringing the director into a "stuck" condition by operating relay 26LU; (2) connects relay 28TM1 to conductor 2521; (3) causes the operation of relay 28DA1 or 28DA2, depending upon the director circuit in service and (4) opens the operating path of relay 28TR or 28LT. The operation of relay 28DA1 or 28DA2, depending upon the director circuit in use, results in the locking of the relay operated under control of its associated release key and brings in an audible alarm and a lamp associated with the director circuit in trouble and prepares a path for either the operation of relay 28TR, 28LT or 28MAJ, the functions of which will be hereinafter described.

In a large switching center having only one director circuit, the operation of relay 28DA1 also removes the holding ground through relay 25CS furnished through the operated contacts of relay 25K1. This prevents the troubled director circuit from interfering with the automatic outward traffic.

After the director circuit is locked in the "stuck" condition, ground is placed on conductor 2521, which causes the operation of relay 28TM1. Relay 28TM1, upon operating, (1) locks under control of relay 28B1; (2) places a supplementary ground on the winding of relay 25CS to hold it operated; (3) connects ground under control of relay 25ST, through the contacts of relays 25TK and 25TM to the conductors 1618 and 1619 to the sequence circuit; and (4) helps prepare a path for the testing of the failure of the sequence circuit to release and for transferring the director circuits, both of which functions take place in the next half second. If conductor 2522 through the miscellaneous alarm circuit had been grounded by the director circuit to operate relay 25AB at the moment relay 25TM operated, relay 25K4 will be operated and ground would have been applied only to conductor 1618. With both conductors 1618 and 1619 to the sequence circuit grounded, the trunk circuit is taken out of service permanently on the key control, but if the director circuit has so requested, the operation of relay 25K4 will permit the grounding of only conductor 1618 in which case the trunk circuit would have been removed from service temporarily under control of the marking signal received from the distant central office. In either case, however, the sequence circuit in taking the trunk out of service releases, removing grounded battery from conductor 1807 and causing the release of relay 25ST. All this occurs within a half second and at the conclusion of this the 28A1 relay releases causing the release of relay 25TM but relay 28TM1 still remains locked up for an additional ½ second. With relay 25TM released, if for some reason or other relay 25ST is still operated, indicating, of course, that the sequence circuit has failed to release, the ground connection furnished by relay 25ST, through back contacts of relay 25TM and front contacts of relay 28TM1 causes relay 28SE to operate. Relay 28SE, upon operating, locks under control of the associated release key 2810 and brings in major alarms 2809 and 2811 in addition to a lamp 2801 indicating that the sequence circuit failed to release. With relay 25ST released, however, ground furnished by relay 28TM1 through back contacts of relays 25K5, 25ST and 25TM and front contacts of relay 25K2, which is still locked up under control of relay 25CS, is connected to conductor 2807.

If relay 28DA2 is normal, indicating director No. 2 as available, this ground causes the operation of relay 28TR which locks under control of relay 28DA1 and places a ground on conductor 2813 which extends through the windings, in parallel, of relays 23T1 to 23T6 in the director circuit where it is instrumental in replacing director circuit No. 1 by director circuit No. 2. If the relay 28DA2 is operated and relay 28DA1 is normal, indicating that the director circuit No. 1 is satisfactory and available, relay 28LT operates causing the release of relay 28TR. Relay 28TR, upon releasing, removes the ground from conductor 2813 to the director circuit placing the director circuit No. 1 in service instead of director circuit No. 2. In transferring to the new director circuit all conductors to the old director circuit from the miscellaneous alarm circuit are open causing the release of relays 25K1, 25AB and 25K4 if operated. If both the relays 28DA1 and 28DA2 are operated when conductor 2807 is grounded indicating, of course, that both director circuits are in trouble and not available, ground on conductor 2807 causes the operation of relay 28MAJ, which locks under control of its associated release keys 2814 and 2815, brings in major alarms 2809 and 2811 and lights a major lamp 2816, lamp 2817, associated with director circuit No. 1 and lamp 2818 associated with circuit No. 2, indicating that both director circuits are in trouble. The operation of relay 28MAJ also removes the locking path of relay 25CS which was prepared by relay 25K1 while it prevents the "stuck" director circuit from interfering with the placing and timing of outward calls. At the conclusion of the additional ½ second, relay 28B1, releasing, causes the release of relay 25TM. Relay 25TM, releasing, removes the additional holding ground from relay 25CS which, upon releasing, (1) causes relay 25K2 to release; (2) opens the holding ground to relays 28A1, 28B1, 28A2, 28B2, 28A3 and 28B3; (3) disconnects the 60—IPM interrupter 2518 from relay 28P which controls relays 28A1, 28B1, 28A2, 28B2, 28A3 and 28B3; and (4) reconnects ground to conductor 1701 of the sequence circuit, making the sequence circuit available.

Extension of the timing interval if conductor 2302 to the miscellaneous alarm circuit is grounded

If the director circuit places ground upon conductor 2302, relay 25K3 of the miscellaneous alarm circuit operates and locks under control of ground furnished by relay 25CS. Relay 25K3, upon operating, removes ground from the outer upper armature of relay 28B3. The time count-

ing circuit composed of relays 28A1, 28B1, 28A2, 28B2, 28A3, 28B3 and 28A4, therefore, continues to count time until 10 seconds have elapsed at which time relays 28A4, 28A3, 28B2, 28B1 and 28A1 are operated and ground furnished by relay 25CS causes the operation of relay 25TM. Therefore, if the miscellaneous alarm circuit is off-normal, the absence of ground on conductor 2301 causes it to time out and operate relay 25TM in 2 seconds. The presence of ground on conductor 2301, operating as it does relays 25K1 and 25K2, causes the alarm circuit to time out in 4 seconds. The additional presence of ground on conductor 2302 causes the operation of relay 25K3, and permits the miscellaneous alarm circuit an interval of 10 seconds before it operates relay 25TM.

Timing out after an interval of 10 seconds

As hereinbefore indicated, the alarm circuit continues to count time as long as the sequence circuit is in use and until it receives notification that a certain time limit should not be exceeded. On an inward call the director circuit makes a preliminary study of its own condition and, if satisfied, places a ground on conductors 2302 and 2522, causing the operation of relays 25K3 and 25AB.

Relay 25AB operates relays 25K4 and 25RO and relay 25K3 operates relay 25K5 together with relay 25K4 and locks under control of relay 25CS. Since relay 25K5 opens the circuit including conductor 2520 to the director circuit, and relay 25K4 opens the circuit including conductor 1619, to the sequence circuit, the miscellaneous alarm circuit, in case it does not time out, must return the director circuit back to service and only remove the trunk temporarily from service. When, therefore, the miscellaneous alarm circuit has counted out an interval of 10 seconds, ground furnished by relay 25CS causes relay 25TM to operate. Relay 25TM operated caused the immediate operation of relay 28TM1 from ground on relay 25K5. Relay 28TM1 operated, locks under control of relay 28B1, places a supplementary ground on the winding of relay 25CS, prepares an operating path for relay 28SE. Ground on conductor 1618 is used in the sequence circuit to disconnect the director circuit from the trunk circuit, returning the director circuit to normal, freeing the sequence circuit, removing grounded battery from conductor 1807 and causing the lighting of the trunk lamp and the release of relay 25CS, since relay 28B1 is already released. If the director circuit returns to normal and grounded battery is removed from conductor 1807, both relays 25K1 and 25ST release. Relay 25CS released causes relays 25K2, 25K3, 25K4 and 25K5 to release; removes 60—IPM interrupter 2518 and holding ground from the time counting relays, releasing all operated counting relays; and connects ground to conductor 1701 of the sequence circuit, thus returning the circuit to normal and to a position to permit the routing and timing of a new call.

In the event that the director circuit does not release the sequence circuit, the closure of conductor 1701 will delay the operation of major alarms 2809 and 2811 until a total of 14 seconds has elapsed. During this additional 4-second period, relays 28A1, 28B1, 28A2, 28B2 and 28B3 continue to count time as during the 10-second period when the front contacts of relays 28A1, 28B1 and 28B2 are now short-circuited by the closure of conductor 1701 so that their release does not release relay 25TM. However, if at the end of the 14-second period the director circuit has not succeeded in releasing the sequence circuit, relay 25ST will still be operated and relay 28A3 will release, causing the release of relay 25TM which will, in turn, operate relay 28SE and sound the major alarms 2809 and 2811.

Functions of lamps and keys

The miscellaneous alarm circuit is equipped with an alarm cut-off key 2502, which upon being operated prevents the miscellaneous alarm circuit from timing out a call and at the same time causes an alarm cut-off lamp 2519 to flash. The circuit is also provided with a sequence busy lamp 2523 to furnish an indication to the maintenance man whenever the sequence circuit is off-normal. Relay 25SA has associated with it a release alarm key 2524 which silences the audible alarm, permanently locking the lamp 2501 in a lighted condition to indicate the type of trouble. Each of the following relays has associated with it a switch and a lamp for a similar purpose, for example, relay 25TKA has switch 2525 and lamp 2515, relay 28SE has switch 2819 and lamp 2801, lamp 28DA1 has switch 2820 and lamp 2817 and relay 28DA2 has switch 2821 and lamp 2818 and relay 28MAJ has key 2815 and lamp 2816. The illumination of lamp 2501 is an indication that the subscriber line circuit or subscriber line equipment on an outward call has failed or that on an inward call the sequence circuit failed to set a director circuit off-normal. The elimination of lamp 2515 is an indication that on an outward call the continuity of the two trunk conductors has been found in trouble. The operation of the sequence lamp 2801 is an indication that the sequence circuit failed and is in trouble. The operation of director 1 or director 2 lamp, such as lamps 2817 and 2818, respectively, is an indication that the particular director circuit is in trouble and the operation of the major alarm lamp 2816 indicates that both directors are in trouble. After the maintenance man has cleared the trouble indicated, the miscellaneous alarm circuit is brought to normal as far as the alarm indications are concerned by the return of the release alarm key to normal, if it has been operated to silence the audible alarm and the momentary operation of the release key associated with the particular alarm. This causes the release of relays 25SA, 25TKA, 28SE, 28DA1, 28DA2 and 28MAJ, removing both audible and visual alarms.

Sequence battery and ground chain alarm

Relay 25SG remains operated from ground supplied by relay 25CS through the ground chain of the sequence circuit. Similarly relay 25SB remains operated from grounded battery supplied by relay 25SU through the battery chain of the sequence circuit. With both relays 25SB and 25SG operated, the plate and filament voltages for the vacuum tube 2526 remain unconnected while the grid element remains grounded and condenser 2527 is in a discharge condition. However, with the sequence circuit in an idle condition, if either the ground or battery chain circuit becomes open, relay 25SB or 25SG releases depending upon the particular chain affected. With the sequence circuit in use during the routing of the call both of these relays also release. With ground removed from the grid element of the vacuum tube 2526 and filament and plate potential applied by the release of either or both of relays 25SG and 25SB, the grid element immediately assumes negative potential relative to the

filament and no plate current flows. A positive charge leaking through resistance **2528** gradually raises the potential of condenser **2527** and also continues to alter the potential of the grid element. After approximately 45 seconds, the grid element having reached a definite potential relative to the filament, a plate current of sufficient magnitude causes relay **25M** to operate, operating in turn relay **25N**. Relay **25N**, upon operating, locks under control of the release sequence key **2810**, causing the operation of relay **28SE**. Relay **28SE**, upon operating, (1) acts as hereinbefore described giving a sequence failure alarm and (2) connects ground over the upper armatures of operated relay **25N**, upper armatures respectively of relays **25SB** and **25SG** to light lamps **2504** and **2505** to indicate the chain in trouble. After clearing the trouble, relay **25SB** or relay **25SG** operates removing the vacuum tube **2526** from the circuit and releasing relay **25M**. Relay **25N** releases when release sequence key **2810** is momentarily operated, returning the circuit to normal.

Falsely operated selecting magnet of line circuit

If a selecting magnet is falsely operated, relay **25D** of the miscellaneous alarm circuit operates due to ground available on conductor **1701**. Relay **25D**, upon operating, opens the main ground conductor **1701**, preventing the routing of any call through the switching unit. If the condition persists for 45 seconds, the ground chain alarm operates giving a major alarm and lighting the sequence ground lamp **2505** as hereinbefore described. The connection lamp **2503** is also lighted and these indications reveal to the attendant the type of existing trouble.

All-trunks-busy circuit at large switching center single and double outlet of trunks

When the line concentrating unit at the large switching center is arranged for double outlet of trunks with provision for overflow of outward calls between outlets, relays **22A** and **22B** are provided, each relay being associated with one of the outlets. If the unit is arranged for a single outlet, only relay **22A** is provided. When the switching unit is arranged for a double outlet without provision of overflow of calls in outlets, two separate all-trunks-busy circuits are provided, one for each outlet. Relay **22A** is provided with one of these circuits and relay **22B** is provided with the other all-trunks-busy circuit. When all the trunks of a group of trunks are busy, the sequence circuit connects ground to the winding of relay **22A** or **22B** depending upon which of these relays is associated with the group. The particular operated relay connects its associated **60**—IPM interrupter of interrupters **2201** and **2204**, to its associated register such as registers **22NCA** and **22NCB**, which, therefore, registers the number of seconds all trunks of the group are busy, at the same time closing a portion of the chain conductor **2214** to the winding of relay **22L**.

All trunks associated with the all-trunks-busy circuit, busy

When all trunks associated with the particular all-trunks-busy circuit are busy, "letters" relay **22L** operates. Relay **22L**, upon operating, transfers at its outer right-hand armature, condenser **2205** from the left-hand contact of relay **22P** to the contact of relay **22INT** and removes at its middle right-hand armature and contact, grounded battery **2206**. This transfer as will be seen, hereinafter results in the production of "letters" signals at the rate of one per second instead of "K" signals at a speed of forty words per minute.

Originating of a call during all-trunks-busy period

When a subscriber originates a call during the all-trunks-busy period, the sequence circuit places a ground on conductor **1804** to operate relay **22ST** which, upon operating, permits relay **22PC** and the magnet of register **22SUB.OFL** to operate. Also relay **22ST**, upon operating, connects ground to conductor **2202** for operating relay **14BB** in the trunk circuit. Busy back relay **14BB** operates and thereby connects a transmission conductor **1432** over conductor **2203** to grounded positive battery at the left-hand contact and armature of relay **22P1**. Also relay **14BB**, upon operating, connects at its inner lower armature and contact, grounded battery to conductor **1431** which extends to ground through the winding of relay **22C** which operates to operate in turn, relay **22D**. Relay **22D**, upon operating, closes at its outer left-hand armature and contact, a circuit traceable from ground, release key **2207**, outer left-hand armature and contact of relay **22D**, outer left-hand armature and contact of relay **22L**, through the winding of relay **22L1** to grounded battery, relay **22L1** operating during the no-circuit condition. Relay **22D**, upon operating, also connects the winding of relay **22E** to the grounded interrupter **2208**. Relay **22E** is of the slow-to-release type and operates in response to the first pulse obtained from interrupter **2208**. Relay **22E**, upon operating, (1) connects at its inner left-hand armature and contact a direct ground for holding relay **22C** operated; (2) extends its own operating ground over its outer left-hand armature and contact to the winding of relay **22F** which operates and (3) connects at its inner right-hand armature and contact a ground for holding relay **22D** operated and at its outer right-hand armature and contact connects ground for holding relay **22L** operated. Relay **22F**, upon operating, produces at its right-hand armature and contact, a ground connection for a circuit for operating rotary stepping magnet **22ROT**—A of selector switch **22SWA** the brush of which is caused to step around its associated contacts during the no-circuit condition. Also relay **22F**, upon operating, removes at its normally closed make-before-break contacts the ground connection from one side of condenser **2205** and connects that side to the secondary, or upper, winding of relay **22P1**, at the same time placing at its inner left-hand armature and contact a ground connection for the right-hand armature of relay **22INT** and the armature of relay **22P**. Meanwhile, the connection of the subscriber line to conductors **1431** and **2203** has returned the sequence circuit to normal, removing ground from conductor **1804** and if the call has been registered on one of the meters controlled by either magnet of register **22NCA** or register **22NCB**, relay **22ST** releases as hereinafter described.

Counting subscriber calls during an all-trunks-busy period

When a subscriber calls during the all-trunks-busy period the ground that is placed on conductor **1804** is continued through the operated left-hand armature and contact of relay **22ST**

to the winding of relay 22PC which operates. Relay 22PC, upon operating, supplements this ground by the ground on its own front contact and insures the operation of the magnet of register 22SUB.OFL. The magnet of register 22SUB.OFL., upon operating, locks to this ground on conductor 1804 and causes the release of relay 22PC. The register controlled by the magnet of register 22SUB.OFL., therefore operates only once on any one single grounding of conductor 1804 by the sequence circuit. The function of relay 22PC is to insure the application of ground for a sufficient period to enable the slow-acting magnet of register 22SUB.OFL. to function. If the all-trunks-busy circuit, the line circuit and the sequence circuit function speedily and tend to remove the ground from conductor 1804 before the message register 22SUB.OFL. has operated the ground on the armature of relay 22PC will insure the operation of the message register. In this particular case this ground on the armature of relay 22PC will be continued back on conductor 1804 and prevent the sequence circuit from dealing with another call until relay 22PC has released and removed this ground or, in other words, until the message register has functioned. Therefore as the signals are connected to each subscriber line the subscriber's call is registered on the register 22SUB.OFL.

Transmission of "letters" to the subscriber station during the "no-circuit" period

When a subscriber station is connected to the all-trunks-busy circuit during the no-circuit period as indicated hereinbefore, relay 22INT follows the 60—IPM pulses from grounded interrupter 2201 and relay 22F follows the pulses from grounded interrupter 2208. With relay 22F normal, condenser 2205 is charged and relay 22P1 is held in its marking, or left-hand, position, transmitting a marking signal to the subscriber's line associated with the all-trunks-busy circuit. When relays 22F and 22INT are operated, ground from the inner left-hand armature and contact of relay 22F discharges condenser 2205 in a circuit traceable from ground at the inner left-hand armature and contact of relay 22F, armature and contact of relay 22INT, front contact and outer right-hand armature of relay 22L, condenser 2205, contact and outer left-hand armature of relay 22F, through the upper winding of relay 22P1 to ground, but this discharge current only helps relay 22P1 to remain in its marking position. As soon as relay 22INT releases, condenser 2205 recharges from grounded positive battery 2209 in a circuit treaceable over conductor 2210, condenser 2205, contact and outer left-hand armature of relay 22F, to ground on the upper winding of relay 22P1, causing relay 22P1 to operate to its spacing, or right-hand, position and when the charging current has sufficiently decreased, relay 22P1 again returns to its marking position. On each subsequent operation and release of relay 22INT during the operation of relay 22F, this cycle is repeated producing a space signal of approximately 22 milliseconds once per second during the active period of interrupter 2208. During the interval when ground is removed, from the interrupted ground conductor 2211, relays 22E and 22F release. The release of relay 22F, among other things, opens the circuit of the secondary, or upper, winding of relay 22P1, allowing condenser 2205 to charge and definitely causing relay 22P1 to operate to its marking, or left-hand, position. The different release times of relays 22E and 22F permit the retention of ground on conductor 1431 for an interval after the last transmitted space signal. The 22 milliseconds space signal which is equivalent to the letters character is transmitted to the subscriber station therefore once per second during the "on" period of interrupter 2208.

A trunk becomes idle while "letters" signals are being sent out to the subscriber station

As soon as a trunk circuit in the group involved becomes idle under this condition, ground is removed from one of conductors 1602 and 1702 by the sequence circuit causing the release of the associated relay of relays 22A and 22B and in turn the release of relay 22L unless it is held operated by relay 22F, in which case it releases after relay 22F releases. The release of relay 22L opens the contact and winding circuit of relay 22INT causing its release and at the same time connects grounded negative battery 2206 to a circuit extending through the upper winding of relay 22P, contact and middle left-hand armature of relay 22L to grounded positive battery 2211. When relay 22F again operates, if relay 22P is not in its right-hand position, a current flows in both the primary, or upper, and secondary, or lower, winding of relay 22P, the current in the primary winding tending to operate the relay to its spacing, or right-hand, position and that in the secondary winding tending to keep the relay in its left-hand position. When the charging current flowing through the secondary, or lower, winding of relay 22P has decreased sufficiently, relay 22P operates on its primary, or upper, winding. As soon as the right-hand contact and armature of relay 22P interengage, the current is reversed in the primary, or upper, winding of relay 22P tending to drive the armature to its left-hand contact. The charge on condenser 2212, however, causes a current to flow through the secondary, or lower, winding in a direction tending to hold relay 22P in its right-hand position. When this discharge current has been sufficiently dissipated, relay 22P is driven to its left-hand position under the influence of the reverse current in its primary, or upper, winding. When the right-hand contact is opened, the reverse current in the primary, or upper, winding ceases and the current through the secondary, or lower, winding and the operating current through the primary, or upper, winding again begins to flow, causing a repetition of the complete cycle. Relay 22P, therefore, operates and releases at a rate of about 9 cycles per second. The discharge and charge of condenser 2212 occur nine times a second instead of once per second. Spacing pulses of 22 milliseconds, nine times per second, create a "K" character on the subscriber teletypewriter as a signal that a trunk is now available. These signals are, of course, produced only during the active period of grounded interrupter 2208. The subscriber disconnects and tries again. If several subscribers have been waiting, one would be serviced by the available trunk and the others, of course, in turn will be again connected to the all-trunks-busy circuit which by that time will be producing letters signals.

Timing the interval "letters" characters are being produced

When relay 22D operates during an all-trunks-busy period, relay 22L1 operates since relay 22L

is operated. Each grounding of interrupted ground conductor 2211 results, as hereinbefore described, in the operation of relay 22F which in turn operates the rotary magnet 22ROTA. In machine ringing switching centers the grounded interrupter places ground on conductor 2211 once every 6 seconds in accordance with the ringing machine interval. In switching centers not equipped with machine ringing, the interrupter 2208 manufactures approximately the same cycle. In any case, if all-trunks-busy condition persists, each grounding of conductor 2211 causes the rotary magnet 22ROTA to step the selector brush of switch 22SWA one terminal. On terminal No. 9 ground is connected through the winding of rotary magnet 22ROTB causing it to step up one terminal. When selector switch SWA reaches terminal No. 10, relay 22L2 operates energizing release magnet RLSA. The selector switch 22SWA is returned to normal and begins stepping around again. When selector switch 22SWB reaches a predetermined terminal, relay 22LA operates and locks causing the letters lamp 2213 to light and an audible signal may be sounded as an indication to the attendant at the switching center that the all-trunks-busy condition has lasted too long. The attendant can, by operating release key 2207, release relay 22LA to silence the audible alarm and extinguish the lamp 2213 and return selector switches 22SWA and 22SWB to normal by releasing relay 22L1. If at any time prior to the operation of relay 22LA a trunk becomes idle, relay 22L releases, causing the release of relay 22L1. The release of relay 22L1 places ground on the release magnet of both selector switches, causing the switches to return to normal.

Line hunting arrangement

A group of subscriber lines terminating at a subscriber's premises may be provided with a line hunting arrangement by modifying each line of the group, except the last line. Lines so modified need not be adjacent numerically or physically on the cross bar switch in the link circuit. Normally, the number of the first line of the group will be pulsed by the teletypewriter operator at the central office and that line will be tested. If it is busy, the test will continue from line to line until an idle line in the group is reached, whereupon the connection will be established. However, the number of any line in the group may be pulsed, in which case that line will be tested and if it is busy, only the higher positioned lines in the group will be tested. Therefore, if a subscriber has a group of lines, some arranged for unattended service, those lines should be the highest positioned of the group. In such a case, a call may be completed oon an unattended basis by pulsing the listed number of the first unattended service line, which will be listed in the directory and requested by the operator or calling subscriber. If the connection is established, it will be to a station provided with the proper type of station arrangements for unattended service, such as shown in Fig. 17 of Krecek United States Patent 2,220,931, granted November 12, 1940. Since the actual determination of the position of a particular line within a given group is purely a matter of cross-connection, any hunting that takes place is not necessarily restricted to the lines bearing higher numbers, but is restricted to the higher position within the group.

A call to a group of subscriber lines—Receipt of incoming code pulses in the director circuit at the small switching center

In the case of a call being to a group of subscriber lines terminating at a subscriber's premises, the incoming code pulses received over transmission conductor 501 of the line trunk are repeated by a gate relay 20—G, as hereinbefore described, for a call to a single line subscriber station. The first character "figures" is received and then followed by the first and second digits of the listed number of the desired line of a group.

Assume, in this case, that the listed number is 26 which represents one of the subscriber lines of the group of lines whose listed numbers are 20 to 29, terminating at a subscriber's premises. The selecting code pulses for No. 2 will be marking, marking, spacing, spacing and marking and those for No. 6 will be marking, spacing, marking, spacing and marking. In response to the incoming pulses for the first digit (No. 2) register relays 19R1 to 19R5 will operate as follows: Relays 19R1, 19R2 and 19R5 will operate to their marking positions and 19R3 and 19R4 to their spacing positions. Accordingly, fanning-out relays 19D1, 19D2 and 19D5 will be operated and relays 19D3 and 19D4 will be unoperated, to close a circuit traceable from grounded conductor 1916, lower armature and contact of relay 19D5, inner lower armature and back contact of each of relays 19D4 and 19D3, innermost lower armature and front contact of relay 19D2, No. 7 armature and front contact of relay 19D1, conductor No. 2 of conductors Nos. 0 to 9, connection at cross-connecting blocks 1914 and 1915, contact and middle right-hand armature of relay 19K1, through the winding of relay 19HB, to grounded battery. Relay 19HB represents the third "tens" group, Nos. 20 to 29, whereas relay 19HA represents the second "tens" group, Nos. 10 to 19, and another relay (not shown) represents the first "tens" group of lines whose listed numbers are 00 to 09.

Relay 19HB operates and indicates that the desired line is one of those in the third group of ten subscriber lines numbered 20 to 29. In other words, relay 19HB corresponds to the "tens" digit of the called number. Relay 19HB, upon operating, locks in a circuit traceable over its lower armature and contact, conductors 1917, 1944 and 1918, to ground at the outer upper armature and front contact of relay 20—C1. This locking circuit also serves to operate and lock relay 19K1. Relay 19K1, upon operating, prevents the H relays for the other "tens" groups from associating with the conductors Nos. 0 to 9 while this call is being established.

Relay 21—L, when operated as hereinbefore described, locks and prepares a path for the operation of relay 21—M. When relay 19R6 returns to its spacing contact after 0.030 second, relay 21—M will operate, closing a circuit extending from ground at the outer upper armature and front contact of relay 20—C1, conductor 2102, upper armature and front contact of relay 21—M, conductor 2103, front contact and inner left-hand armature of relay 19K1, front contact and upper armature of relay 19HB, conductor 1949, through the winding of relay 19H2 to grounded battery. Relay 19H2 which also is associated with the third "tens" group in which the desired, or called, subscriber line No. 26 is found, operates. Relay 19H2, upon operating, connects the closed fanning-out circuit to the desired conductor of conductors Nos. 0 to 9. Re-

lay 21—M, upon operating, (1) locks to ground on conductor 2102; (2) opens the operating path for relays 21—L and 19HB; and (3) prepares an operating path for relay 21—N. Relays 21—L and 19HB, however, remain operated over their locking circuits. After the first digit has been received, the following relays are operated: 20—A, 20—A1, 20—C, 20—C1, 19F, 19K, 21—L, 21—M, 19HB, 19K1, 19H2; relay 20—G is in its marking position; relay 19R6 is in its spacing position; and relays 19R1 to 19R5 and 19D1 to 19D5 in their respective groups, are operated according to the character (No. 2), just received.

The second digit of the called subscriber line number, say No. 6, is received, registered and made to operate the fanning-out relays in a distinctive combination in a manner somewhat similar to the combination for the first digit. The order of received pulses constituting the character No. 6 is marking, spacing, marking, spacing and marking. The fanning-out relays 19D1, 19D3 and 19D5 are operated and relays 19D2 and 19D4 are unoperated in accordance with the No. 6 combination set up on the register relays 19R1 to 19R5. Relay 19R6 operates to its marking position. Relay 19R6 is operated, thereby causing the operation of relay 21—N, the circuit being traceable from grounded battery, through the winding of relay 21—N, front contact and lower armature of relay 21—M, conductor 2122, front contact and upper armature of relay 19K, marking contact and armature of relay 19R6, conductor 1913, back contact and upper armature of relay 21—R, grounded conductor 2102. Relay 21—N, upon operating, (1) opens the circuit of the spacing contact of relay 20—G to prevent any additional incoming pulses from being registered; (2) locks to ground on conductor 2102; (3) opens the operating path of relays 21—M and 19H2; and (4) prepares a path for the operation of relay 21—N1. Relays 21—M and 19H2, however, remain operated over their respective locking circuits. When relay 19R6 returns to its spacing, or left-hand, position it causes the operation of relay 21—N1. Relay 21—N1, upon operating, closes a path from grounded battery, through the windings, in series, of out-of-order relay 21—OO and busy relay 21—BY, front contact and lower armature of relay 21—N1, back contact and outer lower armature of relay 21—R, conductor 2007, middle lower armature and back contact of relay 20—LU, conductor 1916, lower armature and front contact of relay 19D5, inner lower armature and back contact of relay 19D4, inner lower armature and front contact of relay 19D3, innermost upper armature and back contact of relay 19D2, No. 3 armature and front contact of relay 19D1, to the No. 6 conductor of conductors Nos. 0 to 9, armature No. 6 and contact of relay 19H2, conductor 1947, left-hand armature and back contact of relay 30—CH—26, conductor 3001, normally closed contacts of the ring spring of jack 3002A, conductor 3002, through the winding of hold magnet 3H26, to grounded battery. The locking circuit for relay 19H2 may be traced over the upper armature and contact of relay 19HB, inner left-hand armature and contact of relay 19K1, conductor 2103, front contact and upper armature of relay 21—M, grounded conductor 2102. Hold magnet 3H26 corresponds to the line extending to the called subscriber station 2926, the listed number of which is assumed herein to be No. 26. Subscriber stations 2920 to 2925 of which station 2920 is the only one shown and that in diagrammatic form, are assumed herein to be arranged for "attended service only" and stations 2926 to 2929 are assumed to be arranged for non-attended service, only two stations of the latter subgroup being shown, one of which, namely, station 2926 is shown in detail. Also relay 21N1, upon operating, closes at its upper armature and contact, the operating circuit of slow-acting relay 21—N2 which operates.

It will be noted as hereinbefore stated that the register relays 19R1 to 19R5 remain locked in the direction in which they were last operated.

Testing the called subscriber line of a group terminating at a subscriber's premises

Ordinarily the connection of grounded battery through relays 21—OO and 21—BY to the particular called subscriber line enables these two relays to determine if the conductor 3002 to the winding of the hold magnet of the called subscriber line is terminated in a direct ground, which causes the operation of both relays 21—OO and 21—BY or in a high resistance out-of-order ground which may be connected to the ring spring of an out-of-order jack, attached to a jack, say jack 3002B, of the called subscriber line, which results in the operation of relay 21—OO only. This is particularly true where the line is the last of a group. In case no ground was available, neither of the relays 21—OO and 21—BY operates. This test takes place during the slow-operating time of relay 21—N2 which, as indicated above, begins to operate when relay 21—N1 operates. As soon as relay 21—N2 operates, the off-normal ground on the front contact of outer upper armature of relay 20—C1 is connected in a circuit extending over conductor 2102, armature and front contact of relay 21—N2, to the armature of relay 21—OO. Assume that the called subscriber line is idle, in which case ground is not connected to conductor 3002, relay 21—OO will be unoperated and ground connected to its armature by the operation of relay 21—N2 will cause the operation of relay 21—R. Relay 21—R, upon operating, (1) removes relays 21—OO and 21—BY from the conductor 3002 of the called subscriber line and replaces them by relay 21—S; (2) causes the release of relay 21—N1 by removing ground, the ground being furnished over conductor 2102 which is connected to the upper armature; (3) prepares an operating circuit for relay 21—U; and (4) locks to grounded conductor 2102. Relay 21—N1, upon releasing, causes relay 21—N2 to slowly release. During the time that relays 21—N1 and 21—N2 are releasing, ground on the No. 3 armature and contact of relay 13D is connected to a circuit extending through resistance 1301 of high value, conductors 1302 and 1205, outer left-hand armature and contact of relay 19K1, conductor 1921, through the winding of relay 21—S, front contact and outer lower armature of relay 21—R, conductor 2007, middle lower armature and contact of relay 20—LU, conductor 1916, lower armature and contact of relay 19D5, inner lower armature and back contact of relay 19D4, inner lower armature and front contact of relay 19D3, innermost armature and back contact of relay 19D2, No. 3 armature and front contact of relay 19D1, conductor No. 6 of conductors Nos. 0 to 9, armature No. 6 and contact of relay 19H2, conductor 1947, left-hand armature and back contact of relay 30—CH—26, conductor 3001, normally closed contact of ring spring of jack 3002—A,

conductor 3002, through the winding of hold magnet 3H26 to grounded battery. Under the assumed condition of the called subscriber line being idle, grounded battery on the winding of hold magnet 3H26 of the cross bar switch in the link circuit permits relay 2I—S to operate, but due to the high resistance of elements 1301 in the circuit, the hold magnet 3H26 remains unoperated. Relay 2I—S, upon operating, opens the operating circuit of relay 2I—U and closes an operating circuit for relay 2I—S1 which operates in a circuit traceable over the armature and back contact of relay 2I—N2. Relay 2I—S1, upon operating, (1) locks over grounded conductor 2102; (2) short-circuits the winding of relay 2I—S; and (3) holds open the operating circuit of relay 2I—U. With the winding of relay 2I—S short-circuited, ground at the No. 3 armature and contact of relay 13D which is connected to the circuit hereinbefore traced, is now effective to cause the operation of hold magnet 3H26 which operates to move its vertical row of contact sets into engagement with the respectively associated sets of horizontal contacts, the contacts having already been conditioned for operation by the operation of selecting magnet 3SM1. The called subscriber's line No. 26 extending to station 2926 will therefore be connected at contact sets 324 to the trunk circuit 401 which will now function as hereinbefore described to release the sequence circuit. The sequence circuit, in turn, will function to remove the ground from conductor 1204 to release relay 20—A. Relay 20—A, upon releasing, removes ground from the various parts of the circuit including relays 20—C and 20—C1 and releasing relay 20—A1 unless conductor 2008 is connected to ground at relay 12TA, indicating that another inward call is awaiting completion. Relay 20—C1, upon releasing, removes locking ground from a considerable part of the director circuit. If relay 20—A1 releases, the motor will be stopped and all the remaining parts of the circuit will be deenergized. If, however, relay 20—A1 is held operated, the motor is kept running and relays 19R1 to 19R5 and the associated fanning-out relays 19D1 to 19D5 are locked in the condition in which they were operated by the last digit of the called subscriber line number.

Also, hold magnet 3H26, upon operating, closes at its right-hand armature and contact a circuit extending from ground, thence over conductor 323, through the winding of relay 30—AD—26, resistance 3006, to grounded battery 3007 and relay 30—AD—26 operates. Relay 30—AD—26, upon operating, (1) conditions at its right-hand armature a circuit extending from ground at the No. 4 armature and back contact of relay 13D, conductors 3004 and 3005, make-before-break contacts of relay 30—CH—26, right-hand armature and front contact of relay 30—AD—26, through the left and right-hand winding, in series, of relay 30—CH—26, resistance 3006, grounded battery 3007, but relay 30—CH—26 does not operate at this time because the circuit just traced is open at the No. 4 armature and back contact of relay 13D, due to relay 13D being in an operated position at this time, (2) disconnects grounded positive battery 3009 at its left-hand make-before-break contact, and (3) closes at its left-hand armature and front contact a path whereby the tip conductor of station 2926 is connected through to the tip conductor of line trunk 401, the circuit being traceable over conductor 325, tip contact of operated set 324, tip conductors 365 and 376. The ring conductor of station 2926 is connected to the ring conductor of line trunk 401 at the left-hand armature and front contact of hold magnet 3H26 due to the hold magnet being in an operated position, the circuit thus closed extending over conductor 327, left-hand armature and front contact of magnet 3H26, conductor 326, ring contact of operated set 324, to ring conductors 358 and 422. Hold magnet 3H26, upon operating, furthermore (1) completes a locking circuit for itself extending from grounded battery, through the winding of the magnet, conductor 360, sleeve contact of operated set 324, conductor 357, through the winding of relay 4SL in the trunk termination to ground at armature No. 3 and contact of relay 4—ON and relay 4SL operates; (2) opens at its make-before-break contact the operating circuit for lamp relay 3027; and (3) relay 4SL, upon operating, operates relay 4SL1.

Relay 4SL1, upon operating, (1) connects ground at its outermost lower armature and contact to a circuit to be employed if manual ringing is used; (2) connects at its innermost lower armature interrupter 431 to a circuit to be employed if automatic ringing is used; (3) opens at its middle lower armature and contact a circuit extending over conductor 433 for releasing the sequence and the director circuit. The opening of the circuit including conductor 433 extinguishes call disconnect lamp 1201 and releases relay 12ST2. Relay 12ST2, upon releasing, releases relay 12TA which in turn releases gate relay 12TC. The release of relay 12TC releases the selecting magnet 3SM—1 which in turn releases relay 13D. The removal of ground from conductor 433 also restores all the relays in Figs. 11, 12 and 13 that are common to the switching center to their normal idle condition and the sequence circuit is again in condition to handle a new call.

Relay 13D, upon releasing, connects ground at its No. 4 armature and back contact to close a circuit extending over conductors 3004 and 3005, make-before-break contact of relay 30—CH—26, right-hand armature and front contact of relay 30—AD—26, through both windings, in series, of relay 30—CH—26, resistance 3006, to grounded battery 3007 and relay 30—CH—26 operates so that any call following will be routed to the next higher numbered subscriber line. Relay 30—CH—26, upon operating, locks in a circuit traceable to a holding ground at its inner right-hand armature and contact.

Relay 30—CH—26, upon operating, closes at its outer right-hand armature and front contact, a path that interconnects conductor 3010 and the make-before-break contacts of relay 30—AD—26 which at this time are open due to relay 30—AD—26 being in an operated condition. This last traced path is completed at the joint action of the release of the connection to a subscriber station 2926 and the establishment of a new call to a subscriber station when relay 13D again becomes operated. The path thus closed extends from ground at armature No. 5 and front contact of relay 13D, conductor 3010, front contact and outer right-hand armature of relay 30—CH—26, make-before-break contacts of relay 30—AD—26, through the windings in series of relay 30—CH—26, resistance 3006 to grounded battery 3007. Relay 30—CH—26 therefore is prevented from releasing during the time that a new call is being established to a subscriber's station.

A call may be made to any line of the group and if that line is busy it will progress to the next higher numbered line in the group and will continue to progress until the next idle line is found. For example, should the line associated with station 2926 be busy when the connection to it is desired, relay 30—CH—26 will be in an operated condition at the time. The grounded conductor 1916 is extended through the closed contacts of the fanning-out relays 19D1 to 19D5, armature No. 6 of relay 19H2, and over conductor 1947, and conductor 1947 will be transferred from the back contact to the front contact of the left-hand armature of relay 30—CH—26 to complete a path extending over conductor 3021, left-hand armature and back contact of relay 30—CH—27 (not shown but assumed to be in a released condition in that its associated line is assumed to be idle). Assume that the lines respectively associated with relays 30—CH—27 and 30—CH—28 (neither of which is shown) are, at this time, busy, and that, therefore, both relays are in their operated condition; the above-mentioned conductor 3021 will then be extended over the left-hand armature and front contact of each of relays 30—CH—27 and 30—CH—28 in turn, left-hand armature and back contact of relay 30—CH—29 (assuming that the line associated with relay 30—CH—29 is idle), conductor 3022, normally closed contacts of ring spring of the jack, not shown but corresponding to jack 3002A of the line associated with subscriber station 2926, conductor 3023, through the winding of hold magnet 3H29 to grounded battery. Hold magnet 3H29 operates to connect the next idle station 2929 to trunk 401, the connection being established over operated contact set 329.

Keys are respectively provided for all lines, except the last, of a group. These keys, such as key 3025 for the line extending to subscriber station 2926, will operate their respectively associated AD relays, such as relay 30—AD—26 associated with key 3025, and cause the associated subscriber line to be by-passed. These keys may be used any time their respective lines are required to be by-passed if the particular line is to test as a busy, an out-of-order, and an unassigned condition. The make-busy and out-of-order circuit which is usually patched into jacks, such as jack 3002—B for the line extending to subscriber station 2926, shall not be used on lines equipped with CH and AD relays.

Calls may be extended not only to or through the central office but from any station connected to either satellite office through the central office back to any other station connected to either satellite office including a second line of a calling subscriber or a test or service man's station local to either satellite office. Whereas an exemplary form of the invention is disclosed herein the intention is to claim the invention as broadly with respect to equivalents as the state of the art may permit. Thus, the term "channel" or "trunk" is used in the claims in its generic sense, unless otherwise expressed, to include either repeatered or unrepeatered trunks equipped for transmission of direct current impulses, or equivalent groups of carrier current impulses, by open and close transmission, polar transmission, so-called upset duplex transmission, and so-called polarential systems, as well as carrier transmission systems, systems including carrier links or radio links, legs of composite systems, and trunks having conductor systems for two directions of transmission which are different in whole or part. In a similar manner claiming language or words used with respect to other parts, features or functions of the exemplary system disclosed are to be interpreted broadly.

What is claimed is:

1. A telegraph system comprising a local station, a telegraph line therefrom to a first switching center, first telegraph trunk channels from said first switching center to said second switching center, second telegraph trunk channels from said second switching center to a telegraphic office, said local station having an idle condition and operable call means for creating a calling condition, switching instrumentalities whereby operation of said call means controls over said line the extension of a call by selection and connection to said line of a selected idle one of said first channels, telegraph signaling means responsive to the joint operation of said call means and said switching instrumentalities, and other switching instrumentalities responsive to the operation of the first-mentioned switching instrumentalities for furthering said extension to select and connect to said selected first channel an idle one of second channels, to the end that said line and selected trunks are interassociated to form a telegraphic communication path from said local station to said telegraphic office.

2. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and second unattended offices, and telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office.

3. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and second unattended offices, telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, telegraphic transmission and reception means associated with said local station and telegraphic transmission and reception means at said central office associable with said last-named seized trunk for establishing telegraphic intercommunication between said local station and said central office via said trunks.

4. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means including teletypewriter equipment at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and second unattended offices, means operable incident to said seizure to seize an idle trunk to said central office, and a link circuit at said central office for extending said trunk as a telegraphic communication path to teletypewriters at said central office for receiving communication from said teletypewriter equipment at said local station.

5. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between

said first and second unattended offices, telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, and means operable incident to the present non-existence of an idle condition of some one trunk between said first and said second unattended offices to send back over said telegraphic channel distinctive telegraphic signals signifying such present non-existence of an idle condition of some one trunk.

6. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and said second unattended offices, telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, and means operable incident to the present non-existence of an idle trunk between said second unattended office and said central office upon the seizure of a trunk between the first and second unattended offices to send back over said seized trunk and said channel distinctive telegraphic signals significant of said fact.

7. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, telegraph signaling means operable incident to said extension to seize an idle trunk between said first and said second unattended offices; other telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, and call answering means adapted to receive telegraphic signals and applicable to conductive terminals of said last seized trunk at said central office.

8. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, telegraph signaling means operable incident to said extension to seize an idle trunk between said first and said second unattended offices, other telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, call indicating means conditioned to a call indicating condition at said central office by seizure of said last seized trunk, call answering means adapted to receive telegraphic signals and applicable to conductive terminals of said trunk, and means operable by restoration of said call means prior to application of calling answering means to said terminals to release both of said seized trunks to idle conditions permitting their use for other calls.

9. A telegraph system comprising a plurality of local stations, an automatically operating switching office, a second automatically operating switching office, a central office, call means at each of said stations operable to extend a telegraphic channel to said first switching office, telegraph signaling means operable incident to said extension to seize an idle trunk between said first and said second switching offices; and other telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, in combination with telegraphic repeater means, means at said central office operable with the seizure of an idle trunk extending to said second switching office, trunk identifying and connecting means at said second switching office operable under remote control over said trunk by said telegraphic repeater means, means operable at said central office to seize an idle trunk extending to said first switching office, and channel identifying and connecting means at said first switching office operable under remote control from said central office to select a channel to one of said local stations.

10. A telegraph system comprising a plurality of local stations, an automatically operating switching office, a second automatically operating switching office, a central office, call means at each of said stations operable to extend a telegraphic channel to said first switching office, telegraph signaling means operable incident to said extension to seize an idle trunk between said first and said second switching offices, and other telegraph signaling means incident to said seizure to seize an idle trunk to said central office, in combination with telegraphic repeater means at said central office operable with the seizure of an idle trunk extending to said second switching office, trunk identifying and connecting means at said second switching office operable under remote control over said trunk by said telegraphic repeater means operable at said central office to seize an idle trunk extending to said first switching office, and channel identifying and connecting means at said first switching office operable under remote control from said telegraphic repeater means at said central office to select a channel to one of said local stations, wherein said trunk identifying and connecting means includes a director responsive to selective telegraph impulses sent from said telegraphic repeater means at said central office to selectively identify a trunk group of one or a plurality of trunks extending from said second to said first switching office.

11. A telegraph system comprising a plurality of local stations, an automatically operating switching office, a second automatically operating switching office, a central office, call means at each of said stations operable to extend a telegraphic channel to said first switching office, means operable incident to said extension to seize an idle trunk between said first and said second switching offices, and means incident to said seizure to seize an idle trunk to said central office, in combination with means operable at said central office to seize an idle trunk extending to said second switching office, trunk identifying and connecting means at said second switching office under remote control over said trunk by means operable at said central office to seize an idle trunk extending to said first switching office, and channel identifying and connecting means at said first switching office operable under remote control from said central office to select a channel to one of said local stations, wherein said trunk identifying and connecting means includes a director responsive to selective impulses sent from said central office to selectively identify a trunk group, hunting means to hunt for an idle trunk of the group thus identified, and connecting means to transmissively associate a found idle trunk with the central office trunk originally seized.

12. A telegraph system comprising a plurality of local stations, an automatically operating switching office, a second automatically operating switching office, a central office, call means at each of said stations operable to extend a telegraphic channel to said first switching office, means operable incident to said extension to seize an idle trunk between said first and said second

switching offices, and means incident to said seizure to seize an idle trunk to said central office, in combination with means operable at said central office to seize an idle trunk extending to said second switching office, trunk identifying and connecting means at said second switching office operable under remote control over said trunk by means operable at said central office to seize an idle trunk extending to said first switching office, and channel identifying and connecting means at said first switching office operable under remote control from said central office to select a channel to one of said local stations, wherein said trunk identifying and connecting means includes a trunk hunting means to examine each trunk of a group of two or more, and means to seize the first idle trunk of said group.

13. A telegraph system comprising a plurality of local stations, an automatically operating switching office, a second automatically operating switching office, a central office, call means at each of said stations operable to extend a telegraphic channel to said first switching office, means operable incident to said extension to seize an idle trunk between said first and said second switching offices, and means incident to said seizure to seize an idle trunk to said central office, in combination with means operable at said central office to seize an idle trunk extending to said second switching office, trunk identifying and connecting means at said second switching office operable under remote control over said trunk by means operable at said central office to seize an idle trunk extending to said first switching office, and channel identifying and connecting means at said first switching office operable under remote control from said central office to select a channel to one of said local stations, wherein said channel identifying and connecting means includes a pulse responsive director operable under remote control over the trunk seized at the central office and the selected and connected trunk from the second to the first switching office to selectively identify and connect a local station line, if idle, transmissively to said seized and selected trunks.

14. A telegraph system including a central office, trunks extending therefrom to a switching office, trunks extending from the switching office to a secondary switching office, telegraph lines or channels extending individually to respective individual stations, means for seizing a trunk at the central office, selective means at the switching office responsive to permutationally coded pulses sent from the central office to select a trunk from the switching office to the secondary switching office, and selective means at the secondary switching office responsive to further permutationally coded pulses sent over the seized and selected trunks in tandem to selectively identify one of said lines or channels and connect it transmissively in tandem with said seized and selected trunks to establish a path of communication from the individual station of said line to said central office.

15. A telegraph system including a central office, trunks extending therefrom to a switching office, trunks extending from the switching office to a secondary switching office, telegraph lines or channels extending individually to respective individual stations, means for seizing a trunk at the central office, selective means at the switching office responsive to permutationally coded pulses sent from the central office to select a trunk from the switching office to the secondary switching office, and selective means at the secondary switching office responsive to further permutationally coded pulses sent over the seized and selected trunks in tandem to selectively identify one of said lines or channels and connect it transmissively in tandem with said seized and selected trunks to establish a path of communication from the individual station of said line to said central office in combination with means for sending telegraphic signals including break signals both ways over said path, and means whereby, under control of apparatus at said individual station, a disconnect condition as distinguished from a break signal may be created at said central office.

16. A telegraph system including a central office, a source of telegraph signals at said office, trunks extending from said central office to a switching office, trunks assigned in groups extending from said switching office to a secondary switching office, means at said central office for seizing a trunk and thereby gaining access to selective equipment at said switching office, means controlled by selective actuation of said equipment by telegraph pulses from said source relayed over said seized trunk to identify a trunk group, hunting means operable incident to such identification to search said group for an idle trunk of said group, and means operable incident to identification of an idle trunk of said group to establish a connection of said idle trunk in tandem transmissive relation to the seized trunk.

17. A telegraph system including a central office, a source of telegraph signal pulses at said office, trunks extending from said central office to a switching office, trunks assigned in groups extending from said switching office to a secondary switching office, means at said central office for seizing a trunk and thereby gaining access to selective equipment at said switching office, means controlled by selective actuation of said equipment by telegraph pulses from said source relayed over said seized trunk to identify a trunk group, hunting means operable incident to such identification to search said group for an idle trunk of said group, and means operable incident to identification of an idle trunk of said group to establish a connection of said idle trunk in tandem transmissive relation to the seized trunk in combination with means including other sources of the telegraph pulses leaving other idle or subsequently made idle members of said group available for use in establishing other communication paths from said central office to said secondary switching office.

18. A telegraph system including a central office, a source of telegraph pulses at said office, trunks extending from said central office to a switching office, trunks assigned in groups extending from said switching office to a secondary switching office, means at said central office for seizing a trunk and thereby gaining access to selective equipment at said switching office, means controlled by selective actuation of said equipment by telegraph pulses from said source relayed over said seized trunk to identify a trunk group, hunting means operable incident to such identification to search said group for an idle trunk of said group, and means operable incident to identification of an idle trunk of said group to establish a connection of said idle trunk in tandem transmissive relation to the seized trunk in combination with means operable incident to said connection to release said selective equipment

for use in establishing other similar connections during the continuance of said established connection.

19. A telegraph system including a central office, a source of telegraph pulses at said central office, trunks extending from said central office to a switching office, trunks assigned in groups extending from said switching office to a secondary switching office, means at said central office for seizing a trunk and thereby gaining access to selective equipment at said switching office, means controlled by selective actuation of said equipment by telegraph pulses from said source relayed over said seized trunk to identify a trunk group, hunting means operable incident to such identification to search said group for an idle trunk of said group, and means operable incident to identification of an idle trunk of said group to establish a connection of said idle trunk in tandem transmissive relation to the seized trunk in combination with lines or channels from branch or subscriber stations to said switching office, and means responsive to the telegraph pulses from said source whereby different selective actuations of said equipment cause identification of one of said other lines or channels and connection of said one line or channel to said seized trunk in tandem relation.

20. A system of remotely controlled switching of telegraph lines or channels comprising a trunk from a control switching point to a remote controlled switching point, a source of selective telegraph signaling impulses at said control switching point, selective equipment at said controlled switching point operable under control of selecting telegraph signaling impulses arriving over said trunk from the control switching point, a group of circuits extending from said controlled switching point toward a desired station to be called, means operable in response to a certain selection of telegraph signaling impulses arriving over said trunk to identify said group of circuits, means operable incident to and automatically upon said identification to successively test said circuits for availability, and means operable incident to and automatically upon the testing of an available one of said circuits to establish a connection over it from the control switching point toward the desired station to be called via the trunk and the said available circuit.

21. A teletypewriter selective system in which an operator is provided with equipment for seizing a trunk to a remote point, selective register means at said remote point, means operated incident to the seizure for conditioning said register means for reception of selective permutation codes, means operable thereafter by selective actuation of said register means to seize a path or channel from said remote point to a more remote point and associate it transmissively with said trunk, selective equipment at said more remote point, means operated incident to the seizure of said path or channel for conditioning said selective equipment for reception of further permutation codes, and means operated by selective actuation of said selective equipment to identify a further path or channel and associate it with said seized path or channel.

22. A teletypewriter selective system in which an operator is provided with equipment for seizing a trunk to a remote point and for transmitting over said trunk selective telegraph signals in permutation code, selective register means at said remote point, means operated incident to the seizure for conditioning said register means for reception of the selective telegraph signals in permutation code from said source, means operable thereafter by selective actuation of said register means to seize a path or channel from said remote point to a more remote point and associate it transmissively with said trunk, selective equipment at said more remote point, means operated incident to the seizure of said path or channel for conditioning said selective equipment for reception of additional selective telegraph signals in permutation code from said source, and means operated by selective actuation of said selective equipment to identify a further path or channel and associate it with said seized path or channel in combination with means operable incident to the conditioning of said register means to transmit to the operator special line conditions indicating completion of said conditioning.

23. A teletypewriter selective system in which an operator is provided with equipment for seizing a trunk to a remote point and for transmitting over said trunk selective telegraph signals in permutation code, selective register means at said remote point, means operated incident to the seizure for conditioning said register means for reception of the selective telegraph signals in permutation code, means operable thereafter by selective actuation of said register means to seize a path or channel from said remote point to a more remote point and associate it transmissively with said trunk, selective equipment at said more remote point, means operated incident to the seizure of said path or channel for conditioning said selective equipment for reception of additional selective telegraph signals in permutation code, and means operated by selective actuation of said selective equipment to identify a further path or channel and associate it with said seized path or channel in combination with means operable incident to conditioning of the selective equipment to transmit to said operator special line conditions indicating completion of said conditioning.

24. A teletypewriter selective system in which an operator is provided with equipment for seizing a trunk to a remote point, selective register means at said remote point, means operated incident to the seizure for conditioning said register means for reception of selective permutation codes, means operable thereafter by selective actuation of said register means to seize a path or channel from said remote point to a more remote point and associate it transmissively with said trunk, selective equipment at said more remote point, means operated incident to the seizure of said path or channel for conditioning said selective equipment for reception of further permutation codes, and means operated by selective actuation of said selective equipment to identify a further path or channel and associate it with said seized path or channel in combination with means for releasing said selective register means or said selective equipment upon the expiring of a predetermined time after its conditioning without actuation by it of selective permutation codes.

25. A teletypewriter selective system in which an operator is provided with equipment for seizing a trunk to a remote point, selective register means at said remote point, means operated incident to the seizure for conditioning said register means for reception of selective permutation codes, means operable thereafter by selective actuation of said register means to seize a path or channel from said remote point to a more remote point and associate it transmissively with said

trunk, selective equipment at said more remote point, means operated incident to the seizure of said path or channel for conditioning said selective equipment for reception of further permutation codes, and means operated by selective actuation of said selective equipment to identify a further path or channel and associate it with said seized path or channel in combination with means operable a predetermined time after seizure of said selective equipment to release said path or channel and restore it to a condition available for establishing other communication paths between said remote point and said more remote point.

26. A system of telegraphic communication by permutation codes comprising a control station, a primary trunk for code transmission extending to a controlled station, selective equipment at said controlled station to be selectively actuated by codes transmitted over said primary trunk, lines and secondary trunks terminating at said controlled station interchangeably selectable by said equipment, means operable incident to selection of a line to transmissively connect said line to said primary trunk in tandem, means operable incident to selection of a secondary trunk to transmissively connect said selected secondary trunk to said primary trunk in tandem, secondary selective equipment at the remote end of the selected secondary trunk, and means for relaying over said trunks in tandem permutation codes to selectively actuate said last-named selective equipment to select telegraphic transmission paths to more remote points.

27. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel.

28. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with means whereby a disconnect indication other than one of said codes may be sent to said central office over said path, said channel and said trunk from an outlying station.

29. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with means whereby a disconnect indication other than one of said codes may be sent to said central office over said path, said channel and said trunk from an outlying station, holding means at said switching point maintaining said trunk and channel in inter-associated relation, and means operable under control of said office in response to said disconnect indication to release said holding means.

30. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to se-

lection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with means whereby a disconnect indication other than one of said codes may be sent to said central office over said path, said channel and said trunk from an outlying station, and holding means at said more remote switching point for maintaining said channel and an associated path in interassociated relation and means at said switching point whose operation is initiated under control of said office in response to said disconnect indication to release said holding means.

31. A system of telegraphic communication by permutation codes of predetermined timing and number of codes elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with local channels leading from the first-named switching point directly to outlying stations and means whereby alternative codes control said first-named equipment to select one of said local channels, means incident to the seelction to transmissively associate said local channel with said trunk, and means for establishing a call signal at said outlying station over said trunk and channel under control of said office.

32. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with teletypewriter equipment including driving means at said outlying station and means operable under control of said office over said through telegraphic communication circuit to cause said driving means to drive said equipment.

33. A system of telegraphic communication by permutation codes of predetermined timing and number of code elements per selective permutation comprising an office having control of establishing a path of communication selectively to a remote station, a trunk path extending from said office toward said remote station to a switching point, equipment responsive to codes of said timing and number of code elements at said switching point, means for sending said codes over said trunk to selectively actuate said equipment, channels leading away from said equipment to more remote points, means whereby certain of said sent codes select one of said channels, means operative incident to the selection to extend said trunk communicatively over the selected channel, other more remote selective equipment at a remote point upon said selected channel, selectable telegraphic communication paths to outlying stations leading from said remote point, means for actuating said more remote selective equipment over said trunk and said selected channel to select one of said paths, and means operative incident to selection of said path to connect said selected path, said channel and said trunk in tandem to constitute a through telegraphic communication channel in combination with teletypewriter equipment normally unenergized and consequently incapable of recording code combinations at said outlying station, and means controllable over said through telegraphic communication circuit for energizing said equipment and causing it to record code combinations relayed over said trunk, channel, and path.

34. A system for selectively setting up a communication to a selected point which comprises means for seizing a path to a remote point, selector and start-stop distributor equipment at said point available for use with more than one path, means operative incident to the seizure to associate said equipment with said seized path for use, means for relaying over said path codes of start-stop type to selectively actuate said equipment, outgoing subpaths one of which is selectively connected to said path in response to said actuation, more remote selector and start-stop distributor equipment available for use with more than one path, and means operative incident to the seizure of said subpath to seize and temporarily exclusively associate said selector and start-stop distribuor equipment with said one subpath for making a further selection under control of and over said initially seized path.

35. A system for selectively setting up a communication circuit to a selected point which comprises means for seizing a path to a remote point, a source of selective permutation code impulses, selector equipment at said point available for use with more than one path, means operative incident to the seizure to associate said equipment with said seized path for use, means for relaying over said path impulses received from said source to selectively actuate said equipment, outgoing subpaths one of which is selectively connected to said path in response to said actuation, more remote selector equipment available for use with more than one path, and means operative incident to the seizure of said subpath

to seize and temporarily exclusively associate said selector equipment with said subpath for making a further selection with additional impulses from said source over said initially seized path.

36. A system for selectively setting up a communication circuit to a selected point which comprises means for seizing a path to a remote point, a source of selective permutation code impulses, selector equipment at said point available for use with more than one path, means operative incident to the seizure to associate said equipment with said seized path for use, means for relaying over said path impulses received from said source in permutation code to selectively actuate said equipment, outgoing further paths one of which is selectively connected to said path in response to said actuation, more remote selector equipment available for use with more than one path, and means operative incident to the seizure of said further path to seize and temporarily exclusively associate said selector equipment with said one further path for making a further selection with additional impulses from said source over said initially seized path, means operable incident to the seizure of said more remote selective equipment and its association with a path for use to relay over said initially seized path and directed toward the point of initial seizure thereof a telegraph pulse indicative of the completion of said seizure and association.

37. An outlying station having permutation code operated teletypewriter equipment, a telegraph line to a subsatellite office, means for controlling through a contact in said equipment the extension of a path over said line through said subsatellite office via a subtrunk to a principal satellite office, and sequencing means in said principal satellite office allocating a trunk to extend said path over said line and subtrunk to a principal satellite office.

38. A subsatellite office having telegraph lines to local offices each comprising telegraph equipment and a call switch operable to non-call and call conditions and subsatellite office having subtrunks to a principal satellite office which in turn has trunks to a main office, telegraph signaling means automatically operable in response to the operation of said switch to call position to cause said subsatellite office to allocate a trunk to a principal satellite office and connect said line transmissively thereto, and other telegraph signaling means automatically operable by connection of said line to cause said satellite office to allocate a trunk to said principal office and connect said subtrunk thereto.

39. In combination, a normally open telegraph circuit, a series of trunk assignors, corresponding series of groups of trunks, means operable by closure of said circuit to cause the first trunk assignor to assign a trunk of a first group to said circuit, and telegraph signaling means operative incident to assignment of said trunk to cause a second trunk assignor to assign a trunk of a second group to said first trunk to the end that said circuit and assigned trunks are transmissively interconnected.

40. In combination, a telegraph circuit, a series of permutation code selection means each comprising a distributor and marker, means whereby permutation codes are transmitted over said circuit to control said selection means in consecutive sequence to mark a circuit for transmission of further permutation codes, and means operative incident to the marking consecutively of each circuit to connect it in tandem with the firstnamed circuit as a telegraphic communication path.

41. A trunk assigning system comprising a succession of sequence circuits for assigning trunks from successive trunk groups successively to calls proceeding in one direction through the system and a succession of permutation code actuated selective means for selecting trunks for assignment to calls proceeding in the other direction through the system.

42. A system for establishing a telegraph communication path from station A to station C through station B which comprises a telegraphic trunk from station A to station B, a source of permutation code impulses at station A, a group of paths from station B to station C, selective means at station B selectively operable in response to impulses received from said source over said trunk to identify said group, hunting means initiated into operation incident to the identification to choose an idle one of said paths and to connect it transmissively to said trunk.

43. A system for establishing a communication path from station A to station C through station B which comprises a communication trunk from station A to station B, a source of permutation code impulses at station A, selective means at station B selectively operable by a code or codes transmitted from said source, a trunk group extending from station B to station C selectively responsive to the impulses from said source and identifiable from other groups of one or more trunks, hunting means initiated into operation upon such identification to seek an available idle one of said trunks, and means operative incident to finding an available idle trunk to connect it transmissively with said communication trunk.

44. A system for establishing a communication path from station A to station C through station B which comprises a communication trunk from station A to station B, a source of permutation code impulses at station A, selective means at station B selectively operable by a code or codes transmitted from said source, a trunk group extending from station B to station C selectively responsive to the impulses from said source and identifiable from other groups of one or more trunks, hunting means initiated into operation upon such identification to seek an available idle one of said trunks, and means operative incident to finding an available idle trunk to connect it transmissively with said communication trunk in combination with a source of busy signal impulses in permutation code and means operative incident to examining all of said trunks without identifying an available idle one thereof to transmit from said source of busy signal impulses over said communication path towards station A.

45. A system for establishing a communication path from station A to station C through station B which comprises a communication trunk from station A to station B, selective means including a start-stop distributor, responsive to permutation code at station B selectively operable by a code or codes transmitted over said trunk, a trunk group extending from station B to station C selectively identifiable from other groups of one or more trunks, hunting means initiated into operation upon such identification to seek an available idle one of said trunks, and means operative incident to finding an available idle trunk to connect it transmissively with said communication trunk in a path independent of

said selective means including said distributor whereby they are rendered available for use in setting up other communication paths.

46. A telegraphic trunking system having a group of lines extending to a common point and arranged in consecutive order, calling means including a calling telegraphic path for selectively calling any line of said group, means for connecting the said called line, if idle, means, operative when said line is not idle, for seeking among lines of said group ranked above the called line for an idle line, and means for connecting any such idle line to said calling telegraphic path.

47. A telegraphic trunking system having a group of teletypewriter sets, lines from said sets to a common point, said lines being arranged in two groups consisting of a first group and a second group, the lines of each group being ranked one above the other, the sets of said second group of lines only including unattended energizing equipment, calling means including a calling telegraphic path for selectively directing a call to a line of said first group or alternatively to a line of said second group, means operable in response to such direction for connecting any such called line, if idle, to the calling path, means operative when said line is not idle and is a line of said first group for seeking and connecting any idle higher ranking line of said first group or any line of said second group to said calling path, means operative when said line is not idle and is a line of said second group for seeking and connecting any idle higher ranking line of said second group only to said calling path, and means controllable over said path to operate said energizing equipment.

48. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and second unattended offices, means operable incident to said seizure to seize an idle trunk to said central office, means operable incident to said first seizure to connect said seized trunk to said channel, electromagnetic holding means for holding said connection, means operable incident to said second seizure to connect said second seized trunk to said first seized trunk, second electromagnetic holding means for holding said connection, said connections thus held constituting a telegraphic inter-communication channel between said local station and said central office, means operable from said local station for conditioning both of said holding means for release, means at the central office operable upon said conditioning for causing release of said holding means and restoration of said trunks to idle condition, and means in said channels and said trunks adapted to respond to direct current impulses for both supervision and communication.

49. In a communication system, a central office, a plurality of switching centers connectable in tandem to said central office, trunk circuits arranged for full duplex supervisory operation interconnecting one of said switching centers and said central office, other trunk circuits arranged at all times for half-duplex operation interconnecting another of said switching centers and said one switching center, selector means seizable by any one of said first-named trunk circuits and remotely controllable thereover, and other means at each of said switching centers responsive to said selector means for automatically establishing a transmissive interconnection between said one trunk and a trunk arranged for half-duplex operation.

50. In a communication system, a plurality of subscriber stations, a central office, a plurality of switching centers connectable in tandem to said central office, trunk circuits arranged for full-duplex supervisory operation interconnecting one of said switching centers and said central office, other trunk circuits arranged for half-duplex operation interconnecting another of said switching centers and said one switching center, selective means seizable by any one of said first-named trunks and remotely operable thereover, establishing a connection under control of said central office through said plurality of switching centers and between one of said subscriber stations and said central office, and means operative incident to the establishment of said connection to convert said trunk which is full duplex for supervisory operation to half duplex for communication.

51. A teletypewriter switching system comprising a central office, a plurality of switching centers connected in tandem to said central office, a plurality of subscriber stations connected to one of said switching centers, trunk circuits normally arranged for full-duplex operation and interconnecting the other of said switching centers and said central office, other trunk circuits arranged for half-duplex operation and interconnecting said one of said switching centers and said other switching center, permutation code transmission means adapted for connection to any one of said first-named trunk circuits for establishing a connection through one or more switching centers, in tandem, between said central office and one of said subscriber stations for communication purposes.

52. In a telegraphic system, a central office, a satellite office, a plurality of subscriber stations, a plurality of lines respectively connecting said subscriber stations to said satellite office, a group of said lines extending to a group of stations of one subscriber, a trunk connecting said satellite office to said central office, means at said satellite office responsive to telegraphic code transmitted from said central office for automatically selecting for connection any line of said group to said trunk circuit, and other means at said satellite office for automatically selecting for said connection the next idle line of a group when said one subscriber line of said group is busy.

53. In a telegraphic system, a central office, a satellite office, a plurality of subscriber stations, certain of said stations being arranged in groups and certain stations of a group being arranged for attended service and other stations of said group being arranged for unattended service, a line connecting each of said stations with said satellite office, a trunk connecting said satellite office to said central office, means in said satellite office responsive to telegraphic code transmitted from said central office for automatically selecting for connection any one of said subscriber stations of a group to said trunk, other means in said satellite office responsive to telegraphic code transmitted from said central office for automatically connecting to said trunk any one of said certain stations of said group, still other means in said satellite office responsive to telegraphic cde transmitted from said central office for automatically connecting to said trunk one of the other stations of said group, and hunting means at said

satellite office for automatically selecting for said connection the next idle subscriber station of a group when said one station originally selected is busy.

54. In a teletypewriter system, a central office, a satellite office, a plurality of subscriber stations, a plurality of lines respectively connecting said subscriber stations to said satellite office, said lines being arranged, first, in groups and then in subgroups, a trunk connecting said satellite office to said central office, means at said satellite office responsive to permutation code transmitted from said central office, for automatically connecting any one of said lines in any one of said subgroups to said trunk, other means operative in response to the operation of said means for selecting the next higher numbered idle line in said one subgroup when said line, originally selected, is busy, still other means operative in response to the joint operation of said means and said other means for continuing the selecting of the next higher numbered idle line in said one subgroup when the previously selected lines are found busy, until all lines in said group are found busy, and signaling means at said central office for indicating when all lines of said subgroup are busy.

55. A telegraph system comprising a local station, an unattended office, a second unattended office, a central office, call means at said station operable to extend a telegraphic channel to said first unattended office, means operable incident to said extension to seize an idle trunk between said first and said second unattended offices, telegraph signaling means operable incident to said seizure to seize an idle trunk to said central office, switching means including electromagnetic means coordinately arranged and operable incident to said first seizure to connect said seized trunk to said channel, one of said electromagnetic means being individual to the first-mentioned trunk and arranged to condition the first-mentioned trunk for seizure in response to the operation of said call means and the other of said electromagnetic means being individual to said channel and arranged to interconnect said channel and the first-mentioned trunk and to hold said connection, other switching means including electromagnetic means coordinately arranged and operable incident to said second seizure to connect said second seized trunk to said first selected trunk, one of said electromagnetic means on said other switching means being individual to the second-mentioned trunk and arranged to condition the second-mentioned trunk for seizure in response to the operation of said telegraph signaling means, and the other of said electromagnetic means of said other switching means being individual to the first-mentioned trunk and arranged to interconnect said first-mentioned and said second-mentioned trunk and to hold the second-mentioned connection, said connection thus held constituting a telegraphic intercommunication channel between said local station and said central office, means operable from said local station for conditioning both of said holding electromagnetic means for release, and means at the central office operable upon said conditioning for causing the release of said holding electromagnetic means and restoration of said trunks to idle condition.

56. A system for establishing a through telegraphic communication path comprising a first station having a path of telegraphic communication extending to a second station, means for sending impulses comprising selectively coded permutations of a fixed number of different conditions from said first station to said second station, means including selector means operated under control of said codes as received at said second station to select out of a possible plurality of selectable channels one leading to a third station and connecting it transmissively in tandem to form in conjunction with said path a channel of transmission, and means including selector means at said third station operable by additional impulses comprising selectively coded similar permutations for selecting one of a plural number of selectable conductors and connecting it in tandem with said channel of transmission.

57. A system for establishing a through telegraphic communication path comprising a first station having a path of telegraphic communication extending to a second station, means for sending impulses comprising selectively coded permutations of a fixed number of different conditions from said first station to said second station, means including selector means operated under control of said codes as received at said second station to select out of a possible plurality of selectable channels one leading to a third station and connecting it transmissively in tandem to form in conjunction with said path a channel of transmission, means including selector means at said third station operable by additional impulses comprising selectively coded similar permutations for selecting one of a plural number of selectable stations each including a permutation code responsive selector and connecting it in tandem with said channel of transmission, and means including said last-named selector selectively responsive to selectively coded similar permutations sent from said first station.

58. A system for establishing a through telegraphic communication path, delivering a message thereover, and disestablishing said path all under control of a first station, which comprises sending from said first station coded impulses over a channel of impulse transmission to a second station, selective means at said second station operated under control of said coded impulses to select a channel of impulse transmission to a third station and interconnect it to said first-named channel, means at said third station including means operated under control of code impulses transmitted over said interconnected channels as a through transmission path to select a channel of impulse transmission leading to a further station, means at said further station controllable over said channels under sole control from said first station to record at said further station a message transmitted by coded impulses, and means operable under the sole control of said first station to disconnect all said channels selected and connected as aforesaid.

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