March 27, 1945. W. V. K. LARGE ET AL 2,372,329

SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 1

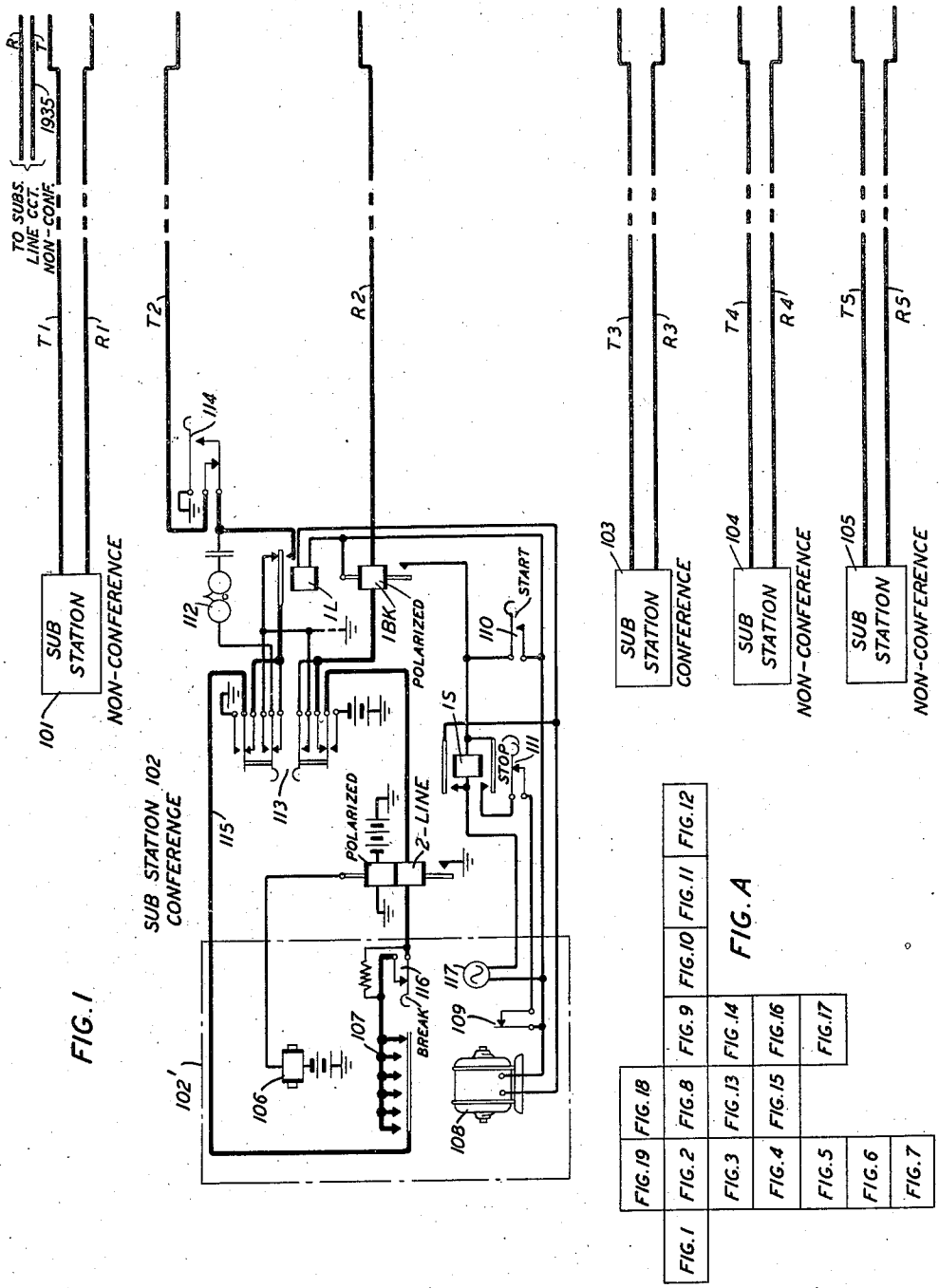

FIG. 1

FIG. A

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 2

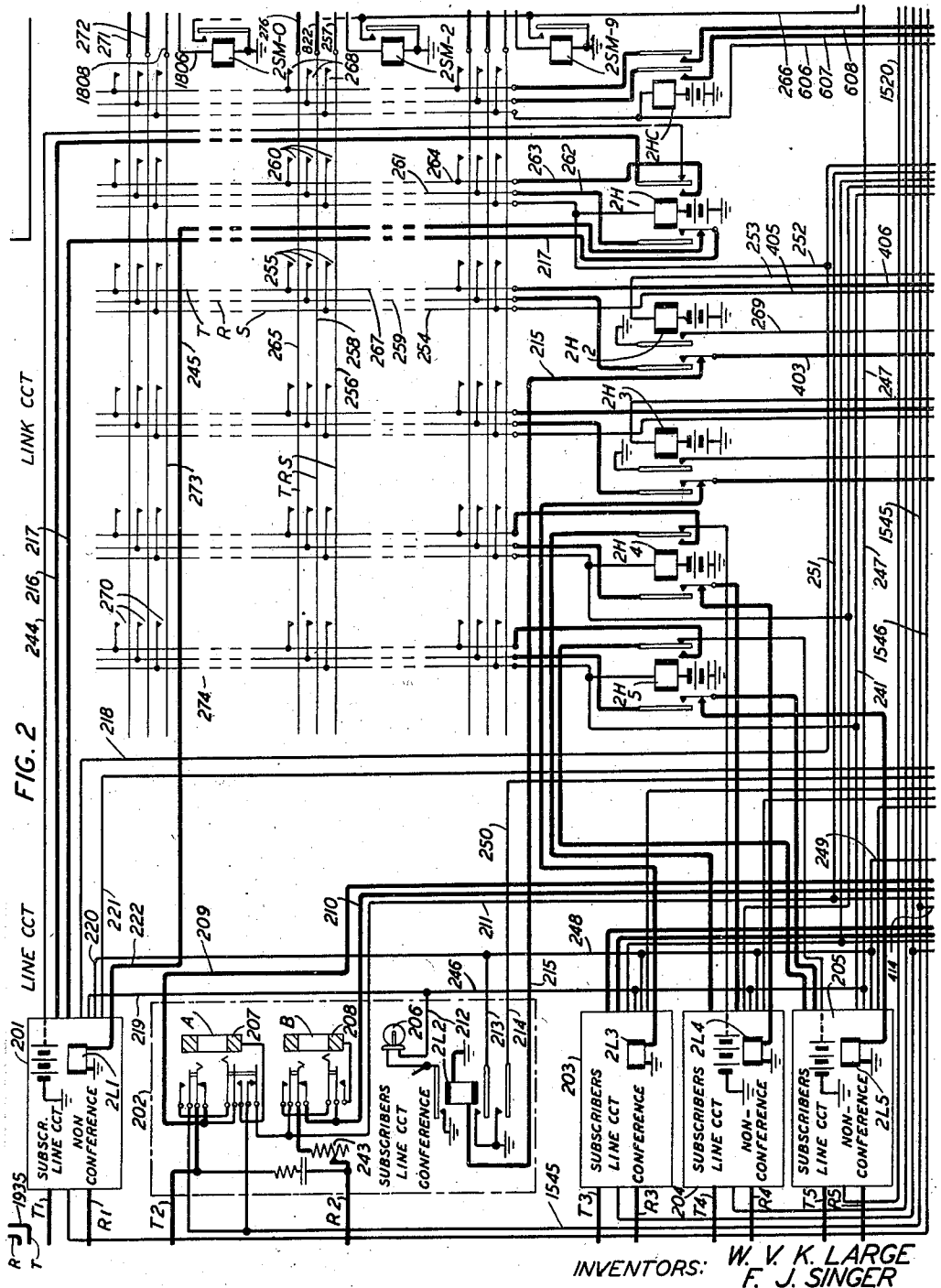

FIG. 2

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 3

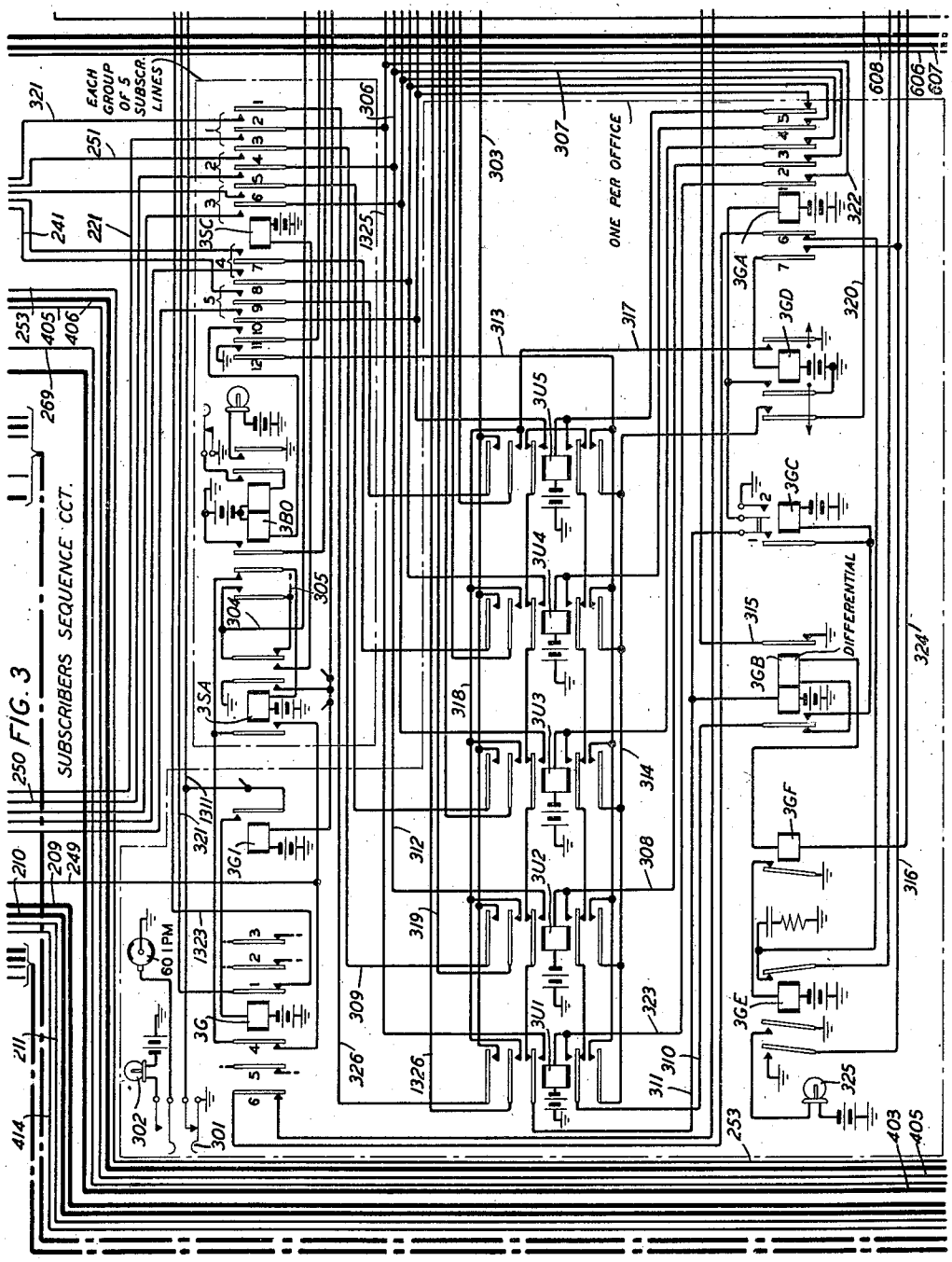

FIG. 3

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 4

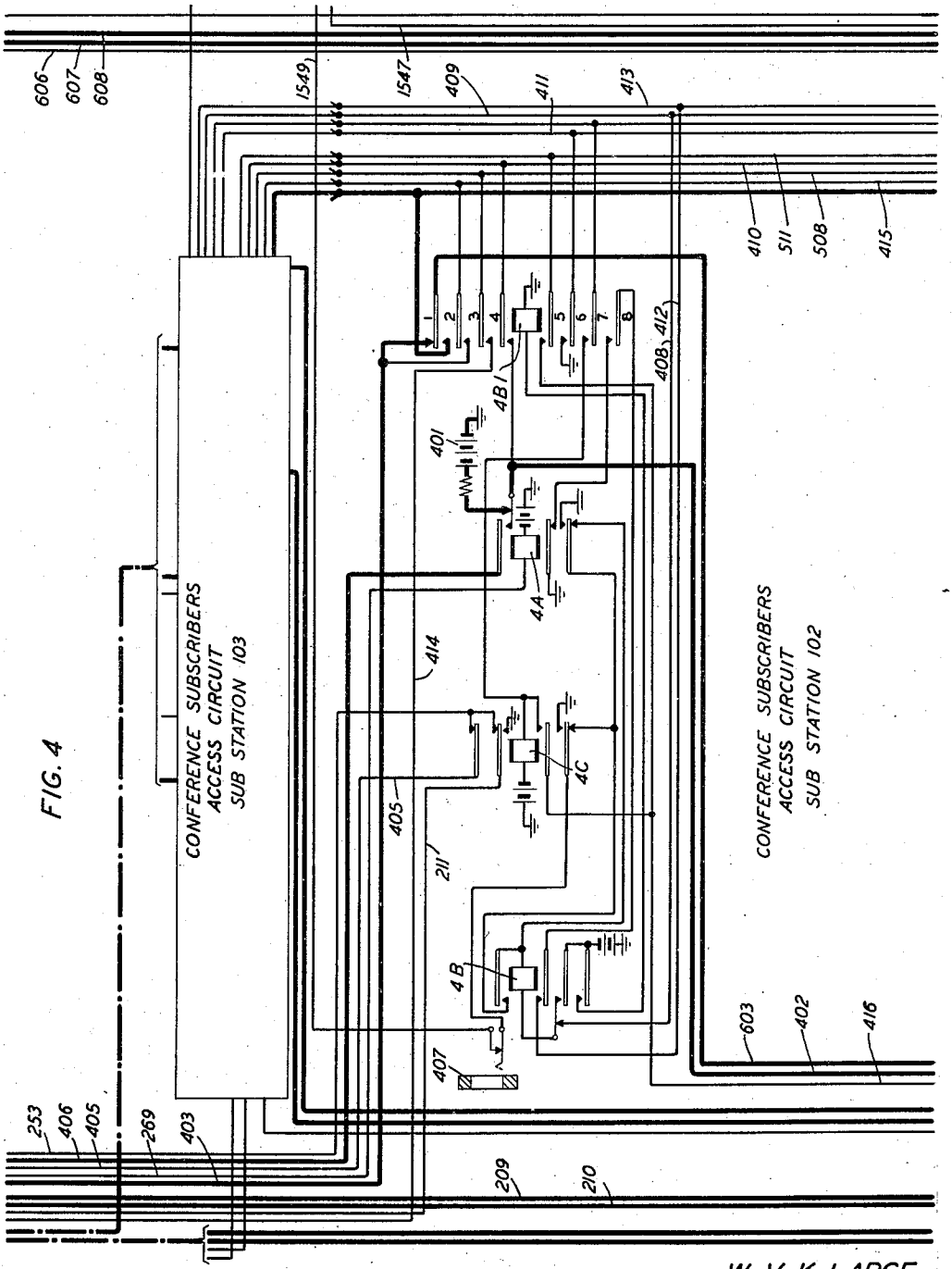

FIG. 4

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 5

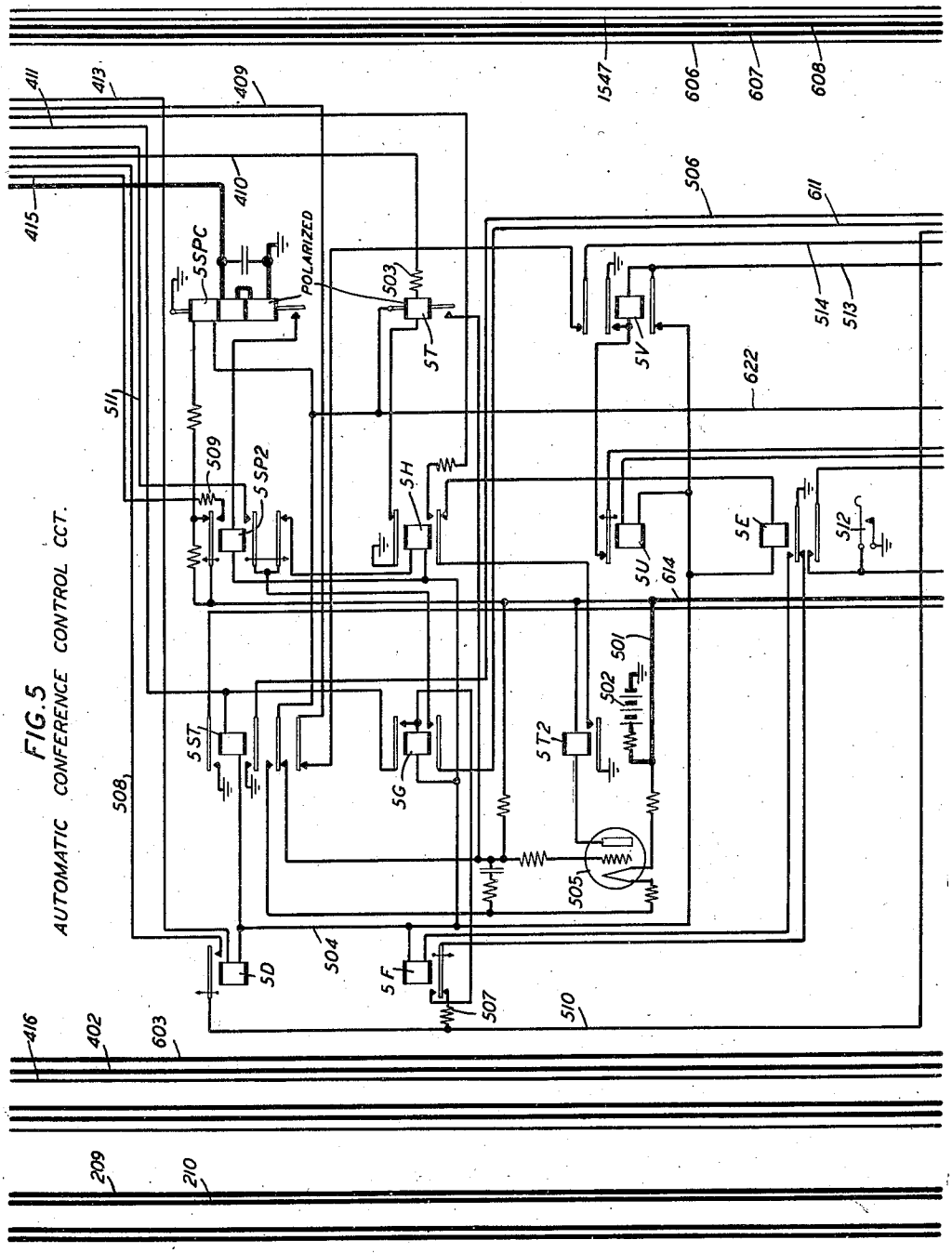

FIG. 5
AUTOMATIC CONFERENCE CONTROL CCT.

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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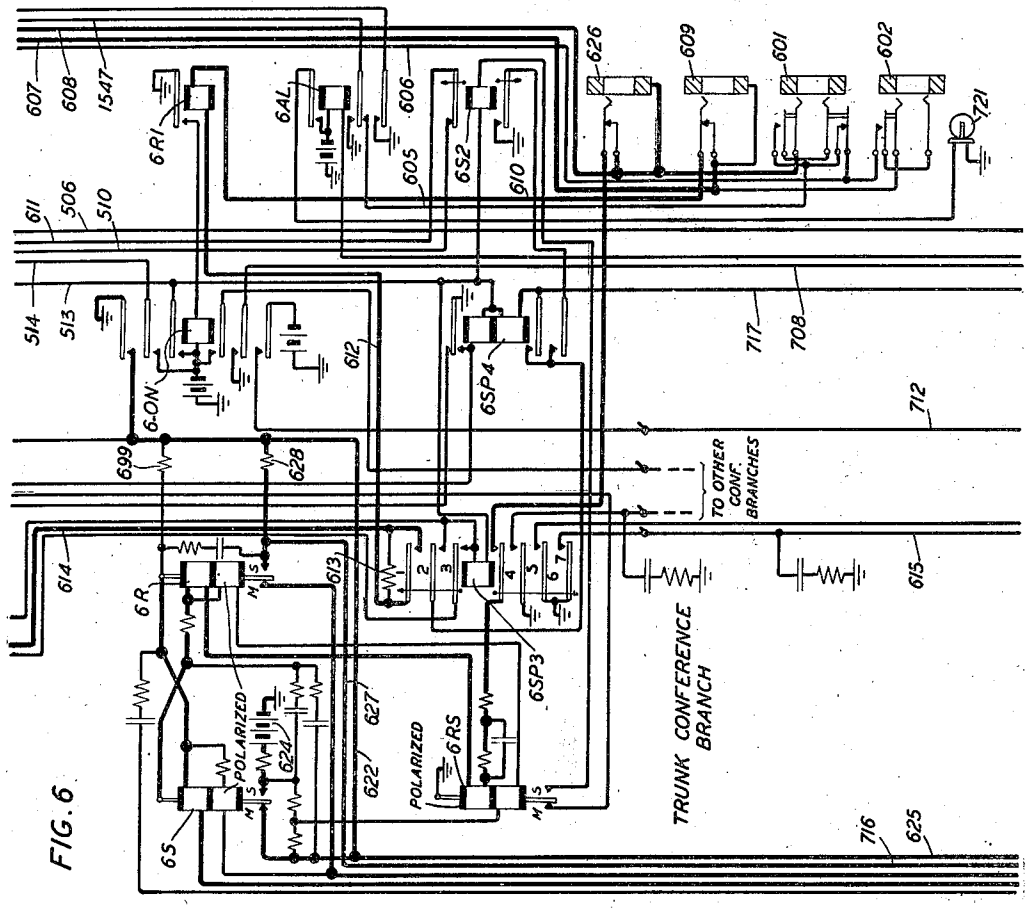
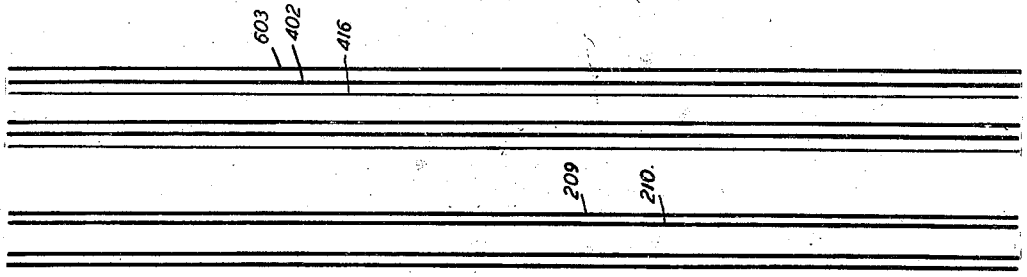


FIG. 6



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 7

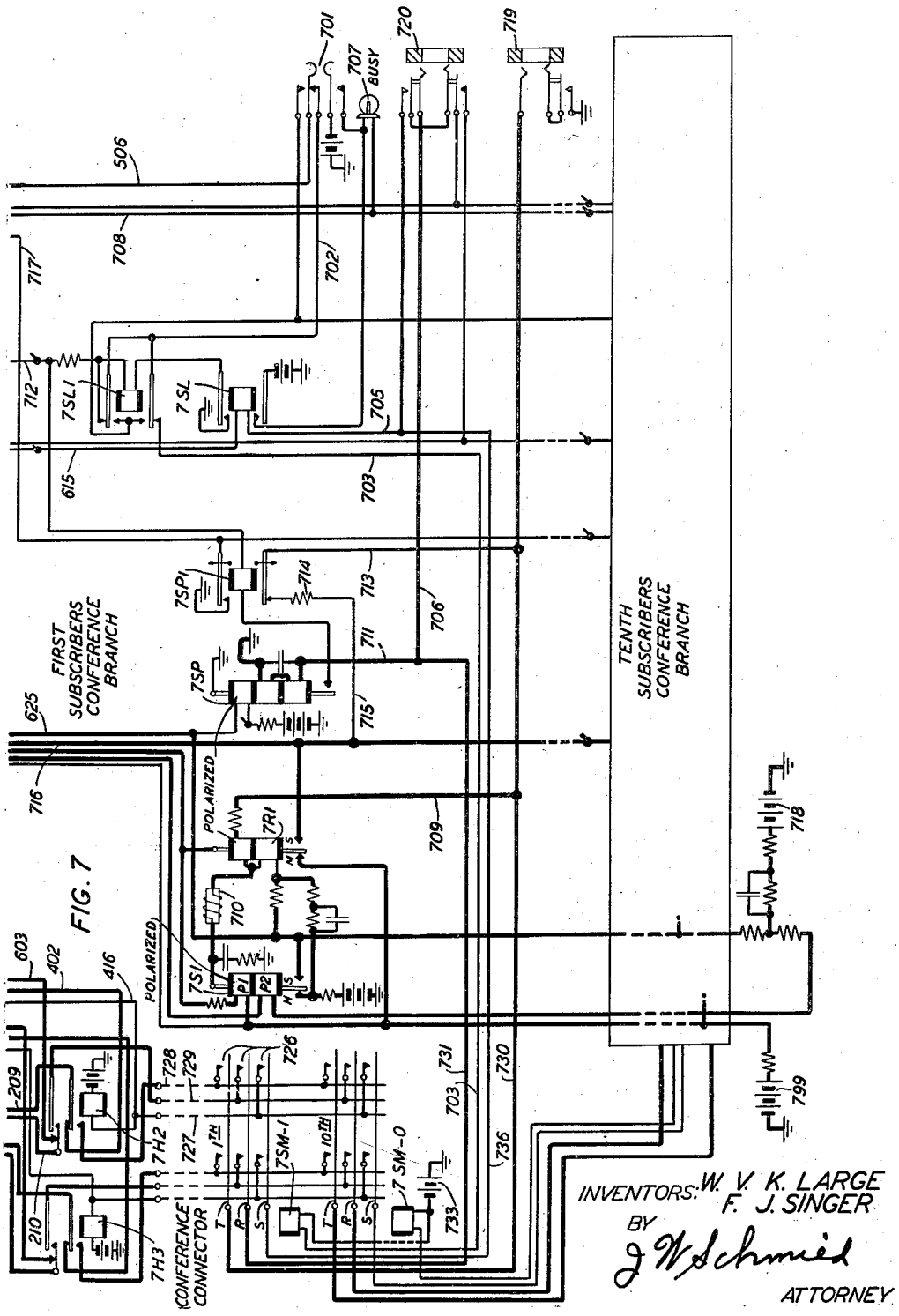

FIG. 7

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 8

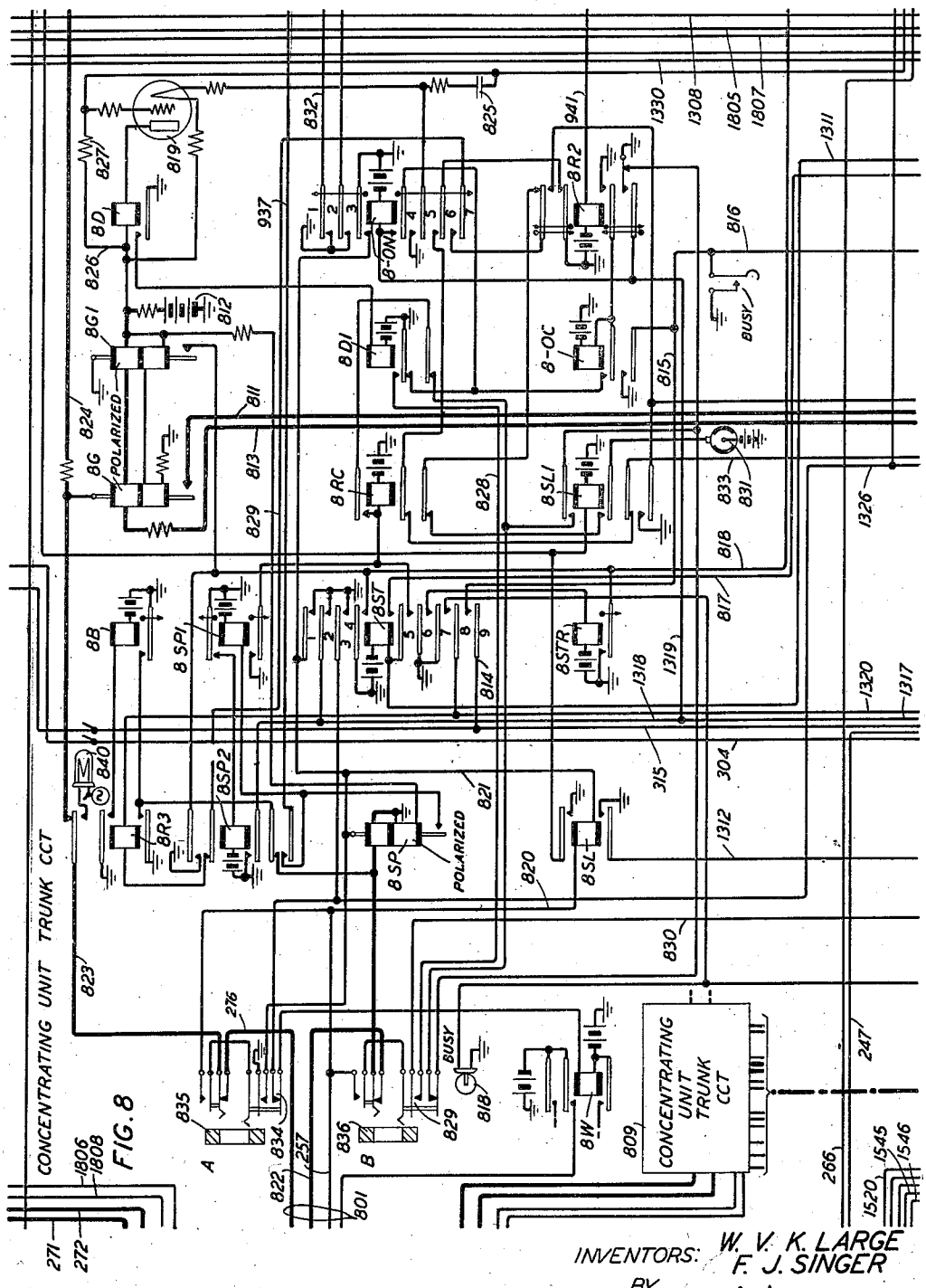

FIG. 8

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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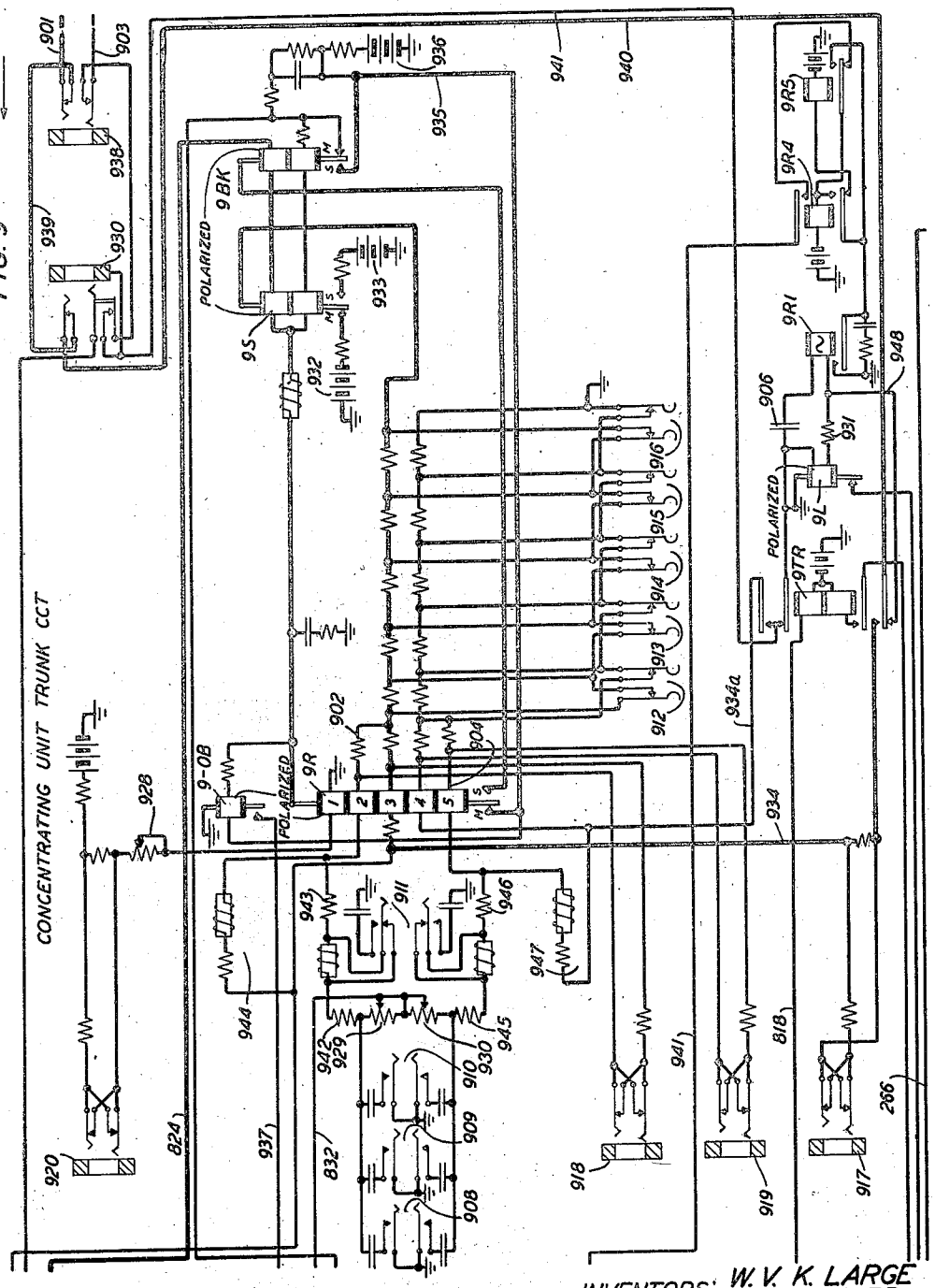
FIG. 9



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 10

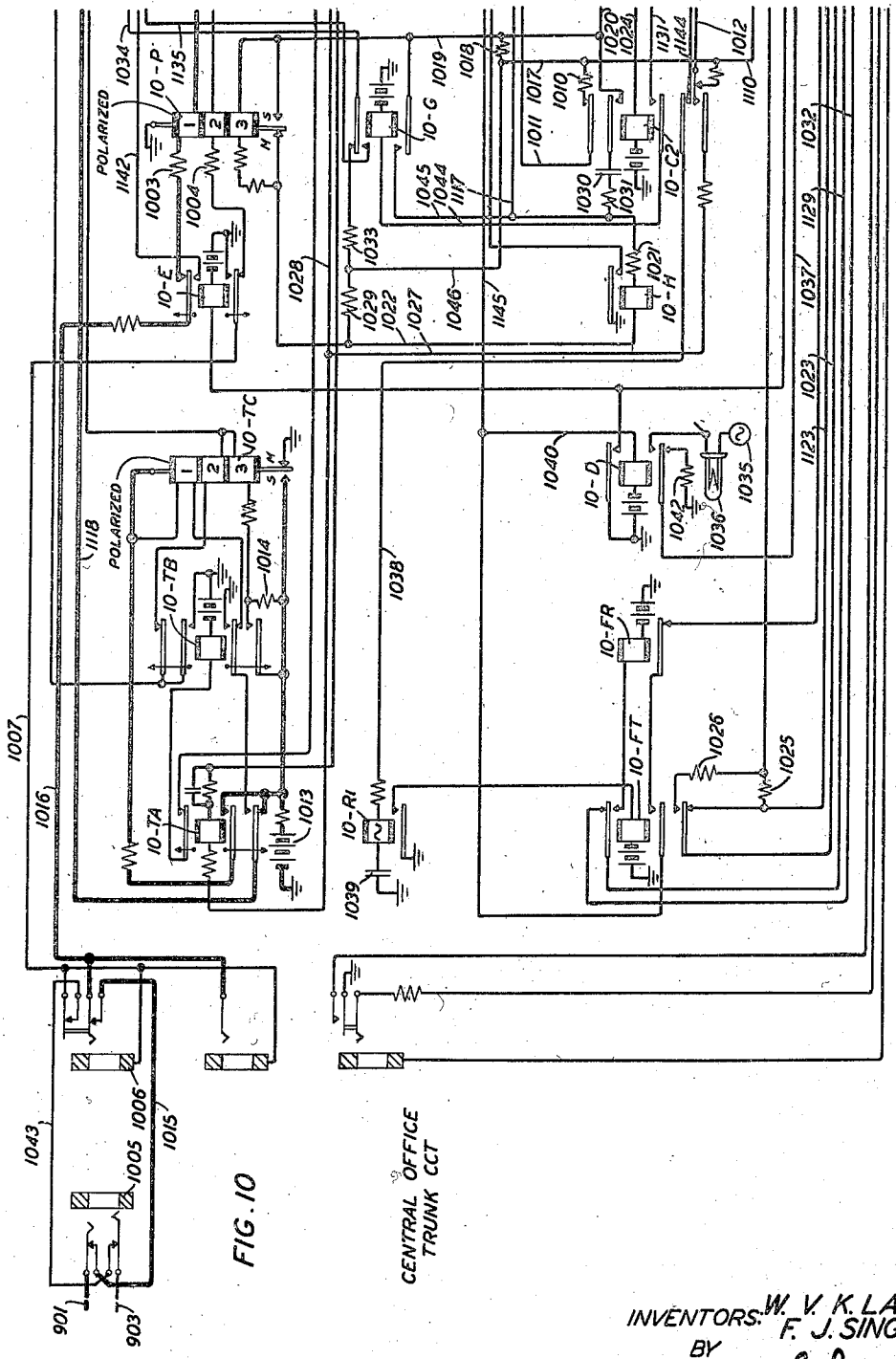

FIG. 10

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 11

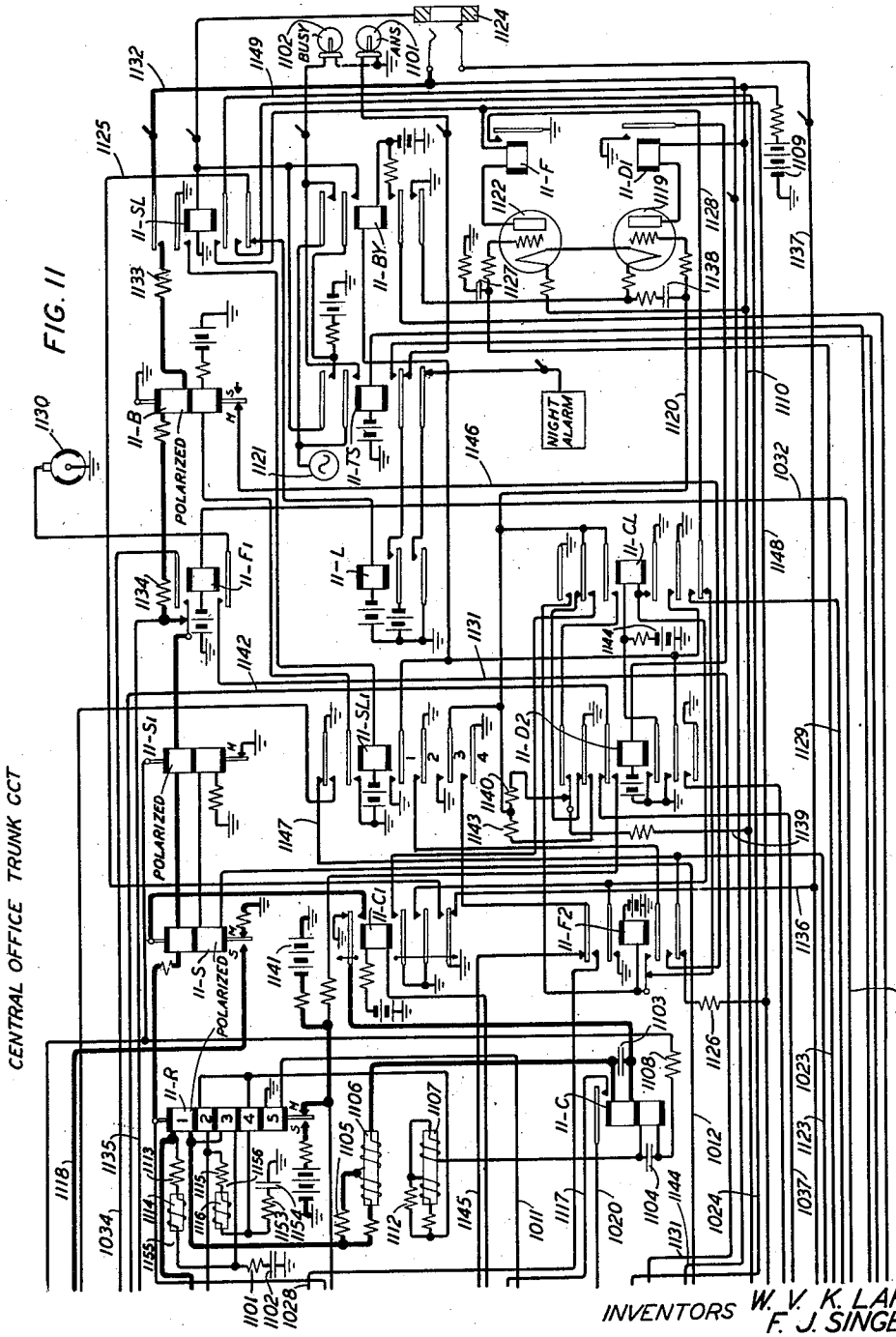

FIG. 11

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 12

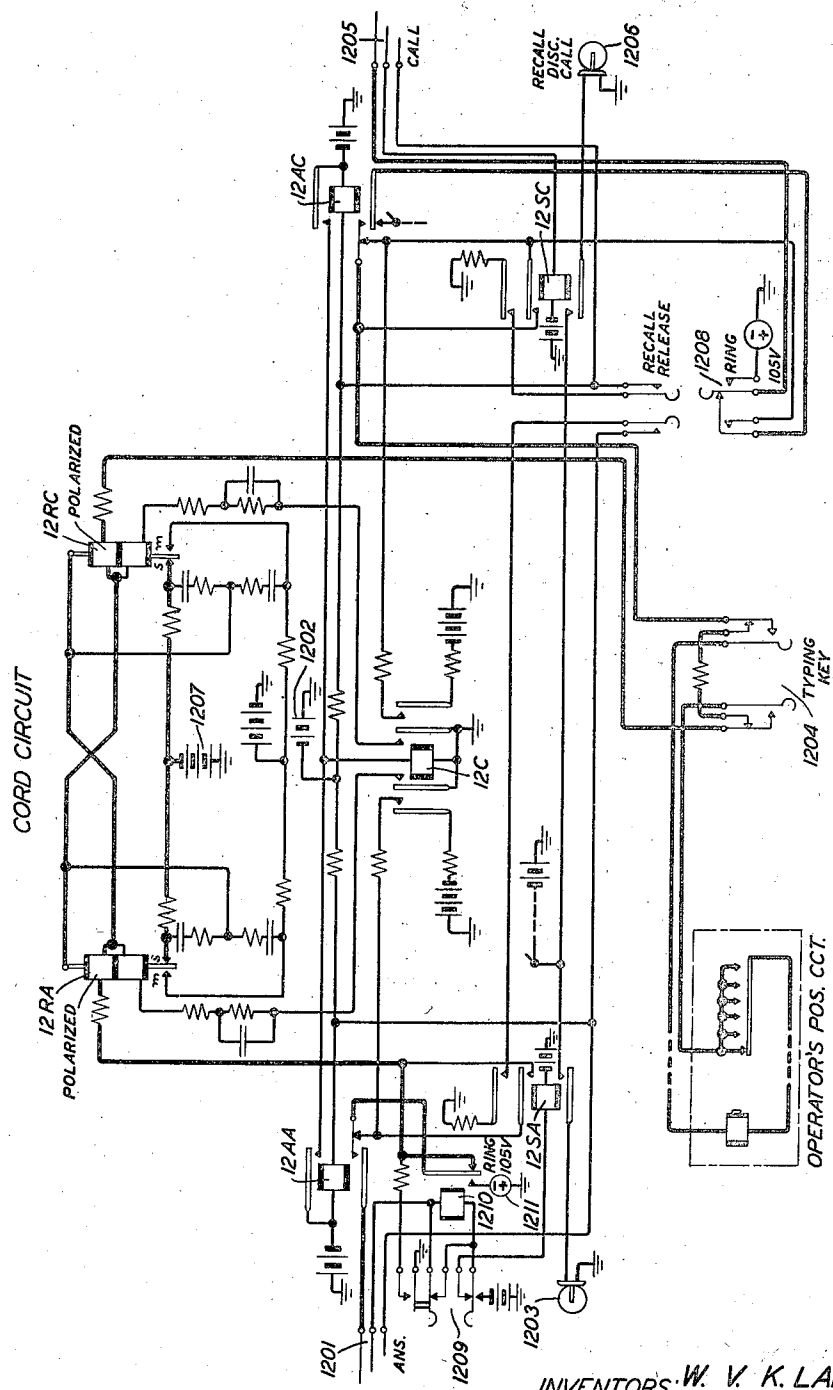

FIG. 12

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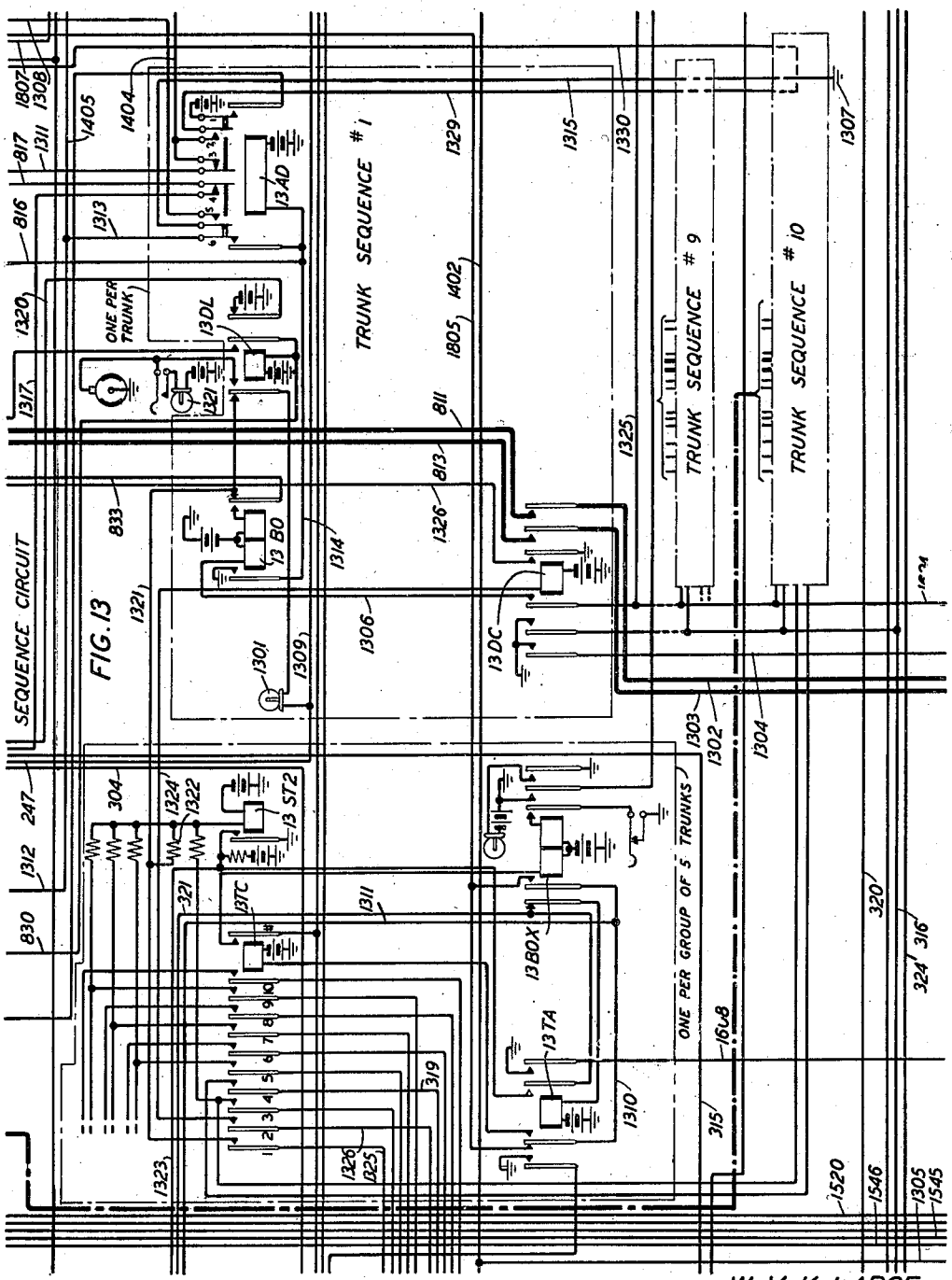
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 13



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 14

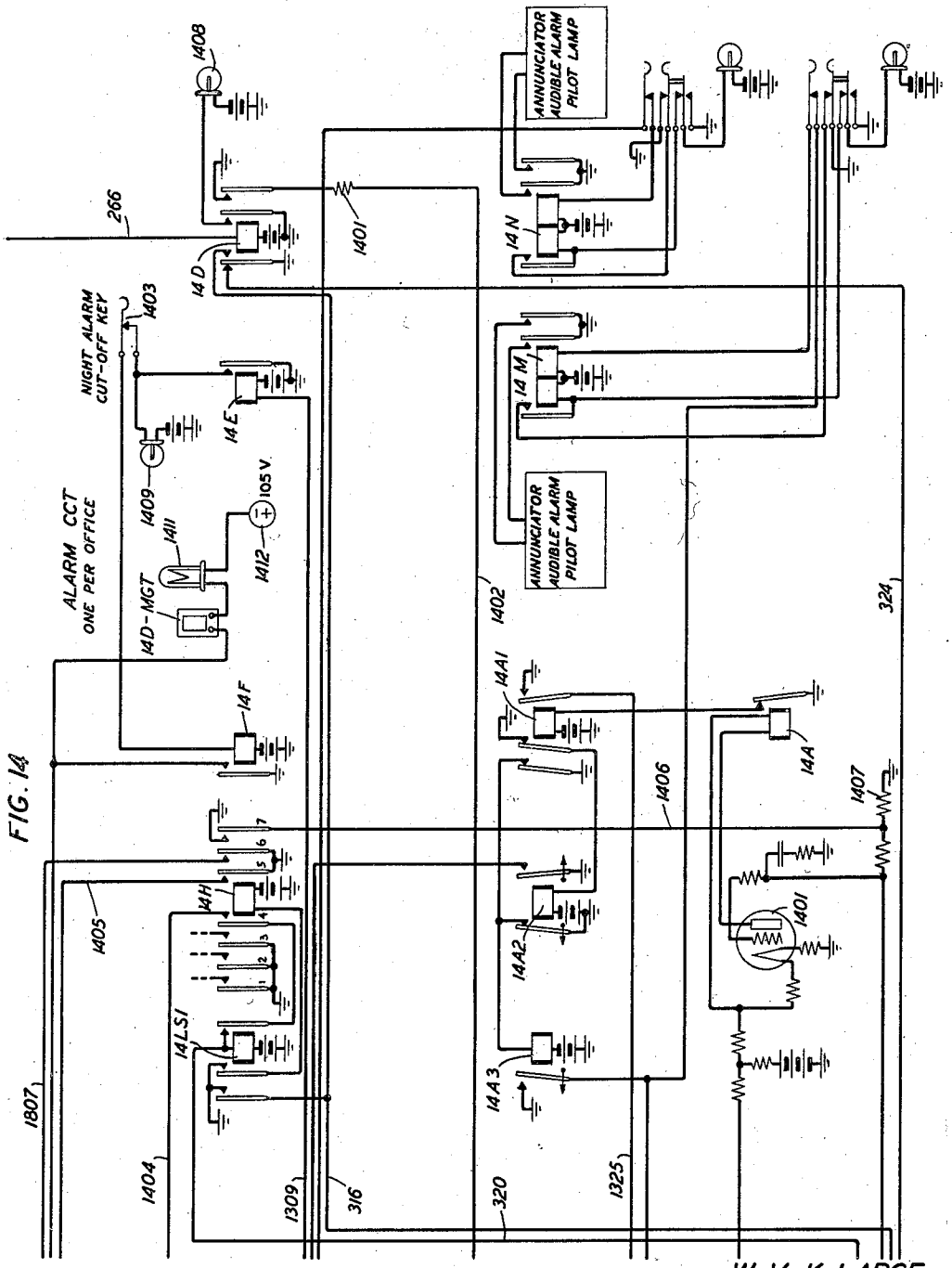

FIG. 14

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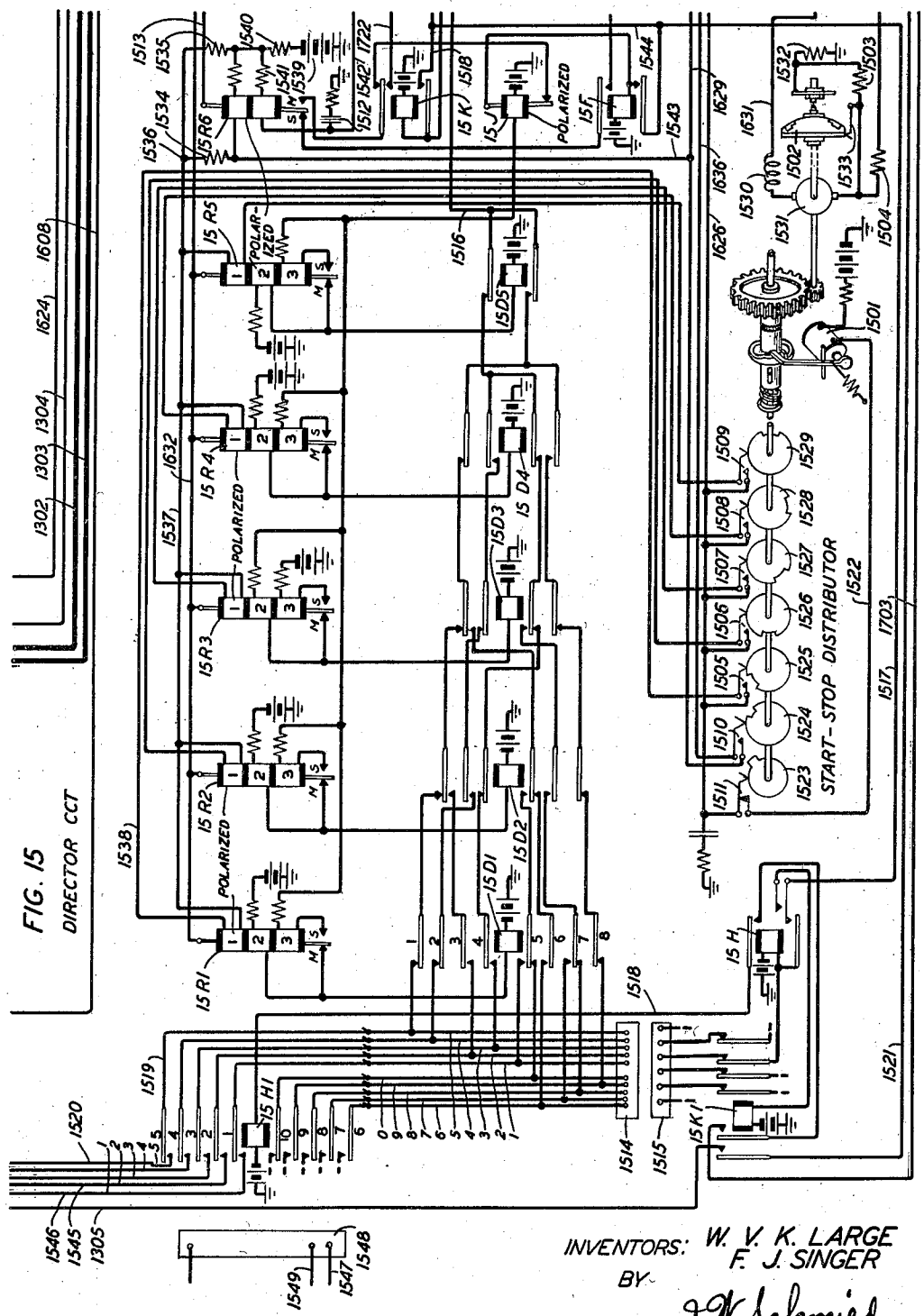
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 15



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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

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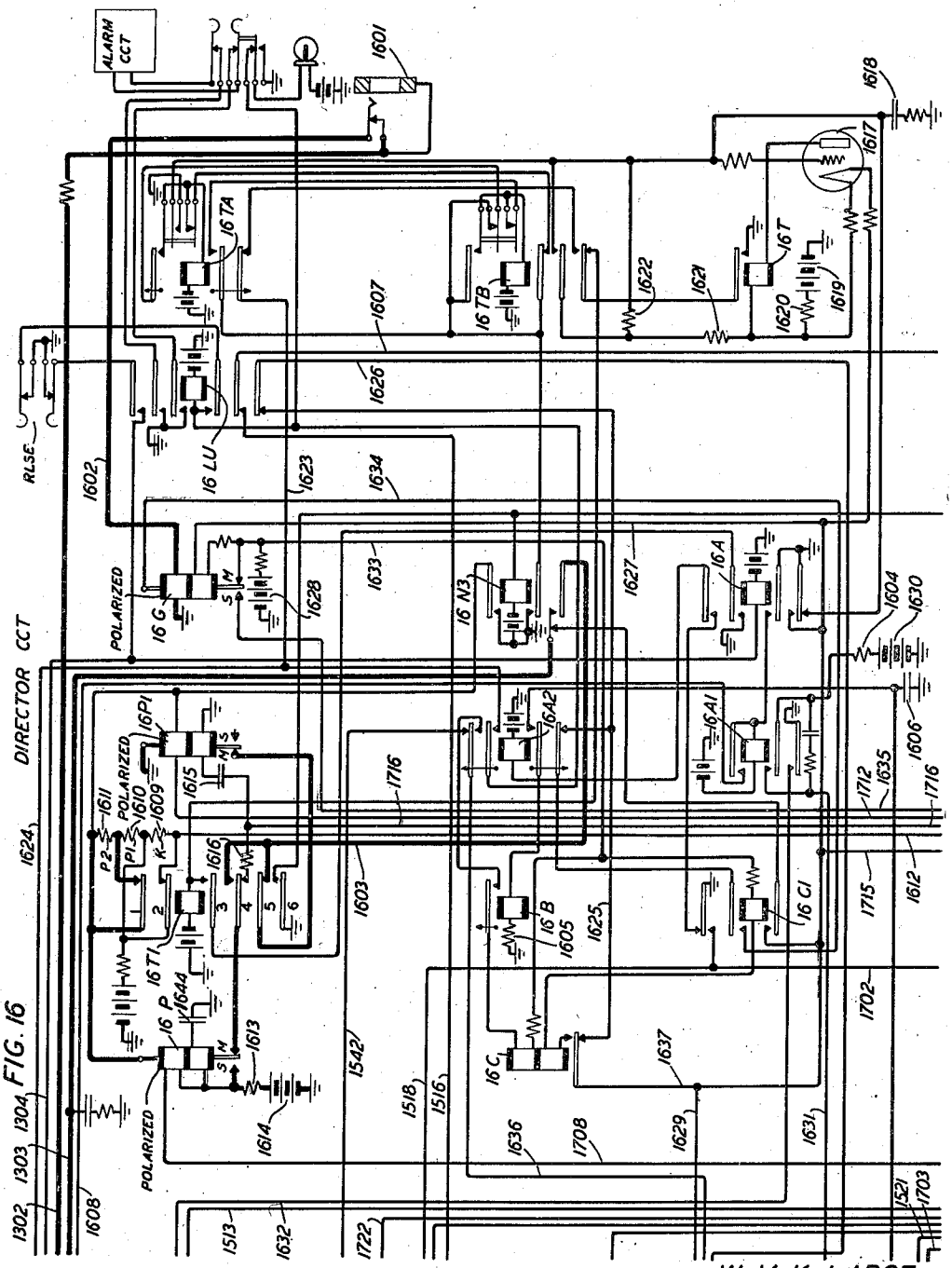

FIG. 16

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 17

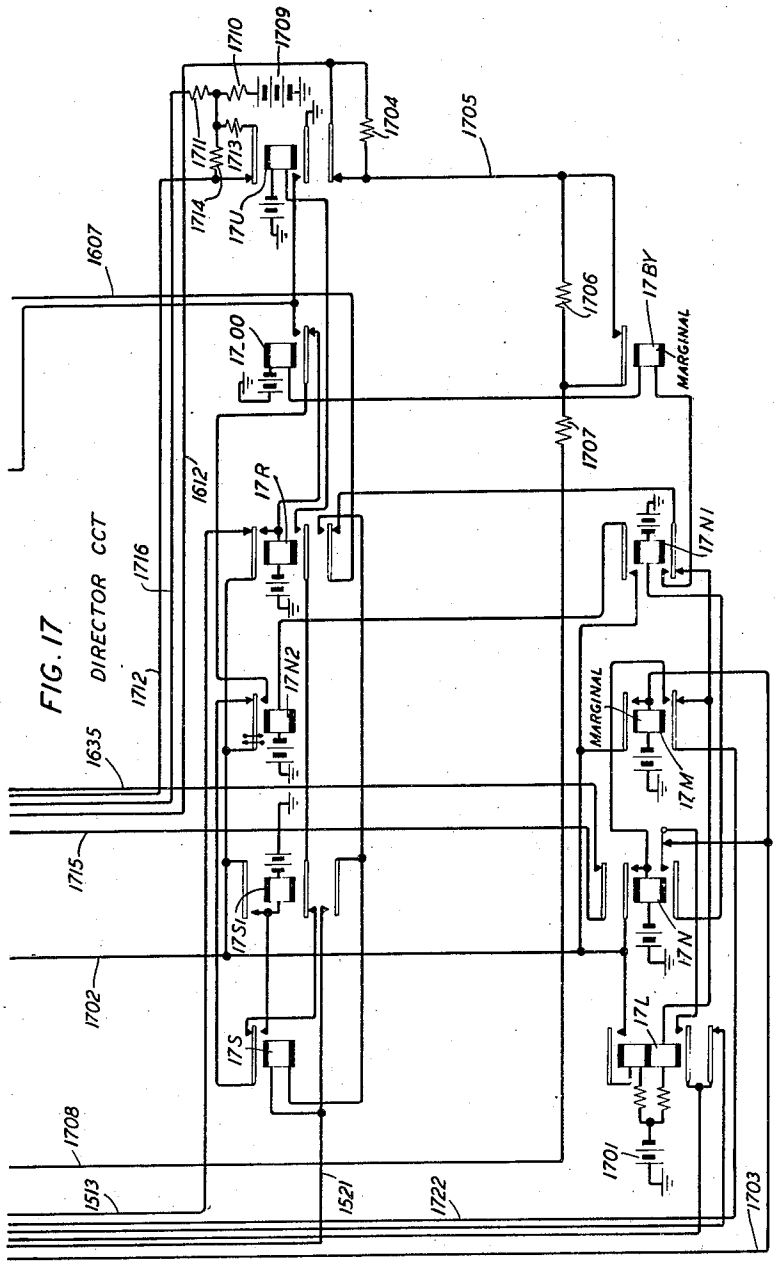

FIG. 17

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SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 18

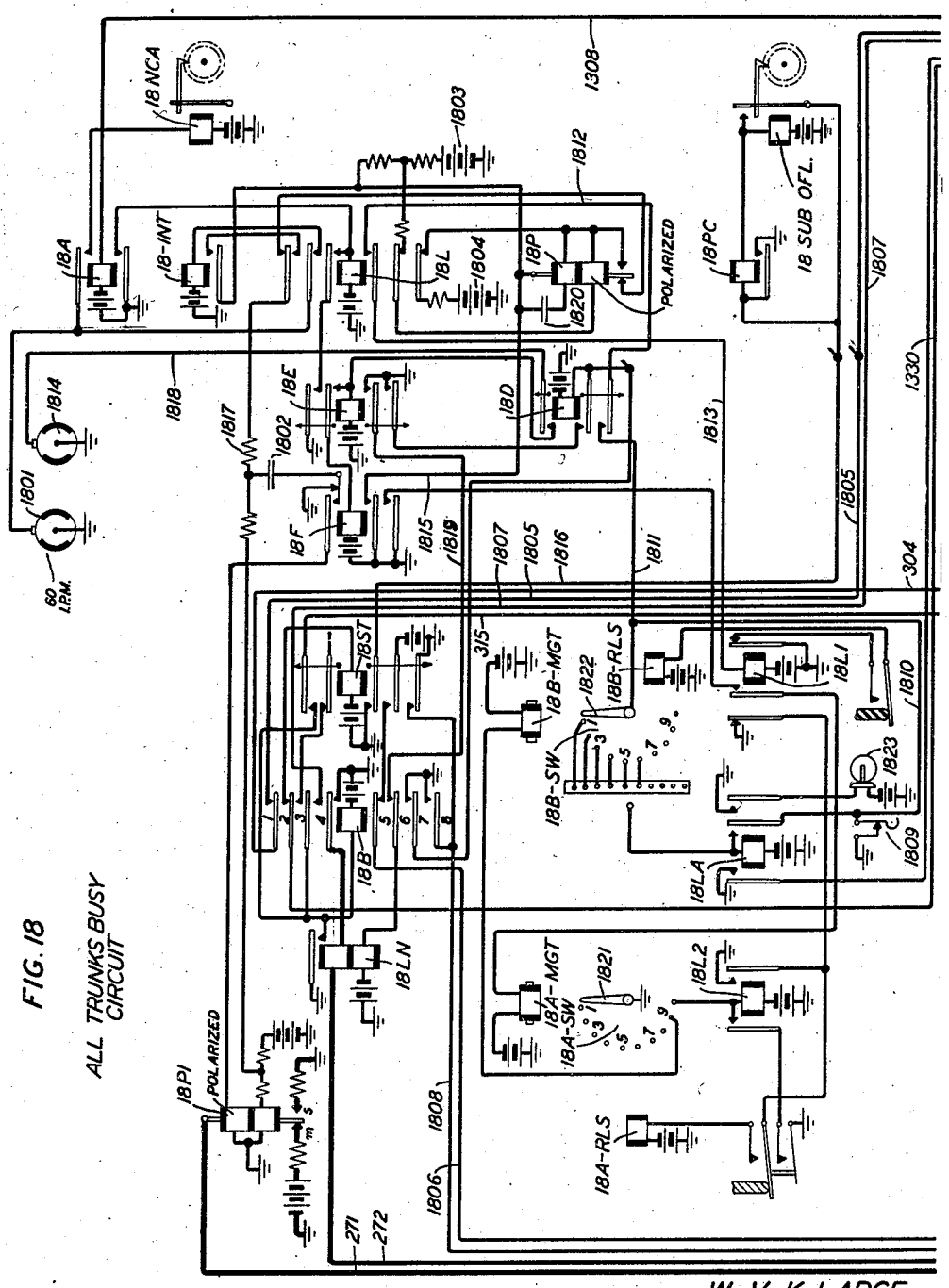

FIG. 18

ALL TRUNKS BUSY CIRCUIT

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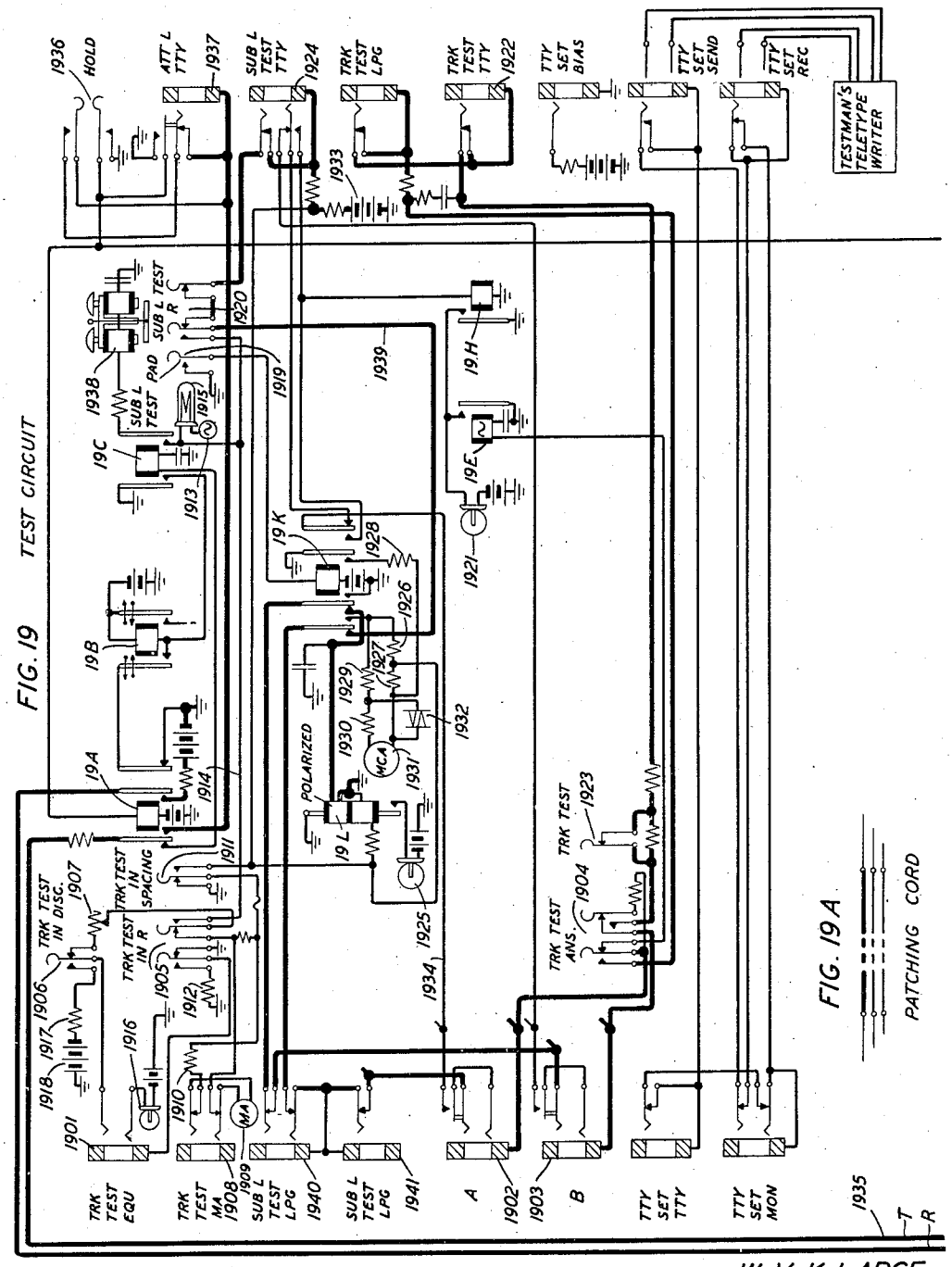
SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Filed Oct. 22, 1942 19 Sheets-Sheet 19



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Patented Mar. 27, 1945 2,372,329

UNITED STATES PATENT OFFICE

2,372,329

SATELLITE TELETYPEWRITER SWITCHING SYSTEM

Wayne V. K. Large, Glenwood Landing, and Fred J. Singer, Rockville Centre, N. Y., assignors to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application October 22, 1942, Serial No. 462,966

19 Claims. (Cl. 178—2)

This invention relates to telegraph switching system and particularly to that class of telegraph switching and transmission systems known as satellite office systems.

The principal elements of a satellite system are, first a number of outlying stations or subscribers' 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 subscribers. 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 subscribers' stations. By means of a small number of trunks sending from the central office or offices to the satellite office and individual lines from the satellite office to each subscriber's station combined with automatic switching arrangements at the satellite office whereby interconnections may be made between any of the trunks and any of the 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 are known. 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; Kinkead and Lucek Patent 2,340,599, dated February 1, 1944; and Krecek Patent 2,368,666, dated February 6, 1945. It will be noted that each of these prior systems includes full-duplex trunks between the central office and the satellite office. The expense of installing and maintaining these trunks is considerable and a principal object of the present invention is to provide a system in which the trunks are half-duplex together with attendant simplification of apparatus and consequent reductions of cost and maintenance.

Another solution of this problem is disclosed in Large Patent 2,356,067, dated August 15, 1944; this system operates upon a jack per line basis (one jack multiple at the central office for each subscriber's line). That arrangement is more expensive to install and maintain than the arrangement of the present application; it operates, of course, upon principles which are considerably different.

Other attempts to give a somewhat similar service have involved the use of dial code which is relatively undesirable from an operating standpoint because it introduces additional transmission elements and other complexities.

Still other arrangements have involved not only the difficulties inherent in the use of dial code but also required the transmission of three signaling conditions over the trunks which made it impossible to use standard telegraph repeaters, if indeed any repeaters at all are useable in the trunks of such systems and, furthermore, such systems are entirely unsuitable for extending communication paths established to the central office beyond the central office and, furthermore, are lacking in satisfactory call and supervisory means.

The present system results from efforts to incorporate the essential and most desirable features of a system such as disclosed in the Kinkead and Lucek Patent 2,340,599, supra, into a system utilizing trunks operating on the half-duplex principle instead of the full-duplex principle together with the attendant simplicity of circuits and economy of operation and maintenance.

In Lucek Patent 2,368,715, dated February 6, 1945, there is disclosed and claimed a system including conference circuits which serve subscribers, whose lines terminate at a satellite office, which may be connected into an intersubscriber's conference circuit under remote control by the adjacent central office operator or under manual control by an attendant, serviceman or night attendant at the satellite office. In that Lucek application, the trunk circuits are of the full-duplex type. This present system as disclosed herein includes the option of equivalent conference circuits in a system employing half-duplex trunks; this, therefore, is another feature of the invention.

In certain localities a system of this type may be required to operate over trunks of different types, some of which may be subject to considerable interference, such as simplex phantom cable circuits, grounded direct current telegraph circuits subject to un-neutralized ground potentials, open wire circuits, etc. The system herein disclosed includes as a feature a balancing conductor whereby voltages emanating from extraneous sources and induced in the transmission trunk may be neutralized, thereby improving the transmission not only with respect to supervisory signals but also with respect to communication signals. This neutralizing conductor is not an element essential for every application of the system and it may be omitted simply by leaving off the conductor.

It is desirable that a system of this type be adapted to operate over trunks subject to high

and variable line leakage. A telegraph transmission system has been devised in recent years wherein the telegraph transmission in either direction is completely independent of variations in line leakage, on the assumption that the leakage is equally distributed throughout the line, or upon the equivalent assumption that the leakage is effectively concentrated at the mid-point of the line. A further feature of the present invention consists of half-duplex trunks so designed and so cooperating with the remaining elements of the system that this advantageous method of transmission may be utilized. Such method of transmission is sometimes referred to as a type B polarential system and such expression will be used herein in reference to it.

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

The drawings consist of nineteen sheets.

Fig. A is a diagram showing how Figs. 1 to 19, inclusive, shall be placed to form a complete circuit diagram illustrating the invention.

Fig. 1 shows a local subscriber's station in detail and four other local subscriber stations in diagrammatic form;

Fig. 2 shows the subscriber's line circuits respectively associated with the local subscriber stations, one of the line circuits being shown in detail. Also shown in Fig. 2 is the link circuit whereby any one or more of the local subscriber stations may be connected to one or more trunk circuits;

Fig. 3 shows the subscriber's sequence circuit;

Figs. 4 to 7 inclusive, show the conference circuit. Fig. 4 represents ten conference subscriber access circuits, one of which is shown in detail and another is shown in diagrammatic form. Fig. 5 shows the automatic control circuit for the conference circuit. Fig. 6 shows the trunk conference branch which is common to the system and is adapted for connection to any one or more of ten of the subscriber stations. Fig. 7 represents ten subscriber conference branch circuits one of which is shown in detail. The subscriber conference branch circuits are adapted for connection to any one or more of ten local subscriber stations to the trunk conference branch circuit. By means of access circuits ten predetermined local subscriber stations may be automatically connected to the trunk conference branch circuit. By means of jacks in each of the subscriber conference branch circuits any one of the local subscriber stations may be manually connected to the trunk branch conference circuit. An access circuit is at times referred to as an applique circuit and may be defined as an assemblage of circuitally interconnected elements supplementing a principal assemblage of circuital elements (which is generally completed and usefully operable in and of itself) to perform or permit the performance of supplemental or additional functions.

Figs. 8 and 9 show the terminating equipment for two concentrating unit trunk circuits, located at the concentrating unit switching center. The terminating equipment for one of these trunk circuits is shown in detail and the other is shown in diagrammatic form;

Figs. 10 and 11 show the terminating equipment located at the central office and terminating one of the trunk circuits, the one trunk being the same as that whose terminating equipment at the concentrating unit switching center is shown in detail in Figs. 8 and 9;

Fig. 12 shows a cord circuit at the central office;

Fig. 13 shows the trunk sequence circuit;

Fig. 14 shows the miscellaneous alarm circuit;

Figs. 15, 16 and 17 show the director circuit;

Fig. 18 shows the all-trunks-busy circuit, and

Fig. 19 shows the test circuit.

The link circuit shown in Fig. 2 comprises a switching instrumentality well known in the art as a "cross bar switch," certain forms of which are described in United States patents to Reynolds 2,021,329, dated November 19, 1935, and 2,047,333, dated July 14, 1936. As disclosed, 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.

The use of reference characters has been kept to a rigid plan. Thus all relays shown in each figure have reference characters consisting of numerals and letters, the numerals shown as prefixes corresponding to the figure number in which the particular relay is located. All other parts of the circuit are designated by numerals only, for instance those parts of Fig. 1 are designated with numerals between 100 and 199, those in Fig. 2 are designated with numerals between 200 and 299 wherein the hundreds digit designates the figures in which the particular part is found.

In some cases, in order to avoid the extending 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 system is composed of parts referred to in engineering parlance as "circuits" and each figure of the drawings is designated with a legend setting forth its relationship to the system. The general functioning of each part of the system is set forth hereinafter under headings individual to the various parts as follows:

Local subscriber station

In Fig. 1 there is illustrated in schematic form a local subscriber station 102 connected with the concentrating unit switching center by a pair of conductors such as those designated T and R. Other local subscriber stations 101, 103, 104 and 105 are shown in diagrammatic form. As will be hereinafter described, station 102 herein shown in schematic form and station 103 are arranged for automatic connection to a conference circuit,

whereas stations 101, 104 and 105 are arranged for non-conference purposes but may, if so desired, be connected to the conference circuit by manual means employed by the attendant at the concentrating unit switching center. One station only, that is, the one shown in schematic form, is selected herein for description of operation in detail.

Referring to local subscriber's station 102 shown in schematic form the subscriber's loop comprises conductors T2 and R2 and a printing telegraph sending and receiving unit 102'. Unit 102' comprises a printer magnet 106, a set of sending contacts 107 and a suitable motor 108 equipped with a pair of stop contacts 109 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 110 for starting the printer set motor, a stop, or break, key 111 for stopping the printer set, a ringer, or bell, 112 whereby the central office operator may signal the subscriber's station, a test key 113 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 114 for signaling the central office and several relays, the functions of which will be hereinafter described.

For the details of the printing telegraph sending and receiving unit 107, reference may be had to United States Patent 1,904,164, granted to S. Morton et al. on April 18, 1933.

Subscriber station line circuit

Each of the subscriber station loop circuits shown in Fig. 1 terminates in a subscriber station line terminating circuit at the concentrating unit switching center as shown in Fig. 2. Only the line terminating circuit 202 associated with printing telegraph sending and receiving unit 102 is shown in detail. The line terminating circuits 201, 203, 204 and 205 respectively associated with the other subscriber stations, are shown in diagrammatic form.

The functions of the subscriber station line terminating 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 206, for circuit 202, when the subscriber calls, until such call is routed to the central office.

3. When all available trunk circuits are busy this circuit will be connected to an all-trunks-busy level on the link, or cross bar, switch and will release the sequence circuit. Connection to the all-trunks-busy level is maintained until the subscriber disconnects.

4. 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.

5. It is provided with a set of test jacks such as jacks 207 and 208 for circuit 202, which will permit testing of the subscriber line for line conditions and for transmission, and for testing the subscriber station circuit.

6. The jacks, such as jacks 207 and 208 for circuit 202, are also available for operation of the unit on a manual basis in case of failure of the automatic apparatus.

7. The jack, such as jack 207, can be used to make the particular line test busy, out-of-order, or unassigned to inward calls.

8. The jacks, such as jacks 207 and 208, are available for continuous monitoring of the subscriber line by means of a test circuit.

9. The same jacks can also be used to patch a subscriber line to a practice circuit.

When a local subscriber originates an outward call, that is, a call through the concentrating unit switching center to the central office switchboard, the closure of the subscriber loop circuit by the operation of the power switch, such as start switch 110 at station 102, causes the operation of the line relay such as relay 2L2 in line terminating equipment 202. The line relay upon operating connects ground at each of its two lower armatures and front contacts to two conductors which extend into the subscriber's sequence circuit shown in Fig. 3. These ground connections cause the sequence circuit to attempt to route the call 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 central office or finds no trunks available.

If the automatic equipment at the concentrating unit switching center finds no available trunk to the central office, the sequence circuit connects the subscriber loop, or line, circuit to the top level in the cross bar switch of the link circuit (Fig. 2), in the same manner that a subscriber loop circuit is connected to one of the lower, or idle, trunk levels. The top level is connected to the all-trunks-busy circuit shown in Fig. 18 and the lower levels are connected to trunk circuits extending to the central office. The all-trunks-busy circuit upon being engaged by a calling subscriber loop produces impulses representing a "no circuit" condition by a "letters" signal or impulses representing a "K" signal, as required, which when transmitted to the subscriber gives an indication relative to the availability of trunks. The subscriber may recall after disconnecting.

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 line to operate. Hold magnets 2H1, 2H2, 2H3, 2H4 and 2H5 are associated with the lines of subscriber stations 101, 102, 103, 104 and 105 respectively. The operation of any one of the hold magnets opens the normally closed contacts of the operated magnets and thereby causes the release of the line relay of the calling subscriber line and releases the sequence circuit. The release of the line relay extinguishes the call lamp, such as lamp 206.

Jacks for each of the subscriber line terminating equipments, such as jacks 207 and 208 for equipment 202, when patched to a similar pair, such as jacks 1902 and 1903 in the test circuit (Fig. 19), permit the test circuit to look toward the subscriber line for testing line, transmission or communicating directly with the subscriber or into the subscriber line relay equipment for testing purposes. These two jacks, such as jacks 207 and 208, are available also for emergency connection between a line and a trunk on a manual basis when the automatic equipment fails. These two jacks when connected to the monitoring jacks 1902 and 1903 of the test circuit will permit continuous monitoring of the subscriber line without interfering with inward or outward calls. Jacks,

such as those designated 207 and 208, of the subscriber line circuit can also be patched to a practice circuit which permits the subscriber to practice. One of these jacks, such as jack 207, when alone patched to an out-of-order or busy jack will cause the subscriber line to test out-of-order or busy to inward calls. A dummy plug inserted into a jack, such as jack 207, will create an unassigned test for inward calls at the same time removing grounded battery from the subscriber line. Each of the subscriber line terminating equipments 201, 204 and 205 is arranged to connect to a trunk circuit via a direct connection to the cross bar switch of the link circuit, but subscriber line terminating equipments 202 and 203 are arranged first for automatic connection to the conference circuit and then extended through the cross bar switch of the link circuit to a trunk circuit. By showing each of line relays 2L1, 2L3, 2L4 and 2L5 and their operating circuits in their respectively associated terminating equipments 201, 203, 204 and 205, an understanding of the operation of these equipments is had by reference to the detailed illustration and description of operation of terminating equipment 202 herein. Conductors 209 to 215 of equipment 202 respectively correspond to conductors 216 to 222 of equipment 201 and to the corresponding conductors shown entering each of the diagrammatic arrangements 203, 204 and 205 in the same relative positions.

Link circuit

This circuit acts as a selectable connecting medium between trunk circuits and subscriber station line terminating circuits. It can also connect a subscriber station line to an all-trunks-busy circuit. It utilizes as its connecting medium a coordinate or cross bar switch structure. Those subscriber stations which are not arranged for automatic connection to the conference circuit are connected directly to their respective holding magnets of the link circuit shown in the right-hand part of Fig. 2. Those that are arranged for automatic connection to the conference circuit are respectively connected to holding magnet of a special link or connector circuit shown in the left-hand part of Fig. 7, the special link circuit forming part of the conference circuit.

The functions of the link circuit are:

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

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

4. The holding magnet contacts perform the "cut-off" functions 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 circuit. For subscriber station 102 the tip and ring conductors are designated T2 and R2 respectively, and will be open at the station when the station is idle. Should the station in question be one arranged for non-conference purposes, grounded battery in the subscriber line terminating equipment and ground connected to the widing of the line relay are furnished for operating the line relay such as line relays 2L1 and 2L2 respectively shown in equipments 201 and 202.

When a subscriber originates a call as by operating the teletypewriter start switch, the tip and the ring conductors of the subscriber's line close to complete the loop circuit through the station teletypewriter, and the line relay such as relay 2L2 of equipment 202 will operate to energize the sequence circuit. When the sequence circuit determines that the subscriber is next in turn, an idle trunk will be seized. The slcting magnt which is associated with the trunk thus selected, such as magnet 2SM1 for trunk 801, and magnet 2SM9 for trunk 809, will be energized to position the selecting fingers of the cross bar switch. The closure of the selector off-normal contacts (armature and contact of the operated selecting magnet) will operate relay 14D, and relay 14D upon operating connects ground through low resistance 1401 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 2H1, 2H2, 2H3, 2H4 and 2H5 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 selected off-normal contacts will cause a resistance ground (resistance 1401) to be routed through the director circuit and the selected subscriber line to grounded battery through the winding of the hold magnet of the selected subscriber line, the hold magnet being one of those designated 2H1 to 2H5. 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.

In the event that all trunks are busy when an outward call is originated from a subscriber station, the sequence circuit causes the selecting magnet 2SM0, associated with the first idle all-trunks-busy circuit as in cases where two all-trunks-busy circuits are provided, to operate whereby ground is connected at the off-normal contacts of the magnet to maintain operated the hold magnet associated with the calling subscriber line. The operated hold magnet locks and disconnects the subscriber line circuit, causing the release of the sequence circuit and the operated selecting magnet. The calling subscriber station is, therefore, held connected to the all-trunks-busy circuit until the latter circuit receives the subscriber's disconnect signal after which it permits the hold magnet to release and return to normal. The connection to the all-trunks-busy circuit is established over the first, or uppermost, level of the cross bar switch shown in Fig. 2.

Sequence and miscellaneous alarm circuit

The sequence and miscellaneous alarm circuit is shown in Figs. 3, 13 and 14, the miscellaneous alarm equipment being shown in Fig. 14. This circuit is designed to care for the sequence of calls through a line concentrating unit switching center as shown in Fig. 3, and is arranged to permit the routing of one call only at any one time through the automatic switching center as shown in Fig. 13.

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 concentrating unit 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 a communication path through the concentrating unit 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 four seconds, will release the call from the seized trunk, locking this trunk out of service, sound an alarm, and 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 sound an alarm after an interval of five, fifteen or fifty seconds, depending upon the progress of the call.

5. In case of trouble on an incoming call which exists for fifteen 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 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. 13 to the next idle trunk immediately after each subscriber calling the central office has obtained a routing through the concentrating unit 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 **301** is operated.

11. During manual service period lamp **1301** 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 **3SA**, **3BO** and **3SC** being common to the lines of each group. In a similar manner relays **13ST2**, **13TA**, **13TC** and **13BOX** are common to a group of a maximum of five trunks, relays **13AD**, **13DC**, **13BO** and **13DL** 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 remaining relays which are shown within the dot and dash line block designated "one per office" in Fig. 3 of the sequence circuit, as well as those relays shown in 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 **301** 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 **301** causes manual service lamp **302** to flash.

Trunk circuit

The equipment shown in Figs. 8 and 9, at the concentrating unit switching center, terminates a two-way half-duplex trunk, arranged for automatic signaling supervisory features, the opposite end of the trunk circuit terminating at the central office. The trunk circuit is shown extending through the second level of the link circuit shown in Fig. 2. A second trunk circuit **809** shown in diagrammatic form, is extended through to the lowermost level of the link circuit.

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

1. On an outward call from a subscriber station connected directly to the concentrating unit switching center, the subscriber loop is connected directly to the selected trunk, a continuous "mark" is sent to the central office to light the lamp in the operator switchboard and the sequence circuit is released.

2. While awaiting the answer to 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" signal to the central office in unison with the operation of the power switch at the subscriber's 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 switchboard to become extinguished and thereby indicate to the equipment at that end that a disconnect release is required. Upon receipt of the negative disconnect signal from the central office,

the concentrating unit switching center equipment returns to normal.

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

5. A prolonged space signal received from the central office or distant subscriber connected thereto, operates the polarized receive relay 9R in this circuit to hold the connection intact. After an interval of six seconds intermittent closures are placed on the trunk at the central office end to enable the subscriber connected to the concentrating unit switching center to register a disconnect signal.

6. When the trunk circuit is seized at the central office end, ringing current is automatically applied to the trunk at that end for a one-second interval, to condition the terminating equipment at the concentrating unit 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 pulses, the high resistance ground condition on that end of the trunk at the concentrating unit 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 obtaining the use of 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 the 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 or line and energizes the link circuit to establish the connection if the called loop, or line, is idle.

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

11. When the trunk circuit is connected to the called line, the sequence and the director circuit are dismissed and the trunk circuit again is terminated in the high resistance ground condition. At the same time a source of ringing current is automatically connected to the called subscriber line if the automatic ringing feature is present. In the case of manual ringing the operator at the central office sends ringing current over the trunk which causes the terminating equipment at the concentrating unit switching center to connect ringing current to the line.

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 concentrating unit 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's line.

14. The trunk circuit is provided with jacks 835 and 836 to permit manual connection of lines in case of failure of the automatic equipment.

15. Jacks are provided for patching a meter to the repeater circuit to measure the current in the line and biasing circuit and to indicate the differential current in receive relay 9R.

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

17. The trunk is operated by a method known in the art as the type B polarential method; with this species of the type B polarential method provision is made for polar sending over the line circuit from the satellite office to a polar receiving repeater at the distant central office; the trunk terminating equipment at the concentrating unit switching center comprises a repeater arranged for polar sending and differential receiving, whereas the trunk terminating equipment at the distant central office comprises a repeater arranged for differential sending and polar receiving. The resistance in series with the winding 3 of relay 9R is approximately equal to the line resistance and produces the type of transmission which is practically independent of resistance in line leakage as disclosed in Cramer 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 902 connected to winding No. 2 of receive relay 9R is provided to balance the telegraph line 901 connected to the repeater. When a balance is obtained between the line 901 and the artificial line 902, the differential effect of the currents in windings Nos. 2 and 3 of receive relay 9R remains constant during transmission of signals by send relay 9S. This balance enables signals to be transmitted in either direction over a single conductor 901.

A duplicate set of balancing equipment is provided for use when a neutralization conductor 903 is required. Conductor 903 serves to neutralize voltages induced in transmission conductor 902 from extraneous sources, such as earth potential differences. Conductor 903 is arranged for connection to winding No. 4 of receive relay 9R and its artificial line is connected to winding No. 5 of relay 9R. The neutralization conductor 903 and artificial line 904 are likewise provided with adjusting networks to effect the necessary balance.

During the idle condition the central office end of the trunk is terminated in ground at the back contact and upper armature of relay 11—C1. At the concentrating unit switching center where the trunk circuit is used for two-wire termination, the second or neutralizing wire forms a loop with the first or transmission wire, through resistance 931 of relatively high value, and winding of relay 9L, the two latter elements being shunted by an alternating current relay 9R1 and condenser 906. The repeater relays 9S and 9BK and the filament of vacuum tube 819 are not energized, the receive relay 9R is energized through its No. 1 winding which is provided for biasing purposes and all the other relays except relays 8G and 8G1 are normal. Relays 8G and 8G1 are held in their left-hand positions as shown by currents in their lower windings.

In the case of emergency such as when the automatic equipment fails to operate, jacks 835 and 836 of the trunk may be manually patched by the attendant to a similar pair, say jacks 207 and 208, in any desired subscriber line circuit so that the trunk will connect through to the desired subscriber's loop. When the double plug is inserted in the two trunk jacks, the selecting magnets associated with the trunk, say magnet 2SM1 for the trunk shown, are prevented from operating and off-normal relay 8—ON operates. When the trunk so engaged is returned to automatic operation, the desired subscriber's line remains busy until the patch is removed. Similarly, the trunk is rendered busy and is prevented from securing a director circuit.

Three balancing keys 908, 909 and 910 are provided for controlling the capacity balance for the operating (transmission) and the neutralizing wire. By connecting the capacity for the operating wire and the neutralizing wire on the same set of keys, a duplicate balance on each of the wires is assured.

Key 911 is provided for connecting and disconnecting the composite balancing equipment in the artificial line circuits of the operating and the neutralizing line. 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 912 to 916 are provided to control the resistance in the apexes of the operating and the neutralizing line. Each of these keys is arranged to affect the resistances in each of the apex circuits alike.

The repeater is equipped with four jacks 917 to 920 so that a test unit meter may be patched into various circuits of the repeater in order to facilitate adjustment and balance. Line jack 917 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 and the reading indicated on the test unit meter is the actual line current. Balance jack 918 is provided for connecting the test unit meter to indicate the differential current between the operating line and its associated artificial line circuit and the reading on the meter is the actual differential current. Balance jack 919 is provided for connecting the test unit meter to indicate the interference on the neutralizing wire for comparison with the interference on the operating wire. Bias jack 920 is provided for connecting the test unit meter in the biasing circuit (winding No. 1) of receive relay 9R so that the biasing current can be adjusted to the proper value for polarential operation, the resistance shunts on the bias jack being so proportioned that 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 918 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 9R. A millimeter suitably adapted for the present system is of the single coil type, has a double indicating scale with a zero mid-point and is designed to operate in opposite directions in accordance with the direction of the operating current. Such a meter is disclosed in Cummings United States Patent 1,809,026, dated June 9, 1931.

The bias potentiometer 928 is provided in the biasing circuit of relay 9R so that the value of current in the biasing circuit may be properly adjusted. The balance resistance potentiometer consists of two units 929 and 930 mounted on a single shaft and is used to obtained direct current balances in the artificial line circuit of the operating and the neutralizing wire.

Receive relay 9R is provided for receiving signals over the trunk shown extending from the distant central office and retransmitting them to the desired local subscriber loop. This relay is equipped with five windings which are arranged for connection in five circuits. Winding No. 1 is used for biasing the relay, winding No. 3 is connected to the line 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 9S is provided for receiving signals from the local subscriber loop and retransmitting them to the line 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 9BK is connected in series with relay 9S and is used for "breaking." Its function is to disable relay 9R while a spacing signal is being sent from the subscriber station. This is accomplished by connecting grounded battery 936 through the contacts of relay 9BK to the spacing contact of relay 9R. When relay 9BK operates to its spacing contact, the battery normally connected to the spacing contact of relay 9R is removed and the spacing and marking contacts of relay 9R are connected together.

In adjusting the trunk, capacity adjusting key 911 should be operated for all composited lines and for lines having a heavy capacity value such as simplex phantom cable lines. Key 911 should be normal for all other lines. With the meter of the test unit connected to jack 918 and while slowly opening and closing the "send" loop of the repeater at jack 811, one may vary the potentiometer 929 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 908, 909 and 910 until the kick of the milliammeter needle in either direction caused by 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.

When one wire is used for transmission and the other for neutralization of ground potentials, the balance on the second wire may be made identical to the balance on the first wire. This may be accomplished by connecting the balancing arrangement of the second wire to the control elements used for the balancing arrangement for the first wire, and by causing them to insert equal impedances.

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 concentrating unit switching center is equipped with a repeater arranged for polar sending and differential receiving and the distant central office is equipped with a repeater arranged for differ-

ential sending and polar receiving. 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 received relay, such as relay 9R, of a polar sending repeater have equal effects on the relay when the distant end of the operating line is connected to ground. The received 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 balancing winding when a spacing signal is transmitted from the distant central office. 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. A system arranged for type "B" polarential operation is disclosed in Fig. 2 of Cramer United States Patent 2,131,870, October 4, 1938.

Equalizing networks 944 and 947 each consisting of retardation coils and resistances connected in series are provided for reducing the characteristic distortion of received signals. These networks are bridged between the operating line and the artificial line circuit on the trunk side of relay 9R. When the repeater is arranged for two-wire operation as shown herein two networks are required, one 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 9R. The strapping of the resistances should be the same in each network and should be chosen to obtain the best transmission. Equalizing networks are chiefly useful on long simplexed phantom cable circuits.

Terminating equipment at the central office switchboard for the trunk circuit extending to the concentrating unit switching center

This equipment provides a termination in the operator's switchboard at the central office for half-duplex trunk circuits extending to a distant line concentrating unit switching center. The line side of the repeater is arranged for half-duplex operation over one line conductor functioning as the operating line with another wire provided for neutralizing induced voltages. The local side is arranged for operation into an operator's cord circuit. The trunk circuit of Figs. 10 and 11 typifies the terminations of the trunks at a central office employing the type of cord circuit illustrated in Fig. 12; modified forms will serve for use with switchboards employing other types of cord circuit.

The functions of the trunk circuit at the switchboard end are as follows:

1. During the idle condition all relays are normal and none energized except relay 11—S and 11—R which are held on their marking contacts by local circuits.

2. When a call is originated by a subscriber through the concentrating unit switching center, current will flow in the line, resulting in the lighting of the answer lamp 1101 and busy lamp 1102. Before the operator has answered, the subscriber may flash the answer lamp by sending a recall. The call may be abandoned and the answer lamp 1101 extinguished by the subscriber disconnecting. The busy lamp 1102 will remain lighted until all equipment has returned to normal.

3. The operator upon answering inserts a cord plug into the jack and the answer lamp 1101 will be extinguished and the transmission path will be extended into the cord circuit over the tip conductor.

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

5. Spacing signals in excess of six seconds transmitted in either direction will cause a distinctive signal to be sent toward the concentrating unit switching center and subscriber station. If the "break" originated at the subscriber station local to the switching center, this signal serves no useful purpose. If the "break" occurred in or beyond the cord circuit, the marking portion of these signals provides intervals in which a subscriber disconnect or recall signal may be recognized.

6. When the subscriber disconnects, the equipment at the concentrating unit switching center connects a high resistance ground, or loop in the case of two-wire operation, to that end of the line circuit. At the switchboard end, ground will be applied to the ring conductor of the cord circuit to light the cord supervisory lamp.

7. The subscriber may recall the operator by sending a disconnect signal immediately followed by a new call. This will momentarily connect a ground to the ring conductor resulting in a flashing cord circuit supervisory lamp.

8. The operator initiates a call by inserting a cord plug in the line jack of any idle trunk. The cord lamp lights and a timed interval of 20-cycle ringing current is automatically sent out over the trunk to the concentrating unit switching center to condition the equipment at that end and to secure a director circuit. The director "ready" signal is a marking condition from the distant end which extinguishes the cord lamp as an indication that the circuit is ready to receive line selecting pulses. The operator will then send upper case teletypewriter code combinations corresponding to the required station number. The reception of these signals at the concentrating unit switching center causes connection of the trunk circuit to the required subscriber station loop and places an open condition on the line to light the calling lamp again as a signal to the operator that she may ring (or that the station is being automatically rung if that feature is used at the concentrating unit switching center). When the subscriber answers, the line returns to the marking condition, and the cord lamp is extinguished.

9. 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. This is registered by the removal of ground from the ring conductor 1137 to extinguish the cord supervisory lamp when current is caused to flow in the line resulting from the subscriber answer.

10. The operator may rering the subscriber, following his disconnect, by applying ringing current to the line.

11. When both subscriber and operator disconnect, this circuit, after an interval of two seconds, places a negative potential on the line for ten seconds to release the equipment at the concentrating unit switching center and at the end of that period the circuit restores to normal.

12. Facilities are provided for balancing the

repeater for use with composited or non-composited lines, or spare cable conductors.

13. Equalization networks reduce the characteristic distortion in the received signals.

14. The telegraph repeater of this circuit is arranged for differential sending and polar receiving.

This repeater is designed to operate half-duplex only. An adjustable balancing network is provided to obtain a sufficient balance for the higher frequency components of the signals. 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 at the concentrating unit, both the marking and spacing line currents are in the same direction and hold relay 11—R of the polar receiving repeater on its marking, or right-hand, contact. The balancing network for the operating line of the trunk circuit consists of one or more suitable resistances connected in series with intermediate strapping and one or more condensers of suitable capacity connected in parallel to each other to a common grounded point, the resistances being represented by that designated 1101 and the condensers being represented by that designated 1102. A duplicate set of balancing equipment comprising one or more resistances connected in series with strapping at their intermediate points and one or more condensers each connected in parallel to the other connected to a common grounded point, the resistances being represented by that designated 1153 and the condensers being represented by that designated 1154, is provided for use in the case of two-wire operation as shown herein. Both sets of condensers are adjusted alike to provide the same balance for each wire.

Relay 11—R is provided for receiving signals from the distant concentrating unit switching center and retransmitting them to the local cord circuit at the operator's switchboard. This relay is equipped with five windings for connection in five circuits. One winding No. 1 is connected to the operating line of the trunk and another winding, No. 3, is connected to an artificial line circuit which is used for balancing the operating line. Windings Nos. 2 and 4 are provided for neutralizing interference, the No. 2 winding is connected to the neutralizing wire of the trunk and the No. 4 winding is connected to the artificial line for balancing the neutralizing wire. Winding No. 5 is used in a local holding circuit when the trunk is in an idle condition.

Relay 11—S is provided for receiving signals from the local cord circuit and retransmitting them to the operating line of the trunk which extends to the distant concentrating unit switching center. This relay is equipped with two windings. One winding is connected in series with the cord circuit tip conductor and the other winding is connected in series with an artificial line.

Relay 11—B is a two-winding relay having one winding connected in series with the operating line extending to the cord circuit tip conductor. This relay is used for supervisory purposes.

Relay 10—P has three windings. Winding No. 1 is connected in series with the operating line of the trunk and winding No. 2 is connected in series with the neutralizing wire. Winding No. 3 is connected into a hold circuit to prevent the relay from operating on small induced line currents when the line is open or grounded at the distant end. Relay 10—P follows the signals received from the distant concentrating unit switching center as does relay 11—R. During transmission to the concentrating unit switching center the absence of any windings in the artificial line circuit causes relay 10—P to leave the marking, or left-hand, contact in some conditions. During transmission from the distant concentrating unit switching center, each transition of the signal as received by relay 10—P causes a surge of current through the winding of relay 10—H. These surges in conjunction with a direct current from the contacts of relay 11—C hold relay 10—H operated during transmission condition.

Relay 11—C has two identical windings. One of these is inserted in the apex of the operating line circuit of the trunk. The second winding is placed in the apex of the neutralizing line. Relay 11—C remains operated except during certain transition periods in the signal. Operation of relay 11—C in turn operates relay 10—H which is used for supervisory purposes. During the transitory period of the signal when relay 11—C releases, the surges from relay 10—P cause relay 10—H to remain operated. The windings of relay 11—C are respectively shunted by condensers 1103 and 1104 to by-pass a large part of the signaling frequency, and thereby improve transmission.

During the idle condition, the operating line of the trunk is connected at the distant concentrating unit switching center to a loop formed with the extension of the neutralizing wire, the loop having a resistance of relatively high value. At the central office end the operating line 901 of the trunk may be traced through the upper armature and back contact of relay 10—E, resistance 1003, winding No. 1 of relay 10—P, winding No. 1 of relay 11—R, resistance 1105, retardation coil 1106, the upper winding of relay 11—C to ground on a back contact of relay 11—C1. The neutralization wire 903 for a two-wire operation may be traced through the lower armature and back contact of relay 10—E, resistance 1004, through the No. 2 winding of relay 10—P, through the No. 2 winding of relay 11—R resistance 1112, retardation coil 1107, through the lower winding of relay 11—C, resistance 1108 to ground at the armature and right-hand contact of relay 11—S1. Grounded battery 1109 is connected over a circuit traceable over conductor 1110, resistance 1010 of relatively high value, middle upper armature and contact of relay 10—C2, conductor 1011, to No. 5 winding of relay 11—R, to ground whereby relay 11—R is held operated to its right-hand, or marking position. Relay 10—C2 through its normally closed make-before-break contact connects grounded battery conductor 1110 to conductor 1012 which extends through the lower windings of relays 11—S and 11—S1, in series, to ground thereby holding relay 11—S in its right-hand, or marking, position.

A noise killer consisting of a retardation coil 1106 and resistance 1105 is provided in the apex of the operating line circuit as a noise suppressor. Provision is made for a similar arrangement consisting of retardation coil 1107 and resistance 1112 in the apex of the neutralizing line circuit. The noise killer is provided in the neutralizing line circuit so that the neutralizing line and the operating line will have equal impedances. This is essential to obtain neutralization over a broad frequency band.

Equalizing networks consisting of two similar units, are provided for reducing the charateristic distortion in the received signal. Each of these units designated 1155 and 1156, is constituted of several resistances connected in series, cut-out strapping at their intermediate points and several retardation coils connected in series with each other and with the resistances, although in each unit only one resistance and one retardation coil are shown (Fig. 11). One unit is bridged between the operating line and its artificial line and the other is bridged between the neutralizing line and its artificial line, the bridging arrangement in each case being on the trunk side of relay 11—R. The resistances in each network should be the same and should be chosen to obtain the best transmission over the trunk circuit. Equalizing networks are chiefly useful on long simplexed phantom cable circuits.

When a two-wire trunk circuit is used the balance on the second wire is made identical to the balance on the first wire. This is accomplished by connecting the balancing arrangement for the second wire the same as for the balancing arrangement for the first wire, the adjustment for balance being made at the concentrating unit switching center as hereinbefore described.

Two trunk circuits when connected together at a switchboard by means of the operator cord circuit shown in Fig. 12, tend to oscillate when the two subscriber loops at the distant ends of the trunks have been opened. This oscillation is such that relay 11—C and the corresponding relay in the trunk circuit connected to the opposite end of the cord circuit, are held operated by the operation of their respectively associated relays, such as that designated 10—P in the trunk shown, as the latter relays follow the oscillation pulses and thus no disconnect condition is registered in the operator cord circuit. This oscillation is eliminated by means of relays 10—TA, 10—TB, 10—TC and 11—S1. Relay 10—TA will operate when receive relay 11—R is in its spacing position thereby opening the operating circuit of normally operated, slow-release relay 10—TB, the normal operation of relay 10—TB referring to that interval of time when the operator cord circuit is connected to jack 1124. Relay 10—TA, upon operating, replaces grounded positive battery at its back contact and outer lower armature with ground at the front contact and inner lower armature of relay 10—TB which is connected to the front contact and outer lower armature of relay 10—TA.

If the spacing condition of receive relay 11—R is of sufficient duration relay 10—TB releases thereby adding a very high resistance 1014 to the circuit extending through the No. 3 winding of relay 10—TC, and connecting the spacing contact of relay 11—S to ground in a circuit traceable over conductor 1118, outer lower armature and front contact of relay 10—TA, inner lower armature and back contact of relay 10—TB through the No. 1 winding, armature and right-hand contact of relay 10—TC to ground. If a break originates from the cord circuit at this time, relay 11—S operates to its spacing contact, connecting negative battery at the marking contact of relay 9S at the concentrating unit switching center to a circuit extending over the operating line of the concentrating unit trunk through the No. 1 winding of relay 11—R, the upper winding of relay 11—C, upper armature and front contact of relay 11—C1, armature and spacing contact of relay 11—S, conductor 1118, outer lower armature and front contact of relay 10—TA, inner lower armature and back contact of relay 10—TB, through winding No. 1, armature and right-hand contact of relay 10—TC to ground. Relay 10—TC operates thereby replacing the last-mentioned ground with grounded positive battery 1013 and placing a spacing, or break, condition toward the concentrating unit switching center. In the disconnect condition before the operator cord is taken down ground is presented to the trunk in both marking and spacing conditions and the tendency to oscillate by charging the line capacity is eliminated.

Operator's cord circuit

The cord circuit shown in Fig. 12 is similar to that shown in Fig. 2 of United States Patent 2,106,357, granted to T. A. Marshall on January 25, 1938. It serves to establish connection between any one of the concentrating unit trunk circuits and a subscriber station connected directly to the central office, or to an intertoll trunk circuit extending to another central office, or to another concentrating unit trunk circuit extending back to the concentrating unit switching center.

In establishing at an operator's switchboard a connection between a concentrating unit trunk and a subscriber station local to the central office, the cord circuit cooperates with the operator's position circuit wherein the operator's teletypewriter set may be connected to the particular cord circuit which is employed.

The functions of the cord circuit and the operator's position circuit are as follows:

1. Answering incoming calls from subscribers or over intertoll trunk circuits, with the answering end of the cord, and for establishing teletypewriter communication via the operator's position circuit.

2. Repeating teletypewriter communications by means of a single line repeater in the cord circuit.

3. Receiving and transmitting recall signals.

4. Receiving and transmitting disconnect signals.

Director circuit

This circuit functions in the line concentrating unit switching center to receive the telegraph pulses sent by the distant operator's teletypewriter and to decipher these pulses, thereby causing the selection of the called subscriber line. The circuit is shown in Figs. 15, 16 and 17.

The functions of the director circuit are as follows:

1. Upon receipt of an inward call from the manual 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 ("DR") signal will be transmitted to the distant end to indicate to the manual operator that the call may be routed through the line concentrating unit switching center.

2. The distributor motor will be stopped after the director has been dismissed unless there is another incoming call awaiting completion. In the latter case the motor would be kept running but the other parts of the circuit would be restored to normal, awaiting the new call. The start magnet is held operated while the distributor motor is coming up to speed to reduce clutch drag.

3. A "figures" teletypewriter character received from the distant manual central office will indicate that the operator has recognized the "DR" signal and will cause the director circuit to accept the next two characters transmitted, from

the distant end, as the called subscriber station number.

4. The next two teletypewriter characters received from the distant office are separated by the receiving distributor into code elements, for causing the proper selecting relay to be operated.

5. 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's line.

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

7. If the called subscriber line has been made out-of-order a series of predetermined code signals corresponding to letter Q will be transmitted to the distant manual central office for a one-second interval; whether these appear on the operator's machine as "Q's" or numeral "1's" will depend upon the case position in which the operator's machine is resting at the moment.

8. 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 signals receivable as characters "K" or "½" will be transmitted to the distant manual central office for a one-second interval.

9. If the manual operator at the central office has transmitted first and second digits of a number for which no subscriber's line is assigned or has transmitted an impossible combination of digits, a series of "V" or "⅜" signals will be returned to the manual operator at the central office for one second.

10. If the subscriber's line is idle the director circuit will cause the link circuit to connect the called subscriber's line to the particular 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.

11. If the director circuit becomes off-normal and is not released within ten seconds, a series of "T" signals is sent to the distant end for one second and the director is then released.

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 large 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 distant central office, receiving and deciphering the called subscriber station number typed and transmitted by the switchboard operator at the distant central office and causing the selection of the proper, or desired, subscriber line.

When an operator at the distant manual switchboard seizes the trunk to the line concentrating unit switching center, the associated trunk terminating equipment at the line concentrating unit switching center functions to cause the sequence circuit to attempt connection to the director circuit. When the trunk terminating equipment at the switching center receives permission to route the call through the switching center, the sequence circuit connects this director circuit to the particular trunk, that is, the trunk selected by the switchboard operator. When the director circuit is connected to the selected trunk by the sequence circuit the distributor motor is started. After the motor has attained its normal operating speed, the director circuit transmits a "director ready" signal to the operator at the central office, disregards any typing and line interference which may occur until a "figures" signal is received, and then responds to the next two character signal combinations to select the called subscriber line. The director circuit also originates and sends K, Q or V signal combinations to the operator at the central office, denoting that the called subscriber line is "busy," "out-of-order" or "unassigned" if such is the case. As soon as the director circuit is released by the sequence circuit, it is available for succeeding calls. The director circuit also generates T signal combinations for transmission to the operator office when the director circuit has been held ten seconds. This reorder signal is transmitted for one second. At the end of this period, the director circuit is released by the sequence circuit and a disconnect signal is sent over the trunk to the operator office.

All-trunks-busy circuit

This circuit shown in Fig. 18 is designed for use in a line concentrating unit switching center as an originating source of "no circuit" signals and "K" signals sent to calling subscribers under certain conditions as hereinbefore mentioned under "Subscriber station line circuit," at the same time providing "no circuit" time integrating registers in addition to subscribers' overflow registers. The functions of the all-trunks-busy circuit are as follows:

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

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

(*a*) Produce and send to each calling subscriber securing a no-trunks level, a "letters," "no circuit," signal;

(*b*) Register by means of registers connected in the subscriber's overflow circuit, the number of attempts subscribers make during the all-trunks-busy period;

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

(*d*) Continue to produce the "letters" signal as long as any subscriber keeps his loop closed.

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" signals to the waiting subscriber.

The timing of an interval in which all trunks are busy is accomplished in the following manner. When all trunks are busy ground connection 1307 connected over the contact No. 5 of a relay in the highest numbered trunk of the trunk sequence circuit, said relay corresponding to that designated 13AD in trunk sequence circuit No. 1, to a circuit extending over conductor 1308, through the winding of relay 18A to grounded battery. Relay 18A operates and at its upper armature and contact connects interrupter 1801 which comprises a source of sixty impulses per minute to its associated register 18NCA which therefore registers the number of seconds that all trunks are busy, at the same time closing the operating circuit for relay 18L.

The all-trunks-busy signal is transmitted by means controlled by the operation of relay 18L which, upon operating, removes at its outermost

upper armature and back contact the connection between the normally closed contact of relay 18P and condenser 1802, at its middle lower armature and outermost lower armature removes grounded battery 1803 and 1804, respectively, from the windings of relay 18P, and at its outermost upper armature and front contact connects condenser 1802 to the armature and contact of relay 18INT. 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 approximately forty words per minute.

A detailed description of the operation of the all-trunks-busy circuit is hereinafter given.

Test circuit

This circuit permits the attendant at the concentrating unit switching center to make connection to the trunk terminating equipment at either the trunk side of the equipment or the subscriber line side and also to the subscriber line equipment. It further permits the attendant to test the supervisory features of the teletypewriter concentrating unit shown at the switching center.

The functions of the circuit are as follows:

1. When the trunk test equipment jack 1901 is patched to the trunk equipment jack 930 and the trunk side of the trunk terminating equipment, the following operations are possible:

(*a*) Origination of a call by applying ringing current to the trunk terminating equipment;

(*b*) Reception of director ready signal from the director circuit;

(*c*) Production of a space signal;

(*d*) Ringing the subscriber station;

(*e*) Reception of indication that station has answered the call;

(*f*) Production of a disconnect signal.

2. When jacks 1902 and 1903 are connected to the similarly designated jacks in a subscriber's line such as those designated 207 and 208 in the subscriber's line 202 the following functions are possible:

(*a*) Reception of a call and transmission from the operator's teletypewriter at the distance central office;

(*b*) Origination of a call and transmission with recall, break and disconnect toward the operator's switchboard at the distant central office;

(*c*) Call and transmission to the subscriber station;

(*d*) Call, recall, transmission and disconnect from the subscriber station;

(*e*) Adjustment of subscriber line loop resistance.

The attendant's teletypewriter may be used for communication with the operator's teletypewriter at the distant central office.

The above-mentioned functions involve means for making termination tests with the central office. From a subscriber line termination in the test circuit, calls may be placed and received in the same manner as at a subscriber station associated with the concentrating unit.

When the test circuit is connected to the line side of a trunk circuit, it simulates supervisory signals normally used on a call originating at the central office. This includes sending 20-cycle ringing current to originate a call, the reception of the director ready signal, sending a space signal, ringing a subscriber station, furnishing an indication that the subscriber has answered and means of sending a disconnect signal. The attendant's teletypewriter may be connected into the transmission path of the line repeater on the "drop" side, that is, at jack 1601, and while the director circuit is connected any station may be called by means of call directing pulses transmitted from the attendant's teletypewriter. The attendant's teletypewriter may also be connected to a director circuit receiving jack in the test circuit and receive the K, Q, V and T signal combinations from the director circuit.

When connected to a subscriber line by means of testing jacks, the test circuit may simulate the subscriber in receiving signals from, and sending signals to, the concentrating unit or it may simulate the concentrating unit in receiving signals from, and sending signals to a subscriber. Line current and leakage resistance of the subscriber line may be measured by extending the line to the telegraph test board by means of the test circuit and adjustments of the subscriber line potentiometers may be checked or made initially by means of the test circuit. Also communication signals may be sent to and received from a station on a neutral basis. A subscriber line may be monitored from the test circuit by use of the attendant's teletypewriter.

Conference circuit

By means of this circuit specially arranged subscriber stations can be attached automatically under the control of an operator at the distant central office. These same subscriber stations and any other subscriber stations connected directly to the line concentrating unit switching center (to a maximum number of ten) can be added manually to the conference by the attendant at the concentrating unit switching center.

The conference equipment permits intercommunication between a trunk extending from the distant central office and two or more subscriber lines directly associated with the line concentrating unit switching center. Subscriber stations beyond the central office may be connected to the same conference over lines or trunks extending beyond the distant central office to subscribers directly or through other central offices.

Each subscriber line arranged for automatic connection to the conference network is assigned an unlisted number in addition to the regular, or listed, number and an unlisted number is also assigned to the trunk conference branch.

For automatic operation, the operator at the distant central office obtains the conference network referred to herein as the conference circuit, in the same manner that a line concentrating unit subscriber station is obtained; by setting up on her teletypewriter, the two-digit number assigned to the trunk conference branch circuit. After the conference circuit is seized and connected to the calling trunk, which is held busy, the operator will proceed over a second trunk, referred to herein as "order" trunk, to call the unlisted number of the first subscriber involved. When the called subscriber answers, he is advised of the conference and instructed to remain on the line. The subscriber line circuit is then automatically transferred to the conference circuit under control of the operator at the central office. The operator will then proceed in the same manner to add to the conference circuit the other desired subscriber's stations, one at a time. When all the desired subscriber lines have been transferred to the conference circuit the second, or "order" trunk is released, and the operator reconnects her teletypewriter to the cord associated with the first calling trunk which is now referred to as the conference trunk and

which extends to the conference circuit. The operator will challenge the subscribers connected to the conference circuit and the conference may start. Any subscriber line not arranged for automatic connection to the conference circuit may be added to the conference by means of manual patching, between subscriber line jacks and jacks in the subscriber conference branches, by the attendant at the line concentrating unit switching center. Similar patching may be made in order to complete calls during emergency conditions.

For these and similar purposes one subscriber line may terminate at the satellite attendant's desk.

For manual operation of the conference circuit, the operator at the distant central office will proceed the same as automatic operation until the conference circuit, is seized and connected to the conference trunk. Instead of calling the first subscriber station involved, the operator will communicate with the attendant at the switching center, who will then establish all desired connections by patching between subscriber line jacks and jacks in the subscriber conference branches. When all desired subscriber lines have been connected to the conference circuit, the attendant will advise the operator over the first, or conference, trunk, and the subscribers will then be challenged by the operator after which the conference may start.

The subscriber conference branch circuits are arranged in five circuit units. Two of these units are required for a conference circuit with ten subscriber conference branches. Those branch circuits are required both for automatic and manual operation.

One trunk conference branch is arranged as a unit since only one is required for a conference circuit. This circuit is required both for automatic and manual operation.

One automatic conference control circuit is arranged as a unit since only one is required for a conference circuit and it is used only for automatic operation.

The subscriber conference access, or applique, circuits are arranged in ten circuit units to be used for automatic operation only, and are respectively assigned to ten subscriber lines arranged for automatic connection.

The functions of the conference circuit are as follows:

1. The operator at the central office obtains the use of the idle conference circuit by sending selecting pulses and otherwise proceeding to call a special number associated with the conference circuit.

2. When the conference circuit is connected to the trunk over which the operator calls the conference number, power is turned on in the conference circuit branches and conference control circuit. The unlisted conference numbers at this time cease to test "unassigned."

3. The conference circuit sends a "space" signal to the trunk to which it is connected.

4. The operator at the central office, to add a specially arranged subscriber to the conference circuit, calls over another, or "order," trunk for the unlisted conference number assigned to the particular subscriber line.

5. If the subscriber line is idle the conference applique associated with the subscriber line seizes the conference control circuit.

6. The conference control circuit, upon seizure, supplies a resistance ground long enough to operate the "hold" magnet associated with the called subscriber line, connecting the line to the "order" trunk and making the line test busy to subsequent calls made to it while it remains held. The conference control circuit also makes all other unlisted conference numbers test unassigned.

7. The called subscriber line connected to the "order" trunk causes the "order" trunk to dismiss the director circuit permitting a signal to be sent to the operator at the central office to ring the called subscriber station.

8. In concentrating units arranged for automatic ringing of the called subscriber stations the trunk dismisses the director circuit and automatically rings the called subscriber station.

9. Before the subscriber answers, the called subscriber line is held to the trunk under control of the trunk circuit and, in turn, under control of the calling operator at the distant central office.

10. If the subscriber fails to answer, the operator can dismiss the subscriber line from the "order" trunk by removing her cord circuit from the trunk jack.

11. When the subscriber answers the conference control circuit causes the "order" trunk supervisory relay to operate.

12. If the subscriber accepts the conference, the operator at the central office sends a two-second break signal which the control circuit uses to connect the subscriber line to the next idle subscriber conference branch immediately after the termination of the break signal.

13. The connection of the subscriber line to the subscriber conference branch causes the conference control circuit to release the "order" trunk supervisory relay and approximately one and one-half seconds later to release the subscriber "hold" magnet, freeing the "order" trunk but at the same time making the subscriber line test busy to other calling operators and returning the subscriber conference access circuit to normal except for one of the relays in the access circuit such as relay 4C and the applique circuit for subscriber station No. 102 and disconnecting the access circuit from the control circuit.

14. If the subscriber refuses to accept the conference the operator at the central office disconnects from the "order" trunk after receiving his disconnect signal, returning the subscriber conference access circuit to normal.

15. The connection of the subscriber line to a subscriber conference branch lights the busy lamp associated with that branch and causes the branch to contribute a mark signal under control of the subscriber instead of the normal mark obtained during the idle period of the branch.

16. After the conference control circuit returns to normal, the subscriber conference branch selected, releases its selecting magnet and prepares to use the next idle branch for the addition of another subscriber line.

17. If more concentrating unit subscriber stations are to be added to the conference, the operator waits until the disconnect lamp changes as an indication of the reconnection of the director circuit to the "order" trunk and then repeats the process for the next subscriber station, calling for the unlisted conference number of the next subscriber station.

18. If no other subscriber station is to be added, the operator at the central office disconnects from the "order" trunk after receiving the disconnect signal.

19. After the operator at the central office has disconnected from the "order" trunk as stated in the immediately preceding paragraph, the operator sends a one-second break signal over the conference trunk which the conference circuit uses to make all remaining unlisted conference numbers test "unassigned" and thus prevent any further addition to the conference circuit; after that the operator types for the start of the conference.

20. If a subscriber station has no secret, or unlisted, conference number the station is not arranged for automatic connection to a conference, the operator at the central office may call the attendant at the concentrating unit who may manually patch the line of the desired subscriber station to the next idle conference branch.

21. In case of failure of the automatic equipment, the attendant at the concentrating unit can set up the conference by manual patching under instruction from the operator at the central office.

22. When a conference subscriber disconnects during the progress of a conference, his line remains connected to the conference circuit until all subscriber stations connected in the conference have been disconnected.

23. When all subscriber stations connected to the conference circuit disconnect, the manual operator at the central office receives a disconnect signal.

24. The conference circuit is arranged to release all automatically connected subscriber stations when all subscribers have disconnected and to prevent a manually patched subscriber station from recalling the operator over the conference trunk.

25. Upon reception of a disconnect signal, the operator at the central office withdraws the cord circuit from the jack of the trunk to which the conference circuit has been connected, releasing the conference circuit.

26. When all subscriber stations connected to a conference circuit have disconnected and if any subscriber stations have been manually connected, a disconnect lamp lights and an alarm is given to indicate to the concentrating unit attendant that the patches should be withdrawn. The alarm and lamp are retired when the patches are withdrawn.

27. In the case of completely manually arranged conference, orders for removal of patches between the trunk and the conference circuit are received from the manual operator at the central office. If the concentrating unit is arranged for complete manual connection the disconnection of the operator at the central office from a conference trunk lights a disconnect lamp which is a signal for the attendant to remove the patch between the conference trunk and the conference circuit.

28. Each subscriber station conference branch is equipped with a busy key to take the branch out of service.

29. Each subscriber station access circuit is equipped with a jack by which the unlisted conference number can be manually made busy or out of order.

The conference circuit at the concentrating unit switching center is divided into three main divisions:

(1) The subscriber line access circuit together with its associated vertical in the conference connector switch which is of the cross bar type;

(2) The automatic conference control circuit; and

(3) The conference circuit proper with a maximum of eleven branches.

Division No. 1 is the special equipment required for each subscriber station which is specially arranged for automatic connection to a conference circuit. Division No. 2 is a group of relays responsible for ordering the particular subscriber station, or line, connection to the next idle conference branch. Division No. 3 contains the polar relays responsible for carrying on of the telegraph communication during a conference and contains, in addition, supervisory equipment for each subscriber conference branch and for the conference trunk branch. The number of subscriber station conference branches in this circuit is limited to ten, but the number of subscriber lines arranged for automatic connection is limited only by the available unlisted numbers one of which each subscriber station so arranged must have. In general, the calling of the subscriber station unlisted number is the key which opens the way for the station's connections to a conference branch and differentiates the incoming call from a call to a single line.

Detailed Description of Operation

Call originated at a subscriber station

For the purpose of illustrating an outward call, that is, a call originating at a subscriber station and extending to the central office, it will be assumed that the call originates at subscriber station **102** which is shown arranged for automatic connection in a conference circuit. Subscriber station **103** is also shown arranged for automatic connection to a conference circuit. However, subscriber stations **101**, **104** and **105**, as hereinabove stated, are represented as non-conference stations inasmuch as these stations are not arranged for automatic connection to the conference circuit, and by manual means employed by the attendant at the concentrating unit switching center any of these non-conference subscriber stations may be connected to the conference circuit.

In Fig. 1 there is illustrated in schematic form a local subscriber station **102** connected with the concentrating unit switching center by a pair of conductors T2 and R2. In an idle condition conductor T2, known as the tip, is connected to a ringer **112** so that incoming calls to this station will be indicated by the sounding of the ringer **112** through the application of ringing current to the tip T2 at the switching center. When the station is in use, switch **110**, referred to herein as the power, or start, switch, is operated to cause conductor T2 to be connected over the normally closed contacts of flash, or recall, key **114**, front contact and armature of relay 1L, lower contacts normally in engagement with spring member 1 of key **113**, conductor **115**, transmitting, or pulsing, contacts **107**, break key **116**, through the lower winding of relay 1—LINE, spring member No. 4 in engagement with its upper contact of key **113**, through the winding of break relay 1BK, to the ring side of the line, conductor R2. Under certain conditions to be explained hereinafter, current will flow through this circuit at a value of about 20 milliamperes for a marking condition and zero current will exist for a spacing condition. With steady marking current established by the condition at the concentrating unit switching center the operation of the sender contacts **107**

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 106 in the proper manner and these same current variations caused by the operation of sending contacts 107 will cause the operation of relay 1—LINE to again operate the printer magnet 106 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 110 at station 102, to the "on" position are as follows: The operation of the power switch closes the loop circuit and causes the associated subscriber line relay to operate, such as relay 2L2, at the line concentrating unit 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 over the uppermost level in the cross bar switch of the link circuit to the all-trunks-busy circuit from which "letters" signals are sent to the calling subscriber. The details of the trunk sequence circuit are omitted to simplify the disclosure; the principles of such circuits are known to those skilled in the art and may be readily applied in the present case; an example is found in Lucek Patent 2,228,279 dated January 14, 1941. When a trunk becomes available, the "letters" signals cease and thereafter groups of the letter "K" signals are received from the all-trunks-busy circuit by the subscriber until the power switch is reoperated to the "off" position.

As soon as the subscriber line is connected to a trunk termination, a trunk relay, such as relay 9TR in the trunk termination shown, operates and thereby removes the high impedance ground effected by resistance 931 having a value of approximately 18,000 ohms, from the trunk conductor 901. With relay 9TR in its unoperated condition the trunk circuit may be traced, in part, over conductor 940, outer lower armature and back contact of relay 9TR, resistance 931, inner upper armature and back contact of relay 9TR, to conductor 941. Relay 9TR, operated, connects conductor 901 to the trunk repeater (winding No. 3 of receive relay 9R and the armature of send relay 9S); thereupon marking (negative) potential from grounded battery 932 is applied to the trunk conductor 901 and the trunk circuit terminating at the distant central office functions to light the line lamp in the switchboard multiple. The operator at the central office connects a cord circuit to a trunk jack associated with the lighter lamp, and receives the number of the desired subscriber station from the calling subscriber party.

When start switch 110 was operated it closed a circuit from one side of power supply 117, through the winding of relay 1S to the other side of the power supply causing relay 1S to operate. Relay 1S, upon operating, locks up through its lower contacts, contacts of stop key 111, motor control contacts 109 of the printer. In operating, relay 1S closes a path through its upper contact to start the motor for the printer set and also to operate relay 1L.

The operation of relay 1L 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 2L2 at the switching center. This last circuit is traceable from grounded positive battery 401, normally closed make-before-break contacts of relay 4A, conductor 402, back contact and inner armature of hold magnet 7H2 of the cross bar switch of conference connector circuit, conductor 209, contacts normally closed with the tip spring of jack 207, conductor T2, normally closed contacts of key 114, front contact and armature of relay 1L, contacts normally closed to spring No. 1 of key 113, conductor 115, transmitting contacts 107, normally closed contacts of break key 116, through the lower winding of relay 1—LINE, No. 4 spring of key 113 at its normally closed contact, through the winding of break relay 1BK, conductor R2, rheostat 243, tip spring of jack 208 and its normally closed contact, conductor 210, normally closed make-before-break contacts of hold magnet 7H2, conductor 603, armature No. 1 and back contact of relay 4B1, conductor 403, normally closed make-before-break contact of hold magnet 2H2, conductor 242, through the winding of line relay 2L2 to ground and relay 2L2 operates. It will be noted in the circuit just described that the operating circuit for relay 2L2 extends through the conference circuit in accordance with a statement hereinbefore made that subscriber station 202 is arranged for automatic connection to the conference circuit. The operating circuit for lamp relay 2L3 is likewise extended through the conference circuit inasmuch as subscriber station 103 is arranged for automatic connection through the conference circuit. However, the lamp relays 2L1, 2L4 and 2L5 have operating circuits which are traceable directly through the normally closed contacts of hold magnets 2H1, 2H4 and 2H5, respectively. The operating circuit for lamp relay 2L1 is traceable from grounded battery, conductor 244, back contact and right-hand armature of hold magnet 2H1, conductor 216, tip conductor T1, through the station circuit of station 101, ring conductor R1, conductor 217, normally closed make-before-break contact of hold magnet 2H1, conductor 245, through the winding of relay 2L1 to ground. Lamp relays 2L1, 2L4 and 2L5 have operating circuits which are not connected to the conference circuit inasmuch as their respectively associated stations 101, 104 and 105 are not arranged for automatic connection to the conference circuit.

Lamp relay 2L2, upon operating, (1) closes at its upper armature and contact an operating circuit for call lamp 206 which is traceable over conductor 246 (which is common to the call lamps associated with the subscriber stations shown), conductors 247 and 1309, through the winding of relay 14E to ground battery and relay 14E operates (relay 14E is effective at night only to cause an audible signal as well as a visual signal alarm when that alarm cut-off key 1403 is released in the position shown); (2) closes to ground at its inner lower armature and contact a circuit extending over conductors 248, 249, and if gate relay 3G is not in an operated position at the time, then over the contact and armature No. 4 of relay 3—G, contact and middle left-hand armature of relay 3BO, through the winding of relay 3SA, to grounded battery and relay 3SA operates; (3)

connects at its outer lower armature and contact a ground connection to a path extending over conductor 250 in preparation for a circuit which will presently be closed by the operation of relays 3SC and 3U2.

Gate relay 3—G is so called because it opens paths which prevents or shuts 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 right-hand armatures 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 to armature No. 1 of relay 3G extends from trunk sequence of No. 1 (shown in Fig. 13), and the conductor connected to armature No. 4 of relay 3G extends from subscriber sequence group No. 1 represented in Fig. 1 by subscribers' stations Nos. 101 to 105.

Relay 3SA, upon operating, (1) locks up at its left-hand armature and contact directly to grounded conductor 249; (2) closes at its inner right-hand armature and contact an operating circuit for relay 3G1; (3) closes at its outer right-hand armature and front contact a circuit traceable from grounded battery through the winding of relay 3SC, front contact and outer right-hand armature of relay 3SA, conductor 304, armature No. 1 and back contact of relay 18B, conductor 1805, back contact and inner left-hand armature of relay 13TA, conductors 1310 and 1311, through the normally closed lower contacts of manual service key 301 to ground, and relay 3SC operates. The operation of relay 3SC depends on relay 13TA and the corresponding relay in each of the other groups of five trunks being in a non-operated condition. Also, relay 3SA, upon operating, opens at its back contact and outer right-hand armature a path extending over conductor 305 to the operating circuits of the relays, corresponding to relay 3SC, in all succeeding groups of five subscriber lines. This assures that even in the case of simultaneous origination of calls in two subscriber line groups only one relay corresponding to relay 3SC will be operated.

The operation of gate relay 3G1 closes a circuit extending from grounded battery, through the winding of gate relay 3G, contact and armature of relay 3G1, to ground at the normally closed lower contacts of manual service key 301 and relay 3G operates and thereby opens at its left-hand armatures the circuits of each of these subscriber station groups and at its right-hand armature each of the trunk groups as hereinbefore stated. The subscriber group engaged in the outward call is held operated by the locking circuit of relay 3SA.

Relay 3SC, upon operating, extends conductors 250 and 251 from the calling subscriber line terminating equipment over two paths, respectively, only one of which, namely that including conductor 250, is completed over the contact and No. 4 armature of relay 3SC, conductors 306 and 307, contacts and No. 2 armature of relay 3GA, conductor 308, through the winding of relay 3U2 to grounded battery and relay 3U2 operates to further extend the other path including conductors 211 and 251, contact and No. 3 armature of 3SC, conductor 309, over the outermost upper armature and front contact of relay 3U2, to conductor 303 which is common to the selecting relays 3U1 to 3U5, inclusive. The selecting relays 3U1 to 3U5 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 3U2 upon operating (1) locks directly to ground at the outer lower armature of lamp relay 2L2, the circuit being traceable from grounded battery, through the winding of relay 3U2, front contact and inner lower armature of relay 3U2, back contact and inner lower armature of relay 3U1, conductor 310, left-hand armature and front contact of relay 3GB, armature and contact No. 1 of relay 3GC, conductor 311, innermost upper armature and back contact of relay 3U1, innermost upper armature and front contact of relay 3U2, conductor 312, No. 4 armature and contact of relay 3SC, conductor 250 to the ground at the outer lower armature of lamp relay 2L2 (relays 3GB and 3GC are operated at this time as hereinafter described); (2) extends conductor 309 of the other path of subscriber station 102 over the outermost upper armature and front contact of relay 3U2, conductor 303, to conductor 1402 and resistance 1401 for future effectiveness; (3) extends at its outer lower armature and contact conductor 313 to conductor 314 and the contact and outer left-hand armature of relay 3GD, a function not useful at this time; (4) extends conductor 312 through the innermost upper armature and front contact of relay 3U2, back contact and innermost upper armature of relay 3U1, conductor 311 through the left-hand winding of relay 3GB to grounded battery whereby relay 3GB operates from the ground at the outer lower armature and contact of relay 2L2; (5) releases normally operated relays 3GF and 3GE because the operating circuit for relay 3GF is opened at the back contact and left-hand armature of relay 3GB, relay 3GB being of the differential type is normally maintained in a released condition although both of its windings having equal resistance values are normally energized; (6) the release of relay 3GE starts the timing circuit of vacuum tube 1401; and (7) connects ground at the No. 12 armature and contact of relay 3SC, over its contact and outer lower armature to conductor 314 for the future operation of relay 14LS1, that is, when relay 3GA operates.

Relay 3GB, upon operating, (1) operates relay 3GC in a circuit traceable from the grounded battery and winding of relay 3GC, front contact and left-hand armature of relay 3GB, conductor 310, inner lower armature and back contact of relay 3U1, inner lower armature and front contact of relay 3U2, conductor 308, No. 2 armature and contact of relay 3GA, conductors 307 and 306, No. 4 armature and contact of relay 3SC to grounded conductor 250; and (2) removes ground at its contact and right-hand armature, from conductor 315 which extends to the all-trunks-busy circuit and also to all the trunk circuits over paths such as that extending over armature No. 9 of relay 8ST. Relay 3GC, upon operating, locks over its left-hand armature and contact in a circuit extending over conductor 311, innermost upper armature and back contact of relay 3U1, innermost upper armature and front contact of relay 3U2, conductor 312, armature No. 4 and contact of relay 3SC to grounded conductor 250. Relay 3GC, upon operating, also causes at its contacts No. 2 an operating circuit for relay 3GA which operates. Relay 3GA is what is known herein as the units gate relay which opens or closes the operating circuits respectively for relays 3U1 to 3U5. Relay 3GA, upon operating, closes at its outer left armature and contact an

operating circuit for relay 3GD, the circuit being traceable from grounded battery, through the winding of relay 3GD, conductor 316, to ground at the outer left-hand armature and contact of relay 3GE. Relay 3GD, upon operating, (1) locks at its inner left-hand armature and contact relay 3GA in an operated position; (2) connects ground at its right-hand armature and contact to a path extending over conductors 317 and 318, contact and middle upper armature of relay 3U2, conductor 319 to armature No. 4 of relay 13TC, a function not useful at this time; and (3) operates relay 14LS1 in a circuit traceable from ground at armature No. 12 of relay 3SC, conductor 313, contact and outer lower armature of relay 3U2, conductor 314, contact and outer left-hand armature of relay 3GD, conductor 320, through the winding of relay 14LS1, to grounded battery and relay 14LS1 operates. Relay 14LS1, upon operating, (1) closes an obvious operating circuit for relay 14H which operates; (2) extends its own operating ground from conductor 320 via its contact and right-hand armature and contact and No. 4 armature of relay 14H to conductor 1404, outer right-hand armature and contact of relay 13AD, conductor 1311, through the winding of start relay 8ST, to grounded battery and relay 8ST operates; and (3) applies at its contact and outer left-hand armature an additional holding ground for relay 3GD, the circuit being traceable over conductor 316, contacts and outer left-hand armature of relay 3GA, to the winding of relay 3GD. The operation of start relay 8ST in the first idle trunk places a calling condition toward the distant central office and closes at its No. 3 armature and contact an operating circuit for relay 8W which operates. Relay 8W, upon operating, closes at its armatures and contacts individual operating circuits for the cross bar switch selecting magnets, such as magnet 2SM—2, on a plurality of switches through which trunk 801 might be connected in multiple. A relay corresponding to relay 8W, also has armatures and contacts for closing individual operating circuits for each of the additional selecting magnets, such as magnet 2SM—9, on the plurality of switches through which its trunk, such as trunk 809 shown diagrammatically, might be multipled. Selecting magnets 2SM0 and 2SM1 are respectively controlled by the start relays in two all-trunks-busy circuits magnet 2SM—1 not being shown in the drawing hereof. The start relay for the all-trunks-busy circuit shown in Fig. 18 is designated 18ST. The cross bar switch selecting magnets 2SM2 to 2SM9, upon operating, close at their armatures and contacts an operating circuit for relay 14D which operates. Relay 14H, upon operating as hereinbefore described, connects ground at its No. 5 armature and contact to conductor 1405 which extends over two parallel paths, one over conductor 1312 to an unoperated armature of relay 8SL and the other over conductor 1313 to an unoperated contact No. 6 of relay 13AD. Also, relay 14H, upon operating, connects ground at its armatures Nos. 2, 3 and 4 to paths similar to that of conductor 1405 but extending to individual trunk circuits other than that shown herein in detail. At its armature No. 6 relay 14H, 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 1406 which serves as a shunt for resistance 1407.

Relay 14D, upon operating, (1) furnishes at its left-hand armature and front contact an additional ground for holding relay 3GD operated; (2) closes at its inner right-hand armature and contact an operating circuit for connection lamp 1408 which lights thereby indicating to the attendant that the calling subscriber line has been connected to an idle trunk; and (3) connects ground at its outer right-hand armature and contact to a circuit traceable through resistance 1401, conductors 1402 and 303, contact and outermost upper armature of relay 3U2, conductor 309, through armature No. 3 and contact of relay 3SC, conductor 251, conductor 211 (Fig. 3), inner upper armature and contact of relay 4C, conductor 253, through the winding of hold magnet 2H2 which operates to complete the connection of the calling subscriber line to the first idle trunk. It will be noted that the circuit just traced extends through the conference circuit inasmuch as the calling station 102 is arranged for automatic connection to the conference circuit. However, should one of the stations not arranged for automatic connection to the conference circuit be the calling station, for example, station 101, the circuit closed at the outer right-hand armature and contact of relay 14D would extend over the front contact and outermost upper armature of relay 3U1, conductor 326, No. 1 armature and contact of relay 3SC, conductors 321 and 252, and then directly through the winding of hold magnet 2H1, to grounded battery and magnet 2H1 would operate to completed the connection of station 101 to the first idle trunk. Hold magnet 2H2, upon operating, opens at its normally closed make-before-break contacts the operating circuit for calling-in, or lamp, relay 2L2 which releases to extinguish lamp 206. Relay 2L2, upon releasing, (1) removes ground at its inner lower armature and contact from the locking circuit of relay 3SA and relay 3SA releases; (2) removes ground at its outer lower armature and contact to open the locking circuit for selecting relay 3U2 which also releases. Relay 3SA, upon releasing, releases relay 3SC which, upon releasing, removes ground from armatures Nos. 3, 4 and 12. Relays 3GB, 14LS1, 14H and 3GC release. Relay 3GB, upon releasing, connects ground at its right-hand armature and contact to a circuit traceable over conductors 315, 814, contact and armature No. 9 of start relay 8ST, conductors 815, 816 and 1314, through the winding of relay 13AD, to grounded battery and relay 13AD operates. A relay, such as relay 13AD, 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. 3 and 13 includes in addition to relay 13AD, relays 13DL, 13BO and 13DC together with the common selecting relays 1101 to 1105 and the gate, or G, relays shown in Fig. 3. Trunk sequence circuit No. 10 is provided in the system herein described as connected with the all-trunks-busy circuit which is connected, as hereinbefore stated, to the top level of the cross bar switch in the link circuit.

Relay 13AD, upon operating, (1) locks to ground in a circuit traceable over its left-hand armature and contact No. 6, conductors 1313 and 1312, to ground at the lower armature and contact of relay 8SL, which is operated at this time in response to the operation of both start relay

8ST in the trunk circuit and hold magnet 2H2 in the link circuit; (2) closes at contact No. 5 one completing point in the operating path of relay 18A in the all-trunks-busy circuit, the circuit being traceable from grounded battery, through the winding of relay 18A, conductor 1308, No. 5 contact of relay 13AD, conductor 1315, through the contact No. 5 of each of the relays corresponding to relay 13AD, to ground connection 1307 in the last, or No. 10, trunk sequence circuit; (3) transfers conductor 1404 from contact No. 3 to contact No. 2 of the relay so that should the trunk shown in Figs. 8 and 9 be busy the next call will be routed over conductor 1329 to the relay, corresponding to relay 13AD, in the trunk sequence circuit associated with the next idle trunk; (4) opens at contacts Nos. 3 and 4 both the operating and the locking circuits, respectively, for start relay 8ST 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 8ST releases.

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 8ST, when it operated, (1) closed at its No. 4 armature and contact an operating circuit for relay 9 TR; (2) at its No. 6 armature and contact closed an operating circuit for relay 8RC which operated; (3) at its No. 7 armature closed an operating circuit for relay 8STR which operated; (4) at its No. 2 armature closed an operating circuit for relay 8—ON which operated; (5) at its No. 3 armature closed an operating circuit for relay 8W which operated; (6) closed at its No. 8 armature and contact an operating circuit for busy lamp 818 which became lighted. Relay 9TR, upon operating, transferred at its outer lower armature trunk circuit 901 from resistance 931 of high value which is normally connected through the winding of relay 9L, to conductor 934, winding 3 of relay 9R to the armature of repeater relay 9S. The path through conductors 941 and 903 to the same ground is transferred over a front contact of relay 9TR to conductor 934*a* to winding 4 of relay 9R and resistance to the armature of sending relay 9S. Relay 8STR, upon operating, added another ground to the operating circuit of relay 9TR and thereby increases the release time of relay 9TR after relay 8ST releases. This insures registration at the central office even though the call is quickly abandoned. Relay 8—ON, upon operating, (1) locked at its No. 4 armature and contact to a normal ground at the back contact and inner lower armature of relay 8D1; and (2) connected ground at its armatures Nos. 1 and 2 to the windings of the repeater relays whereby such windings are energized, armature No. 1 serving to energize the artificial line windings Nos. 2 and 5 of receive relay 9R and armature No. 2 serving to energize the lower, or artificial line, windings of both relays 9BK and 9S; (3) at its No. 5 armature completed the filament circuit for vacuum tube 819; and (4) connected at its No. 3 armature an additional ground to the operating circuit for relay 8SL.

Relay 8SL, in an operated position, connected ground at its lower armature to conductor 1312 and at its upper armature closed an operating circuit for relay 8SL1 which operated. Hold magnet 2H2, in an operated position, opened the operating circuit for calling-in relay 2L2 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 3GB to a circuit traceable over conductors 315 and 814, contact and No. 9 armature of relay 8ST (before relay 8ST was released), conductors 815 and 816, through the winding of relay 13AD to grounded battery. The trunk advance relay 13AD operated to advance the next call to the next idle trunk and opened both the operating and the locking circuit for start relay 8ST which released, as hereinbefore stated.

The calling subscriber line circuit is now complete from ground on the winding of relay 8SP, normally closed contact at tip spring of jack 836, conductor 822, conductor 258, operated contact set 255, conductor 259, outer left-hand armature and front contact of hold magnet 2H2, conductor 403, No. 1 armature of relay 4B1, conductor 603, normally closed make-before-break contact of magnet 7H2, conductor 210, normally closed contacts at tip spring of jack 208, 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 207, conductor 209, inner upper armature and back contact of hold magnet 7H2, conductor 402, front contact and upper armature of relay 4A which operated in response to the operation of magnet 2H2, conductors 406 and 267, operated contact set 255, conductors 265 and 266, normally closed contact at the tip spring of jack 835, conductor 823, outer upper armature and back contact of relay 8R3, conductor 824, through the upper windings, in series, of relays 9BK and 9S, armature and marking contact of receive relay 9R, conductor 935, to grounded battery 936. This places a marking condition on the trunk looking toward the distant central office because both relays 9BK and 9S are maintained in their marking positions, send relay 9S being effective to transmit the marking condition toward the central office. Relay 8SP operates and closes at its armature and contact an operating circuit for relay 8SP1, the circuit extending to ground on armature No. 3 of relay 8—ON. Relay 8SP1, upon operating, operates in turn relays 8SP2 and 8RC. Relay 8SP2, upon operating, furnishes at its outer upper armature and contact a ground to hold relay 9TR operated even though start relay 8SP is released, relay 8SP2 being held operated by slow-to-release relay 8SP1.

At the distant end of the trunk which terminates at the central office, the marking condition applied by relay 9S results in the registration of a call and the lighting of a lamp in the operator's switchboard as will be hereinafter described in more detail. The operator answers and the circuit is in the transmission condition, that is, arranged for communication.

The release of start relay 8ST effected the release of relay 8W which in turn effected the release of selecting magnets 2SM2 to 2SM9. The selecting magnets, upon releasing, remove ground from the operating circuit of relay 14D and relay 14D releases thereby extinguishing lamp 1408. Relay 3GE reoperated following the release of relays 3GD and 3GA. Thus all relays in Figs. 3, 13 and 14 are in their normal condition with the exception of relay 13AD and the sequence circuit is now ready to route a new call.

Central office—A call received at the concentrating unit switching center from a subscriber station

As stated, a call originating at a subscriber station and received through the concentrating unit switching center connects negative marking potential to the switching center and of the trunk and is effective at the central office to operate relay 11—C in a circuit traceable over tip conductor 901, back contact at tip spring of jack 1005, conductor 1015, lower normally closed contact at tip spring of jack 1006, conductor 1016, upper armature and back contact of relay 10—E through the No. 1 winding of relay 10—P, through the upper winding of receive relay 11—R, resistance 1105, retardation coil 1106, through the winding of relay 11—C to ground at the upper armature and back contact of relay 11—C1. Relay 11—C, upon operating, closes at its armature and contact a circuit extending from grounded battery 1109, conductors 1110 and 1017, resistance 1018, conductors 1019 and 1020, armature and contact of relay 11—C, conductor 1117, resistance 1021, through the winding of alternating current relay 10—H, conductor 1022, to ground the marking, or left-hand, contact and armature of relay 10—P. Relay 10—H operates and in turn closes an obvious operating circuit for relay 11—C1. Relay 11—C1, upon operating, completes the transmission circuit to ground at the marking contact of relay 11—S. Relay 11—C1 at its outermost lower armature and front contact closes an operating circuit for relay 11—L which operates to close an operating circuit for answer lamp 1101 in the operated switchboard. Relay 11—C1, upon operating, closes an operating circuit for relay 11—CL also, which locks to ground on its innermost lower armature and front contact. Relay 11—CL, upon operating, (1) closes at its uppermost outer armature and contact an operating circuit for relay 11—F2 which operates; (2) closes at its outermost lower armature and front contact a future operating circuit for relay 11—F1; (3) transfers the grid element of vacuum tube 1119 from a ground connection at the middle upper armature and back contact of relay 11—D2 to a ground connection at the innermost lower armature and front contact of relay 11—C1, the grounded circuit being traceable over conductor 1120, middle upper armature and front contact of relay 11—CL to the innermost lower armature and front contact of relay 11—C1; and (4) closes at its middle lower armature and contact an operating circuit for relay 11—BY which operates to close at its outer upper armature and contact a circuit extending from source 1121 of alternating current, through busy lamp 1102 at the operator's switchboard and the lamp lights; and to close at its outer lower armature and contact an energizing circuit for the filament of vacuum tubes 1119 and 1122. Vacuum tube 1122 is held inactive at this time by ground potential connected in a circuit traceable from ground at the outer upper armature and back contact of relay 11—SL1, conductors 1147 and 1123, back contact and outer lower armature of relay 10—FT, conductor 1023, to the grid of vacuum tube 1122. A second ground connection is had at this time for vacuum tube 1122 at the armature and marking contact of relay 11—B which is included in a circuit traceable over the front contact and outer lower armature of relay 11—F2 to conductors 1123 and 1023 as hereinbefore stated.

Operator answers

The operator, upon noting the lighting of answer lamp 1101, inserts the answer plug, such as plug 1201, of one of her calling cord circuits into jack 1124 and thereby connects grounded battery 1202 over the sleeve conductors of plug 1201 and jack 1124 to operate relay 11—SL. Sleeve relay 11—SL, upon operating, (1) opens at its outer lower armature and back contact the operating circuit for relay 11—L which releases to extinguish answer lamp 1101; (2) closes at its outer lower armature and front contact an operating circuit for relay 10—C2, the circuit being traced from grounded battery, through the winding of relay 10—C2, conductor 1024, front contact and outer lower armature of relay 11—SL, conductor 1125, to ground at the front contact and outermost lower armature of slow-release relay 11—C1 and relay 10—C2 operates; (3) closes at its inner upper armature and contact an obvious operating circuit for relay 11—SL1 which operates; (4) completes at its outer upper armature and contact the transmission circuit to the cord circuit; (5) connects at its inner lower armature and front contact grounded battery 1109 to the winding of relay 11—F and to resistances 1126, 1025 and 1026. Relay 11—SL1, upon operating, (1) removes at its outer upper armature and back contact one of the two ground connections from the grid element of vacuum tube 1122; (2) provides at its No. 2 armature and contact a locking ground for relay 11—F2; (3) completes at its inner upper armature and contact the biasing circuit extending through the lower winding of relay 11—B; (4) connects at its No. 3 armature and contact a ground to the grid of vacuum tube 1119; and (5) connects at its outer upper armature and front contact a ground connection to a circuit traceable through winding No. 2 of relay 10—TC. Relay 10—C2, upon operating, (1) removes at its outer upper armature and contact grounded battery 1109 from the No. 5 winding of relay 11—R; (2) prepares at its innermost lower armature and contact a future operating circuit for relay 10—G; and (3) opens at its middle lower armature and contact the operating circuit for alternating current relay 10—R1. Relay 10—C2, upon operating, also transfers the circuit including the biasing, or lower, windings in series of relays 11—S and 11—S1, conductor 1012, from grounded battery 1109 to a path extending over the outermost lower armature and front contact of relay 10—C2, conductors 1027 and 1028 to the transmission circuit to form an apex at the armature of relay 11—R. Relay 10—C2, upon operating, closes at its innermost upper armature and contact a path for holding relay 10—H in an operated position during the time the subscriber at station 102 is sending, even though relay 10—P follows the signals. The action is as follows: During the time interval when relay 10—P is on its marking, or left-hand, contact and the contact of relay 11—C is opened, one end of resistance 1029 and one end of the winding of relay 10—H is grounded. Grounded battery 1109 which is connected to a path including resistance 1018 and the inner upper armature and contact of relay 10—C2, charges condenser 1030 and current through resistances 1031 and 1021 and the winding of relay 10—H to ground on the marking, or left-hand, contact of relay 10—P holds relay 10—H operated. When relay 10—P operates to its spacing contact one side of condenser 1030 and resistance 1018 is grounded and the current

in relay 10—H reverses and continues to hold relay 10—H operated. During long marking or spacing signals, relay 11—C operates to hold relay 10—H operated. The biasing current in winding No. 3 of relay 10—P tends to operate the relay to its spacing, or right-hand, contact, but the marking current in the No. 1 winding of the relay is twice as great and in the opposite direction to the current in the No. 3 winding so that the relay is operated to its marking, or left-hand, contact. The circuit is now ready for communication between the calling subscriber at station 102 and the operator at the switchboard in the central office. Relay 10—P follows the signals sent by the subscriber and in turn holds relay 10—H operated.

Subscriber sends a break signal

During communication between the subscriber at station 102 and the operator at the switchboard in the central office and particularly at the time when the operator is transmitting, should the subscriber at station 102 desire to interrupt the transmission from the central office, the subscriber operates break signal key 116 and positive spacing polarity from battery source 933 will be applied to the line at the concentrating unit switching center during the time the break key is depressed. During this time the subscriber loop current is reduced from 20 milliamperes to 5 milliamperes. This current is sufficient to hold relay 8SP operated but permits send relay 9S to operate to its spacing, or right-hand, position and thereby place a spacing condition on trunk conductor 901. At the central office end in response to the spacing condition, relay 11—C continues to hold relay 10—H and its associated relays operated, however, and relay 11—B is operated to its spacing, or right-hand, contact. As well known in the art, the operator at any station provided with a "break" key may interrupt sending from another station and take control of the transmission circuit in simplex or half-duplex operation by operating the break key for a short interval. This makes the line circuit spacing and stops proper printing at all stations. At the station whose sending is interrupted, the "break" is noticed from the fact that the machine, or teletypewriter, fails to print properly when keyboard keys are depressed. When this condition is noticed the operator usually stops sending and awaits a message from the "breaking" station. At the completion of the break, relays 11—R and 10—P operate to their marking contacts and the circuit is again ready for transmission. If the subscriber sends a break signal exceeding six seconds, vacuum tube 1122 will function but performs no useful operation at this time. A break signal having a duration exceeding six seconds permits condenser 1127 to acquire a sufficient charge from grounded battery 1109, through resistance 1025 to cause vacuum tube 1122 to operate relay 11—F, the charge on condenser 1127 being stored during the interval of long duration at which time ground at the armature of relay 11—B is connected to the spacing, or right-hand, contact of the relay.

Break signal to the subscriber at station 102

A break signal transmitted from the cord circuit at the central office will operate relay 11—B to its spacing, or right-hand, contact. Relay 11—C will continue to hold relay 10—H and its associated relays operated. Relay 10—P continues for a while to operate its armature between its marking and spacing contacts in response to transmission from the subscriber station. When relay 10—P is in its marking position, the circuit for holding relay 10—H operated may be traced from grounded battery 1109, conductors 1110 and 1017; resistance 1018, conductors 1019 and 1020, armature and contact of relay 11—C, conductor 1117, resistance 1021, through the winding of relay 10—H, conductor 1022, to ground at the marking contact and armature of relay 10—P. When relay 10—P is in its spacing condition the circuit for holding relay 10—H operated, may be traced over another path which extends from grounded battery 1109, conductors 1110, 1017 and 1046, resistance 1029, conductor 1022, through the winding of relay 10—H, resistance 1021, conductor 1117, contact and armature of relay 11—C, conductors 1020, and 1019, to ground at the right-hand, or spacing, contact and armature of relay 10—P. The operation of relay 11—B to its spacing, or right-hand, contact removes ground from condenser 1127 and allows the condenser to charge in a circuit extending from grounded battery 1109, conductor 1149, inner lower armature and contact of relay 11—SL, conductor 1148, through resistance 1025, conductor 1023, condenser 1127, to ground.

The break signal from the central office is received at the concentrating unit switching center as a spacing condition on trunk conductor 901. Relay 9R operates to its spacing, or right-hand, contacts and the subscriber loop current is reduced to zero. This will cause relay 8SP to release. Relay 8SP, upon releasing, would tend to release relay 8SP1 and thus relay 8SP2: However, relay 9—OB operates to its right-hand contact and furnishes ground potential to a circuit traceable over conductor 937, outer lower armature and contact of relay 8SP2, through the winding of relay 8SP1 to grounded battery and relay 8SP1 is maintained operated. When the loop is again closed to a marking condition, relay 11—B at the central office reoperates to its marking, or left-hand, contact whereby condenser 1127 is discharged, thus preventing the grid element of vacuum tube 1122 from reaching such a potential that plate current will operate relay 11—F.

If the break signal from the cord circuit exceeds six seconds, the removal of ground from condenser 1127 for that period of time permits vacuum tube 1122 to operate relay 11—F which in turn operates relay 11—F1 in a circuit traceable from ground at the armature and contact of relay 11—F, conductor 1128, outermost lower armature and front contact of relay 11—CL, conductor 1129, upper armature and back contact of relay 10—FT, conductor 1032, through the winding of relay 11—F1 to grounded battery, and relay 11—F1 operates to close the subscriber's loop. Relay 11—F1, upon operating, also closes at its lower armature and contact a circuit extending from interrupter 1130, lower armature and contact of relay 11—F1, conductor 1131, front contact and innermost armature of relay 10—C2, through the winding of relay 10—G, to grounded battery. Relay 10—G operates and releases with the pulses supplied by interrupter 1130. Relay 10—G, upon operating, removes at its upper armature and back contact grounded positive marking battery from the upper winding of relay 11—S and closes the loop through to the cord circuit, the circuit from which the grounded positive marking battery is removed may be traceable from battery 1109, conductors 1110 and 1017, resistance 1033, back contact and upper armature

of relay 10—G, conductor 1034, upper armature and front contact of relay 11—F1, through the upper windings in series of relay 11—S1 and 11—S to the armature of relay 11—R, and the other circuit which closes the loop through the cord circuit may be traceable from the armature of relay 12RC, through the upper winding of relay 12RA, front contact and lower armature of relay 12AA, tip conductors of plug 1201 and jack 1124, conductor 1132, outer upper armature and contact of relay 11—SL, resistance 1133, through the upper winding of relay 11—B, resistance 1134, conductor 1135, front contact and armature of relay 10—G, conductor 1034, upper armature and front contact of relay 11—F1 through the upper windings in series of relays 11—S1 and 11—S to the armature of relay 11—R. If the operator's cord circuit is still in spacing condition, relay 11—B remains on its spacing, or right-hand, contact and relays 11—S, 11—S1 and 10—G remain operated and the repeater sends a spacing signal out to the concentrating unit switching center. Also relay 10—G, upon operating, closes at its lower armature and contact a circuit extending from grounded positive battery 1109, conductors 1110 and 1017, resistance 1018, lower armature and contact of relay 10—G, resistance 1021, through the winding of relay 10—H, conductor 1022, to ground at the armature of relay 10—P, and relay 10—H is thereby held in its operated position during the spacing interval. The repeated operation and release of relay 10—G in response to the pulses furnished by interrupter 1130, sets up a corresponding action in relay 11—S which in turn transmits the interruption over the trunk conductor 901 to the subscriber's station connected at the concentrating unit switching center. The reception of a marking condition at intervals at the subscriber station will permit the concentrator unit switching center subscriber to register a recall or disconnect. If the subscriber disconnects, relay 11—C which may or may not release depending upon the amount of leakage present on the trunk conductor when the trunk conductor is in a spacing condition, will release when the trunk repeater at the central office sends a marking signal out on the trunk conductor with the next release of relay 10—G. Thus the operation and release of relay 10—G caused the send relay 11—S to transmit space and mark signals alternately to the concentrating unit switching center. If relay 10—G is operated and the space signal changes to mark in the cord circuit loop, relay 11—B will operate to its marking contact and release relay 11—F which will result in the release of relays 11—F1 and 10—G and the circuit will be ready for communication.

Concentrating unit subscriber disconnects

When the concentrating unit subscriber disconnects, the subscriber loop is open at his station and relay 8SP releases thereby causing the subsequent release, in turn, of relays 8SP1 and 8SP2. Relay 8SP2, upon releasing, opens at its outer upper armature and contact the operating circuit for relay 9TR which releases. Relay 9TR, upon releasing, transfers at its outer lower armature, trunk conductors 901 and 940, from the trunk repeater to the high resistance ground which is extended over conductors 903 and 941, contact and inner upper armature of relay 9TR, through the winding of relay 9L, resistance 931, to the back contact and outer lower armature of relay 9TR. The connection of high resistance 931 at the concentrating unit switching center to the trunk circuit causes relay 11—C to release which then releases relay 10—H and in turn relay 11—C1 releases. Relay 11—C1, upon releasing, connects at its outermost lower armature and back contact a ground connection to a circuit traceable over conductors 1136 and 1137, ring conductors of jack 1124 and plug 1201, through the winding of relay 12SA, to grounded battery. Relay 12SA, upon operating, lights supervisory lamp 1203. Relay 11—C1, upon releasing, also opens at its outermost lower armature the operating circuit for relay 10—C2 and at its upper armature transfers the transmission conductor from the armature of relay 11—S to ground at its back contact associated with its upper armature. Relay 10—C2 releases and closes an operating circuit for relay 11—R, the circuit being traceable from grounded battery 1109, conductors 1110 and 1017, resistance 1010, middle upper armature and contact of relay 10—C2, conductor 1011, through the winding No. 5 of relay 11—R, to ground. Relay 11—R operates to its marking contact and thereby causes relay 11—S to operate to its marking contact.

When the operator removes the cord plug 1201 from jack 1124, relays 11—SL and 11—SL1, release in turn. Relay 11—LS1 upon releasing, removes ground at its No. 3 armature and condenser 1138 thereby charges in a circuit extending from grounded battery 1109, conductors 1140 and 1139, normally closed make-before-break contact of relay 11—D2, resistance 1140, conductor 1120, condenser 1138 to ground at the outer lower armature and contact of relay 11—BY. Condenser 1138 charges to a potential sufficient to make vacuum tube 1119 conductive and thereby operate relay 11—D1. Relay 11—D1, upon operating, closes an operating circuit for relay 11—D2 which operates. Relay 11—D2, upon operating, (1) closes at its outermost upper armature and front contact a circuit extending over the front contact and innermost upper armature of relay 11—CL to complete the charge of condenser 1138; (2) connects at its outermost lower armature and contact a ground connection to the operating circuit for relay 10—E which operates; (3) connects grounded negative battery 1141 at its front contact and innermost upper armature to a circuit extending over conductor 1142, front contact and upper armature of relay 10—E, conductors 1016 and 1015, to the outgoing trunk conductor 901 to effect the release of the operated apparatus at the concentrating unit switching center; (4) connects at its middle upper armature and front contact a ground connection to a path extending through resistance 1143, conductor 1120, condenser 1138, filaments of vacuum tubes 1119 and 1122, to grounded battery 1109 whereby condenser 1138 continues to charge; (5) connects ground at its innermost lower armature and contact to grounded battery 1144 thereby shunting the winding of relay 11—CL which releases; and (6) supplies at its middle lower armature and contact a ground connection for holding busy relay 11—BY operated. Relay 11—CL, upon releasing, (1) removes ground at its outermost upper armature and contact from the operating circuit of relay 11—F2 which releases; and (2) opens at its innermost upper armature and contact the charging circuit for condenser 1138 which starts discharging through resistance 1143. After approximately two seconds the plate current in vacuum tube 1119 is reduced by the reduction in grid element po-

tential to a point where relay 11—D1 releases thereby releasing relay 11—D2. The release of relay 11—D2 opens at its middle lower armature and contact the holding circuit for relay 11—BY which releases and the circuit is thus restored to normal idle condition.

During the interval when the timing of approximately two seconds for the operation of vacuum tube 1119 is effected grounded negative battery is connected to the trunk conductor 901, and relay 9L operates to its off-normal position for the duration of the negative battery pulse thereby removing ground from the grid condenser 825. Condenser 825 is then charged in a circuit extending from grounded battery 812, conductor 826, condenser 825 to ground at the No. 5 armature and contact of relay 8—ON and in one second the grid potential of vacuum tube 819 is raised so that sufficient plate current flows to operate relay 8D which, upon operating, operates relay 8D1. Relay 8D1, upon operating, disconnects at its inner lower armature and back contact ground connections from the locking circuit for relay 8—ON and at its outer lower armature and contact the locking circuit for relay 8RC. Relays 8—ON and 8RC release. Also in the event that the subscriber station is connected by manually operable means to the trunk circuit patching cords will be inserted in jacks 811 and 812 and at this time relay 8D1 upon being operated connects ground at its inner armature and front contact to a circuit traceable over the conductor 828, operated contacts 829, conductor 830, through the winding of relay 13DL, to grounded battery and relay 13DL operates to light a call-disconnect lamp 1301 as a signal that the manually operable means (patching cord) may be removed from the jacks 811 and 812, the removal of the cord causing the release of relay 13DL and the extinguishing of lamp 1301. Relay 8—ON, upon releasing, opens the filament circuit of vacuum tube 819 whereby relays 8D and 8D1 are released and the circuit is again in normal idle condition.

Operator rerings

If the operator upon receiving a disconnect signal from the subscriber wishes to rering the subscriber station, ringing current from source 1035 is applied to a circuit extending through lamp 1036, front contact and lower armature of relay 10—D, conductor 1037, back contact and innermost lower armature of relay 11—D2, conductor 1142, front contact and upper armature of relay 10—E, conductor 1016, through the normally closed tip contacts of jack 1006, conductor 1015, normally closed tip contacts of jack 1005, trunk conductor 901, normally closed tip contacts of jack 938, conductor 939, normally closed tip contacts of jack 930, conductor 940, outer lower armature and back contact of relay 9TR, through the winding of relay 9R1, condenser 906, inner upper armature and back contact of relay 9TR, conductor 941 back to ground at the central office. Relay 9R1 operates thereby operating in turn relay 9R5. Relay 9R5, upon operating, operates relay 9R4 which, in turn, upon operating, causes relay 9R5 to release. Relay 9R5, upon releasing, causes relay 8R2 to operate which in turn causes relay 8R3 to operate in a circuit traceable from grounded battery at the outer right-hand armature and contact of relay 13DL, conductor 1320, through the winding of relay 8R3, back contact and inner upper armature of relay 8SP2, conductor 829, armature No. 7 and contact of relay 8—ON, outer upper armature and front contact of relay 8R2, to ground at the outermost lower armature and contact of relay 8SL1. Relay 8R3, upon operating, (1) connects ground at its lower armature and contact to a path extending over the middle lower armature and contact of relay 8SP2, through the normally closed tip contacts of jack 812, to the ring conductor 822 which extends over the ring side of the subscriber's loop; (2) operates relay 8B; and (3) transfers the tip conductor 823 from the loop side of the repeater relay to source 840 of ringing current which operates the subscriber's station bell 112. This arrangement makes it necessary to ring on the answer cord plug 1201 and therefore the position circuit is associated with the cord shown in Fig. 12 by operating typing key 1204 after which the ring answer key 1209 (an element used in cord circuits of the prior art) is operated to control relay 1210 in the cord circuit. Relay 1210, upon operating, connects source 1211 of continuous ringing current in the cord circuit to the answering cord plug 1201. When the operator releases ringing key 1209, relays 9R1, 8R2, 8R3 and 9R4 release to remove the subscriber loop from the ringing source 830. Relay 8B which also connected ground to ring conductor 822 releases after an interval sufficient to allow the loop capacity to become discharged. If the circuit is arranged for automatic ringing, that is, interrupter 831 is provided to furnish interrupted ground pulses, relay 8R3 will be operated by the pulses from source 831 to apply ringing current from source 840 to the subscriber loop at regular intervals.

Recall signals from the subscriber station

Recall signals are transmitted from the concentrating unit subscriber station by momentarily opening recall, or flash, key 114 or momentarily operating power switch 110 to its "off" position in which case switch 110 is immediately operated back to the "on" position. Momentarily operating power switch 110 to it "off" position is, in effect, a disconnect followed by a new call. When the power switch is in the off position relays 8SP, 8SP1 and 8SP2 release and as hereinbefore described relay 9TR releases thereby terminating the trunk conductor in the high resistance ground condition by connecting resistance 931 of high value in the trunk circuit. Relay 11—C releases and in turn releases relay 10—H. The release of relay 10—H causes relays 11—C1 and 10—C2 to release in turn. Relay 11—C1, upon releasing, functions as hereinbefore described and ground on the ring conductor of cord plug 1201 causes supervisory lamp 1203 to light. When the power switch 110 is returned in its "on" position, a marking condition will again be placed on the trunk by the concentrating unit. Relay 11—C and in turn relays 10—H, 11—C1 and 10—C2 will operate, restoring the circuit to the communication condition. The removal of ground from the ring circuit of the answer cord plug 1201 causes the cord supervisory lamp 1203 to flash as an indication of a recall signal. The operation of the power switch to its "on" position likewise causes relays 8SP, 8SP1 and 8SP2 and 9TR to reoperate and the trunk circuit is again in marking condition.

The subscriber may send a recall or disconnect signal during the time the trunk circuit is in marking condition, when a trouble break exists on the switchboard side of the terminal repeater. When this condition exists the trunk circuit times out after approximately six seconds and causes

relay 11R to send out long marking and short spacing signals over the line to the concentrating unit subscriber.

Call originating at the central office for a subscriber station

The establishment of a call about to be described herein is assumed to be to a subscriber station having attended service. The operator, upon selecting, an idle trunk extending to the concentrating unit switching center, inserts one of her calling cord plugs, say plug 1205 into jack 1124, which corresponds to the selected trunk thereby completing a circuit from grounded battery, through the winding of relay 12AC, sleeve conductors of plug 1205 and jack 1124, through the winding of relay 11—SL, to ground. However, before the insertion of plug 1205 the operator selects a particular cord circuit by operating the typing key of that particular cord, say key 1204. Relays 12AC and 11—SL operate. Relay 12SC operates in a circuit traceable from grounded battery, through the winding of relay 12SC, ring conductor of plug 1205 and jack 1124, conductors 1137 and 1136, to ground at the outermost lower armature and back contact of relay 11—C1. Relay 12SC, upon operating, lights the call lamp 1206. Relay 12AC, upon operating, (1) closes at its upper armature and contact an operating circuit for relay 12C which operates, and (2) closes at its lower armature and contact a path traceable from grounded negative battery 1207, spacing or right-hand contact and armature of relay 12RA through the upper and lower windings, in parallel, of relay 12RC, operated off-normal, left-hand contacts of key 1204, through the operator's position circuit, operated off-normal right-hand contact of key 1204, front contact and lower armature of relay 12AC, normally closed contact of ring key 1208, tip conductors of plug 1205 and jack 1124, conductor 1132, outer upper armature and contact of relay 11—SL, through the upper winding of relay 11—B normally closed make-before-break contact of relay 11—F1, through the upper winding in series of relays 11—S1 and 11—S, armature and marking, or right-hand, contact of relay 11—R to grounded negative battery 1141. Relays 12RC, 11—B, 11—S1 and 11—S are held in the position shown by current flowing through their respective biasing windings.

Relay 11—SL, upon operating, closes an operating circuit for relay 11—SL1 which operates to establish the biasing current for relay 11—B. Relay 11—SL1, upon operating, closes at its No. 4 armature and contact a circuit extending from ground, outer upper armature and back contact of relay 11—F2, conductors 1145 and 1040, through the winding of relay 10—D, to grounded battery and relay 10—D operates to close at its upper armature and contact an operating circuit for relay 10—E and at its lower armature and front contact a circuit extending from source 1035 of ringing current, through lamp 1036, front contact and lower armature of relay 10—D, conductor 1037, back contact and innermost upper armature of relay 11—D2, conductor 1142, front contact and upper armature of operated relay 10—E, conductor 1016, normally closed tip contacts of jack 1006, conductor 1015, normally closed tip contacts of jack 1005, tip conductor 901 which extends through the concentrating unit switching center. Relay 10—E, upon operating, transfers at its lower armature and contact conductor 1007, from resistance 1004, to ground thereby providing metallic circuit ringing inasmuch as conductor 1007 is connected to the neutralizing wire 903 which extends to the concentrating unit switching center. Relay 11—SL1, upon operating, also (1) closes at its contact and No. 1 armature and operating circuit for busy relay 11—BY which operates to close at its outer lower armature and contact a circuit for energizing and lighting the filament of vacuum tubes 1119 and 1122, (2) disconnects ground at its outer upper armature and back contact from a circuit extending over conductor 1147, outer lower armature and back contact of relay 11—F2, resistance 1126, conductor 1148, front contact and inner lower armature of relay 11—SL, conductor 1149 to grounded battery 1109, thereby connecting grounded battery 1109 in a circuit now extending over conductor 1149, inner lower armature and front contact of relay 11—SL, conductor 1148, resistance 1126 in parallel with resistance 1025, back contact and outer lower armature of relay 10—FT, and conductor 1023 as the charging path for condenser 1127, the grounded battery 1109 being also connected through resistance 1029 to the winding of relay 10—H, and (3) connects at its No. 3 armature and contact ground to the path extending over conductor 1120, condenser 1138 and the filaments of tubes 1119 and 1122. After approximately one and one-half seconds tube 1122 becomes conductive to operate relay 11—F which operates and closes at its armature and contact a circuit traceable over conductor 1128, outermost lower armature and back contact of relay 11—CL, normally closed make-before-break contacts of relay 11—F2, through the winding of relay 11—F2 to grounded battery. Relay 11—F2 operates and locks up in a circuit traceable to the contact and No. 2 armature of relay 11—SL1. Relay 11—F2, upon operating, (1) removes resistance 1126 as a shunt across resistance 1025, connects condenser 1127 to the circuit which is traceable over conductor 1023, outer lower armature and back contact of relay 10—FT, conductor 1123, outer lower armature and front contact of relay 11—F2, conductor 1146, to ground at the marking contact of relay 11—B, in which circuit condenser 1127 is discharged, (2), closes at its inner upper armature and contact an operating ciircuit for relay 11—CL, and (3) opens at its outer upper armature and back contact the operating circuit for relay 10—D which releases. Relay 10—D, upon releasing, (1) replaces the ringing current on the trunk conductor 901 with ground through resistance 1042 in order that any charged condition of the trunk conductor 901 may be dissipated and (2) opens at its upper armature and contact the operating circuit for relay 10—E which releases to transfer the trunk conductor 901 and conductor 1016 to the repeater circuit.

The call from the central office is received at the concentrating unit switching center as a one-second interval of ringing current from source 1035 as hereinbefore described. This ringing current is received over trunk conductor 901, normally closed tip contact of jack 938, conductor 939, normally closed tip contacts of jack 930, conductor 940, outer lower armature and back contact of relay 9TR, through the winding of alternating current relay 9R1, condenser 906, inner upper armature and contact of relay 9TR, conductor 941, lower normally closed contact of jacks 930 and 938, trunk conductor 903, normally closed ring contacts of jack 1005, conductor 1043, upper normally closed contacts of jack 1006, conductor

1007, lower armature and front contact of operated relay 10—E to ground, relay 10—E being operated at the time the ringing current is applied to the trunk conductors. The ringing current on the trunk conductors operates relay 9R1. Relay 9R1, upon operating, closes at its armature and contact a circuit traceable over the lower armature and back contact of relay 9R4, through the winding of relay 9R5, to grounded battery, and relay 9R5 operates. Relay 9R5, upon operating, closes at its armature and front contact an operating circuit for relay 9R4 which operates and at its lower armature performs two functions, namely, closes a locking circuit for itself and opens the operating circuit for relay 9R5 which now releases. Relay 9R5, upon releasing, closes at its armature and back contact an operating circuit for relay 8R2 traceable from ground on the contact and armature of relay 9R1, lower armature and front contact of relay 9R4, armature and back contact of relay 9R5, contact and upper armature of relay 9R4, conductor 941, through the winding of relay 8R2, to grounded battery and relay 8R2 operates. Relay 8R2, upon operating, (1) closes at its outer lower armature and contact an operating circuit for relay 8—ON which operates and locks in a circuit traceable over its No. 4 armature and contact to ground at the back contact and armature of relay 8D1; and (2) closes at its inner lower armature and contact an operating circuit for relay 8—OC, which operates. Relay 8—ON, upon operating, connects ground at its Nos. 1 and 2 armatures to circuits adapted to energize certain windings of the repeater relay 9R, the circuit closed at the No. 1 armature being traceable over conductor 832 and then over two parallel paths, respectively traceable over resistors 929 and 930. The path over resistance 929 is further traceable over resistors 942 and 943, through winding No. 2 of relay 9R, through a noise-killer network including resistance 923, retardation coil 920, to grounded negative battery at the marking contact and armature of relay 9S. The path over resistance 930 is traceable through resistances 945 and 946, the No. 5 winding of relay 9R, through a noise-killer network including retardation coil 924 and resistance 925 to ground. Also relay 8—ON, upon operating, (1) completes at its No. 5 armature and contact the energizing circuit for the filament of vacuum tube 819 and the filament lights; (2) connects at its No. 3 armature and contact a ground connection to the future operating circuit of relay 8SL; and (3) closes at its No. 6 armature and contact a point in a path which is now open at the inner upper armature and contact of relay 8R2, the path being traceable over the inner lower armature and contact of relay 8RC, back contact and middle lower armature of relay 8SL1, conductor 833 to the sequence circuit where at the right-hand armature and back contact of relay 13BO it divides into two other paths one extending over conductor 1321, resistance 1322, through the winding of relay 13ST2, to grounded battery and the other extending over the back contact and left-hand armature of relay 13DL, call-disconnect lamp 1301, conductor 1309, through the winding of relay 14E, to grounded battery. Relay 8—OC, upon operating, connects at its outer lower armature and contact a ground connection to a path extending over conductor 816, through the trunk sequence circuit, where the path is traceable through the winding of trunk advance relay 13AD, to grounded battery, and relay 13AD operates to remove the selected trunk from the sequence circuit chain and to condition for use the next idle trunk.

At the end of the ringing period relays 9R1, 9R4 and 8R2 release and ground from the back contact and inner upper armature of relay 8R2 completes the circuit hereinbefore traced over conductor 833 to seize the sequence circuit and operate relays 13ST2 and 14E. Relay 14E, upon operating, closes an alarm circuit wherein lamp 1409 lights and if the call is at night, cut-off key 1403 will be in its normal position and relay 14F operates. Relay 14F, upon operating, closes at its armature and contact a buzzer circuit extending through buzzer magnet 14D—MGT, lamp 1411 to a source 1412 of continuous ringing current and the buzzer magnet 14DMGT operates to give an audible signal to the attendant at the concentrating unit switching center. Relay 13ST2, upon operating, closes at its armature and contact a circuit extending from ground, conductor 1323, contact and armature No. 1 of relay 3G, conductor 321, contact and outer left-hand armature of relay 13BOX, through the winding of relay 13TA, to grounded battery, and relay 13TA operates and locks in a circuit traceable over its inner right-hand armature and contact to ground at the armature and contact of relay 13ST2. Relay 13TA, upon operating, opens at its inner left-hand armature and back contact the circuit for operating the subscriber cut-in relay 3SC, to prevent the establishment of a call originating at a subscriber station; (2) closes at its inner left-hand armature and front contact an operating circuit for relay 13TC, the circuit being traceable from grounded battery, through the winding of relay 13TC, front contact and inner left-hand armature of relay 13TA, conductors 1310 and 1311, to ground at the closed contact of manual service key 301; and (3) connects ground at its outer right-hand armature and front contact to conductor 1608, which extends to the contact and upper armature of relay 16A1 which at this time is unoperated. Relay 16A1 is the start relay for the motor of the start-stop distributor in the director circuit and the grounded conductor 1608 serves as a locking circuit for the motor start relay when the latter is operated.

Relay 13TC, 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. 3. 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 13TC will extend conductors 1321 and 1324 to conductors 1325 and 1326, respectively. The ground on conductor 833 when relay 8R2 released is now extended over conductors 1325 and 322, in series, contact and armature No. 1 of relay 3GA, conductor 323, through the winding of relay 3U1, to grounded battery and relay 3U1 operates. Relay 3U1, upon operating, closes at its front contact and inner lower armature a locking circuit for itself, the circuit extending over conductor 310, left-hand armature, back contact and right-hand winding of relay 3GB, through the winding of relay 3GF, conductor 324, to ground at the back contact and left-hand armature of relay 14D. Relay 3GB operates over a circuit traceable over its left-hand winding. Relay 3GB, upon operating, operates relay 3GC which, in turn, operates relay 3GA. Relay 3GB, upon operating, causes the release of relays 3GF and 3GE, successively. Relay 3GE,

upon releasing, causes lamp 325 to light indicating that the sequence circuit is busy. The release of relay 3GE also causes slow-to-release relay 3GD to operate. Relay 3GD, upon operating, connects ground at its right-hand armature to a circuit traceable over conductors 317 and 318, contact and middle upper armature of relay 3UI, conductor 1326, No. 2 armature and contact of relay 13TC, conductor 1324, through the winding of director circuit relay 13DC, to grounded battery and relay 13DC operates. Also relay 3GD, upon operating, closes at its outer left-hand armature and contact a point in the operating circuit of relay 14LS1, but inasmuch as relay 3SC is unoperated at the time, relay 14LS1 does not operate and consequently relay 14H does not operate on a call originating at the central office.

Relay 13DC, upon operating, (1) places ground at its contact and outermost left-hand armature on conductor 1304 for operating director start relay 16A and relay 16A operates; (2) connects transmission conductors 1302 and 1303 of the director circuit to conductors 811 and 813, respectively, of the trunk circuit; (3) connects at its innermost left-hand armature and contact, the left-hand winding of relay 13BO to a circuit extending in parallel paths over conductor 1624 and alarm conductor 1325, respectively; (4) connects at its innermost right-hand armature and contact a ground connection to a path which extends over conductor 1326, contact 834, through the winding of relay 8W, to grounded battery, relay 8W operating for a purpose to be hereinafter described; (5) connects at its middle left-hand armature and contact, an additional ground for locking relay 3GD. Ground connected to conductor 1326 which leads to the trunk circuit causes through the operation of relay 8W, the operation of selecting magnets, such as 2SM—2 of the cross bar switch shown, of the link circuit. The operation of the selecting magnet 2SM—2 to 2SM9 and also that of selecting magnet, magnets 2SM—0 and 2SM—1 connect ground at the armatures and contacts of these magnets to conductor 266 which extends to grounded battery through the winding of relay 14D and relay 14D operates. In this case relay 14D, upon operating, causes connection lamp 1408 to light, and supplies an additional holding ground for relay 3GD.

Director circuit.

When the selected trunk at the concentrating unit switching center receives permission to route the call through the switching center, the sequence circuit connects the director circuit to the particular, or selected, trunk. The inward transmission path from the trunk circuit is in marking condition and by means of the contact and armature of gate relay 8G, is connected to conductor 811 which extends over the contact and outermost right-hand armature of relay 13DC, conductor 1302, normally closed contacts of jack 1601, conductor 1602, through the upper winding of relay 16G, to ground. The outward transmission path to the trunk includes conductor 1303, middle right-hand armature and contact of relay 13DC, conductor 813, upper windings, in series, of relays 8G and 8GI, to grounded battery 812. The sequence circuit, upon seizing the director circuit, placed ground, as hereinbefore stated, on conductor 1304 which caused the operation of relay 16A. Relay 16A, upon operating, (1) operates relay 16A1; (2) removes at its outer lower armature and back contact the ground connection from the grid element of vacuum tube 1617; (3) closes at its outer upper armature and contact an operating circuit from ground, outer upper armature and back contact of relay 16C1, outer upper armature and contact of relay 16A, through the winding of relay 16A2, to grounded battery and relay 16A2 operates; (4) supplies a future locking ground for relays 16T1 and 16TB as will be hereinafter described; (5) supplies at its outer lower armature and front contact a ground connection to (*a*) a path extending over conductor 1637, armature and back contact of relay 16C, conductor 1625, contact and outermost lower armature of relay 16LU, conductor 1626, normally closed contacts 1511, conductor 1522, through the winding of start magnet 1501, to grounded battery, conductor 1626 also furnishing ground for the unoperated receiving contacts 1505 to 1509, (*b*) to conductor 1627 which extends through the lower winding of relay 16G, to grounded battery 1628, the current in the lower winding tending to bias relay 16G to its spacing, or left-hand, position, (*c*) to conductor 1629 to the normally opened contacts 1510 which are in engageable relation with stop cam 1524, (*d*) to the potentiometer formed by resistances 1534 and 1535, which is later used in operating the relays 15R1 to 15R5, (*e*) to the upper winding of relay 15R6 which biases this relay to its spacing, or left-hand, contact and (*f*) to the front contact at the lower armature of relay 16C1 which contact when closed is later used to start the director ready signal. Relay 16A1, when operated, closes at its inner lower armature and contact, an operating circuit for the distributor motor, the circuit being traceable from grounded battery 1630, resistance 1604, inner lower armature and contact of relay 16A1, conductor 1631, field winding 1530, motor 1531, resistances 1503 and 1532, to ground and the governor contacts 1533 which are closed while the motor is coming up to speed. Relay 16A1, upon operating, performs other functions, namely, (1) closes a locking circuit for itself extending over the upper armature and contact, conductor 1608, to ground at the outer right-hand armature of relay 13TA 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, through the armatures of relays 15R1 to 15R5 which permits these relays to lock in either direction in which they may be operated, the circuit being traceable over conductor 1632. While the motor is attaining speed, the distributor cams are operating to cause brief closure of each receiving contact, in turn, the contacts being designated 1505 to 1509, respectively. Relays 15R1 to 15R5 will therefore operate and lock in the spacing, or right-hand, direction due to these closures to ground.

The spacing locking paths of relays 15R1 to 15R5 are through the winding of relay 15J and their respective No. 3 windings. Therefore relay 15J will operate as soon as any one of relays 15R1 to 15R5 operates to spacing. Relay 15J, upon operating, opens the operating path of relay 15F preventing its premature operation. Meanwhile relay 16A2, upon operating, has, in effect, placed the sensitive slow-to-release relay 16B across the governor contacts 1533, prepared in advance a path for operating the fast-operating relay 16C, and has opened at its outer lower armature and contact a future operating circuit extending from the armature of relay 16G, to the distributor contacts.

When full speed is reached the governor con-

tacts open momentarily removing the short circuit from resistance 1503 of relatively high value and allowing relay 16B to operate through resistances 1504 and 1605. Relay 16B being of the slow-releasing type, with the help of condenser 1606 holds over governor contact closures thus operating relay 16C as soon as the "stop pulse" contacts 1510 close at the end of each character signal received.

Relay 16C, upon operating, removes ground from the receiving contacts 1505 to 1509 and start contacts 1511 whereby start magnet 1501 releases, latching the clutch and preventing further operation of the contact cams. Relay 16C, upon operating, locks in a circuit traceable from grounded conductor 1637, armature and front contact and lower winding of relay 16C, through the winding of relay 16C1, conductor 1633 to grounded battery 1628 and relay 16C1 operates. Relay 16C1, 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 1637, contact and lower armature of relay 16C1, normally closed make-before-break contact of relay 16N3, conductor 1303, middle right-hand armature and contact of relay 16DC, conductor 813, through the upper windings, in series, of relays 8G and 8G1, to grounded battery 812. Relays 8G and 8G1 operate, relay 8G 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. Relay 16C1, in operating, also (1) connects at its inner upper armature and contact the armature of relay 16G to a circuit extending over the distributor receiving contacts 1505 to 1509 and start contacts 1511 which circuit is opened at the outer lower armature and contact of relay 16A2 preparatory to receiving the pulses from the loop repeater; (2) opens at its outer upper armature and back contact, the operating circuit for relay 16A2 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 15R6. Relay 16A2, upon releasing, removes relay 16B from the governor contacts, completes the circuit from the armature of relay 16G to the receiving contacts 1505 to 1509 and starting contacts 1511 and transfers the stop pulse contacts 1510 from the upper winding of relay 16C to the operating, or lower, winding of relay 15R6 preparatory to receiving pulses from the loop repeater. After the "director ready" signal is sent the following relays are held operated, 16A, 16A1, 16C, 16C1, 15J, and relay 16G is held operated to its marking, or right-hand, position and relays 15R1 to 15R5 to spacing, or right-hand, positions. The circuit is now prepared to receive pulses from the central office.

Receipt of director ready signal at central office

At the concentrating unit switching center the reception of the ringing current transmitted from the central office has conditioned the equipment at the concentrating unit switching center for the receipt of the call and has established connection to a director circuit. This places a negative potential on the concentrating unit switching center end of the trunk.

The negative potential, or marking condition, on the trunk at the concentrating unit switching center is received over transmission conductor 901 of the trunk circuit to operate relay 11—C in a circuit which extends over the normally closed tip contacts of jack 1005, conductor 1015, the normally closed tip contacts of jack 1006, conductor 1016, upper armature and back contact of relay 10—E, through the winding No. 1 of relay 10—P, through winding No. 1 of relay 11—R, resistance 1105, retardation coil 1106, through the upper winding of relay 11—C, upper armature and back contact of relay 11—C1 to ground. Relay 11—C, upon operating, closes an operating circuit for relay 10—H, the circuit being traceable from grounded battery 1109, conductors 1110 and 1017, resistance 1018, conductors 1019 and 1020, armature and contact of relay 11—C, conductor 1117, resistance 1021, through the winding of relay 10—H, conductor 1022, to ground at the armature and marking contact of relay 10—P and relay 10—H operates. Relay 10—H, upon operating, closes at its armature and contact an operating circuit for relay 11—C1 which operates. Relay 11C1, upon operating, removes at its outermost lower armature and back contact the ground connection from the ring conductor of jack 1124 and thereby causes relay 12SC of the cord circuit to release. Relay 12SC, upon releasing, extinguishes supervisory lamp 1206 as an indication to the operator that she may send the selective pulses for selecting the desired subscriber station connected at the concentrating unit switching center. Relay 11—C1, upon operating, also transfers the transmission circuit at its upper armature from ground at the back contact to ground connected through the marking, or right-hand, contact and armature of relay 11—S and front contact of relay 11—C1. Relay 11—C1, upon operating, also connects ground at its innermost lower armature and contact, for condenser 1138 and grid element of tube 1119, via the middle upper armature and front contact of relay 11—CL which at this time is in an operated condition, and the vacuum tube 1119 is thereby held inactive. Relay 11—C1, upon operating, also closes at its outermost lower armature and front contact an operating circuit for relay 10—C2, the circuit being traceable from grounded battery, through the winding of relay 10—C2, conductor 1024, front contact and outer lower armature of relay 11—SL, coiductor 1125, to the front contact and outermost lower armature of relay 11—C1. The operator then sends pulses representing, first, "figures," and then the listed code number of the desired subscriber 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 station in a conference circuit. The description to immediately follow applies to a direct connection and therefore the subscriber station number will be identified as the listed number.

Receipt of code pulses at the concentrating unit switching center

The operator at the central office sends pulses representing the preliminary signal "figures" followed by the two digits of the called subscriber station listed number. These pulses are received over the transmission conductor 901 of the trunk circuit, normally closed tip contacts of jack 938, conductor 939, normally closed tip contacts of jack 930, conductor 940, outer lower armature and front contact of relay 9TR, conductor 934, through

the No. 3 winding of relay 9R, through the armature and marking, or left-hand, contact of relay 9S, to grounded battery 932. Relay 9R, upon operating, repeats the incoming pulses over conductor 824, armature and contact of relay 8G which at this time is in its operated, or right-hand, position, conductor 811, contact and outermost right-hand armature of relay 11—DC, conductor 1302, normally closed tip contact of jack 1601, conductor 1602, to the upper winding of relay 16G to ground. The director in conjunction with the sequence circuit decodes the pulses and prepares to make connection to the required subscriber 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 813 and therefore repeated by relay 8G and 8G1, and then by relay 9S of the repeater to the transmission conductor 901 of the trunk and eventually appears on the operator's teletypewriter at the central office. Relay 8G1 follows these pulses but relay 9TR which is controlled by relay 9G1 has sufficiently low release characteristics to remain operated.

Receipt of incoming code pulses in the director circuit

The incoming code pulses received over transmission conductor 901 of the trunk circuit are repeated by relay 16G which is normally held to its marking, or right-hand, contact. The distributor motor (Fig. 15) is running but the receiving contacts 1505 to 1509 are not operated because the stop magnet 1501 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 16G to its spacing, or left-hand, position, thereby closing a circuit extending from grounded battery, through the winding of start magnet 1501, conductor 1522, normally closed start contacts 1511, conductor 1626, outermost lower armature and back contact of relay 16LU, conductor 1625, contact and outer lower armature of relay 16A2, inner upper armature and front contact of relay 16C1, conductor 1634, armature and spacing contact of relay 16G, conductor 1635, contact and outer upper armature of relay 17N, conductor 1715, and 1637, to ground at the front contact and outer lower armature of relay 16A, start magnet 1501 operates and therefore the cams 1523 to 1529 begin rotating under the control of the distributing motor. The motor speed and receiving contacts 1505 to 1509 are adjusted so that at the time the first selecting pulse (marking) of the character is received from relay 16G, contacts 1505 are closed to complete a circuit extending from point 1536 in the potentiometer comprising resistances 1534 and 1535, conductor 1537, through winding No. 1 of relay 15R1, conductor 1538, closed contact 1505, conductor 1626, outermost lower armature and contact of relay 16LU, conductor 1625, contact and outer lower armature of relay 16A2, inner upper armature and contact of relay 16C1, conductor 1634, to the armature of relay 16G. If the first selecting pulse is marking, relay 15R1 will operate and lock to its marking, or left-hand, contact. Similarly, relay 15R2 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 16G	Register relay	Fan relay operated
1	Marking	(15R1) marking	Relay 15D1.
2	do	(15R2 marking	Relay 15D2.
3	Spacing	(15R3) spacing	
4	Marking	(15R4) marking	Relay 15D4.
5	do	(15R5) marking	Relay 15D5.

With relays 15R1 to 15R5 operated as above, it will be noted that none of the locking paths of these relays pass through the winding of relay 15J, but if any one is operated, in the reverse direction, relay 15J will be energized. Relay 15J 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 1510 are momentarily closed by cam 1524 and start contacts 1511 are momentarily opened by cam 1523. When start contacts 1511 are opened, start magnet 1501 releases. A momentary closure of contact 1510 at the time the stop pulse is received by relay 16G, a circuit is closed from battery 1539, resistances 1540 and 1541, through the lower winding of relay 15R6, conductor 1542, back contact and outer upper armature of relay 16A2, conductor 1636, closed contact 1510, conductors 1629 and 1637, front contact and outer lower armature of relay 16A, to ground and relay 15R6 operates to its marking, or right-hand, contact, overcoming the effect of the biasing current flowing in the upper winding. The charge on timing condenser 1512 causes relay 15R6 to remain in its marking, or right-hand, position for .030 second after the stop pulse contacts 1510 open, the discharge circuit extending from ground at the outer lower armature and front contact of relay 16A, conductors 1637, 1629 and 1543, through the upper and lower windings, in series, of relay 15R6 through conductor 1512 to ground. This allows time for the operation of relay 15F in a circuit which is traceable from grounded battery, through the winding of relay 15F, armature and contact of relay 15J, back contact and upper armature of relay 15K, marking contact and armature of relay 15R6, conductor 1513, back contact and upper armature of relay 17R, conductor 1702, front contact and outer upper armature of relay 16C1 to ground. Relay 15F operates and locks to ground over conductors 1544 and 1518, to ground at the front contact and outer upper armature of relay 16C1. Relay 15F, upon operating, prepares a path for operating relay 15K when relay 15R6 returns to its spacing, or left-hand, contact. In this way relay 15K operates and locks to ground over conductor 1518 to ground at the front contact and outer upper armature of relay 16C1 and transfers the marking contact of relay 15R6 from the contact and armature of relay 15J to conductor 1722 which is connected for the succeeding counting relay, in preparation for the registration of the next two digits, that is, the two digits of the called subscriber station listed number.

The reception of "figures" has therefore set up a combination of relays 15R1 to 15R5 locking direct to grounded battery instead of through the winding of relay 15J thereby releasing relay 15J 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 16A, 16A1, 16C, 16C1, 15D1, 15D2, 15D4, 15D5, 15F, 15K; relays 16G, 15R1, 15R2, 15R4, 15R5, are in their respective marking positions; relays 15R3 and 15R6 are in their respective spacing positions. The operation of relays 15D1, 15D2, 15D4, and 15D5 performs no useful function at this time.

Reception and deciphering of the first and second digits

The first digit of the called subscriber's listed number will be repeated by relay 16G, broken up pulse by pulse by the distributor contacts and recorded by relays 15R1 to 15R5 in much the same manner as the "figures" character was received. Relay 15R1 is operated in accordance with the position of relay 16G at the middle of the first pulse, relay 15R2 according to the second pulse, etc. In each case the operating, or No. 1, winding of each of relays 15R1 to 15R5 can quickly overcome its associated holding windings No. 2 or 3, but otherwise these relays hold in whichever direction they are operated under control of motor start relay 16A1.

Assume that the listed number of the called subscriber's station is No. 12, the operation resulting from the reception of No. 1 will be herein described first and the order of the received pulses constituting the character No. 1 are marking, marking, marking, spacing and marking. In accordance with the description hereinbefore given, relay 15R1 will be in its marking, or left-hand, position, relays 15R2 and 15R3 will also be in their respective marking, or left-hand, positions, relay 15R4 will be in its spacing, or right-hand, position and relay 15R5 will be in its marking, or left-hand, position. With relay 15R1 in its marking position, a circuit is closed from ground at the outer lower armature and contact of relay 16A1, conductor 1632, armature and marking contact of relay 15R1, through the winding of relay 15D1 to grounded battery and relay 15D1 operates. In a similar manner relays 15D2, 15D3 and 15D5 are operated. At the conclusion of the reception of the code elements of the No. 1 signal, relay 15R6 again operates to its marking, or right-hand, position and is again held for an additional period of .030 second. Relay 15R4 which is operated to its spacing, or right-hand, contact in response to the fourth pulse of the No. 1 digit, closes a circuit for operating relay 15J but, as hereinbefore stated, performs no useful function after the "figures" character has been received. At the conclusion of the reception of the code elements of the particular character transmitted, relay 15R6 again operates to its marking position and is again held for an additional period of .030 second. Relay 15R6, in operating, to its marking contact causes the operation of relay 17L in a circuit traceable from grounded battery 1701, through the lower winding of relay 17L, back contact and lower armature of relay 17M, conductor 1722, front contact and upper armature of relay 15K, marking, or right-hand, contact and armature of relay 15R6, conductor 1513, back contact and upper armature of relay 17R, conductor 1702, to ground at the outer upper armature and front contact of relay 16C1. Relay 17L operates and locks up to ground furnished by relay 16C1. Relay 15R6 also furnishes ground over the normal contacts of relays 17M, 17N1, 17R and 16LU to the armature of relay 15D5. From the armature of relay 15D5 the grounded circuit is fanned out by means of the combination of operated and/or unoperated fanning-out relays 15D1 to 15D5 to one of ten conductors designated 0 to 9. Each of the conductors 0 to 9 is arranged by means of cross-connection blocks 1514 and 1515 to operate a relay, such as relay 15H representing the tens group in which the desired subscriber's station may be found, the operating circuit for relay 15H being traceable from grounded negative battery, through the winding of the relay, armature and contact of relay 15K1, one of the conductors designated 0 to 9, for example, say conductor No. 1 which represents the tens group in which the called subscriber's station No. 12 is located, front contact and armature No. 5 of relay 15D1, front contact and innermost lower armature of relay 15D2, front contact and outer upper armature of relay 15D3, back contact and outer upper armature of relay 15D4, front contact and lower armature of relay 15D5, conductor 1516, back contact and middle lower armature of relay 16LU, conductor 1607, outer lower armature and back contact of relay 17R, lower armature and back contact of relay 17N1, back contact and lower armature of relay 17M, conductor 1722, front contact and upper armature of relay 15K, marking contact and armature of relay 15R6, conductor 1513, back contact and upper armature of relay 17R, conductor 1702, to ground at the front contact and outer upper armature of relay 16C1. Thus relay 15H, upon operating, limits selection of the desired subscriber's station to one of those in the first group of ten stations, in other words, the operated relay corresponds to the tens group of the particular called subscriber line. Relay 15H, upon operating, locks in a circuit traceable from its lower armature and contact, conductors 1517 and 1518 to ground at the outer upper armature and front contact of relay 16C1, this locking circuit also serving to operate and lock relay 15K1. Relay 15K1, upon operating, definitely removes any H relay, such as relay 15H, from its associated conductor of conductors Nos. 0 to 9. Relay 17L, upon operating, prepares a path for the operation of relay 17M. When relay 15R6 returns to its spacing contact after .030 second, relay 17M will operate, close a circuit extending from ground at the outer upper armature and front contact of relay 16C1, conductor 1702, upper armature and front contact of relay 17M, conductor 1703, front contact and inner left-hand armature of relay 15K1, front contact and upper armature of relay 15H, conductor 1518, through the winding of relay 15H1, to grounded battery. Relay 15H1 is associated with the particular tens group in which the desired, or called, subscriber line is found. Relay 15H1, upon operating, connects the fanning-out conductor No. 1 of the corresponding conductors Nos. 0 to 9 to the particular tens group of the called subscriber station. The other relays corresponding to relay 15H1 and respectively associated with the other tens groups are prevented from operating during the time that one of the tens group relay, such as relay 15H1, is operated. Relay 17M, upon operating, (1) locks to ground on conductor 1702; (2) opens the operating paths of relays 17L and 15H and prepares an operating path for relay 17N. Relays 17L and 15H, however, remain operated over their locking circuits. After the first digit has been received the following relays are operated: 16A, 16A1, 16C, 16C1, 15F, 15K, 17L, 17M, 15H, 15K1, and 15H1. Relay 16G is in its marking position and relay 15R6 is in its spacing position. Relays

15R1 to 15R5 and 15D1 to 15D5 are operated according to the character just received.

The second digit of the called subscriber station 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 the received pulses constituting the character No. 2 is marking, marking, spacing, spacing and marking. The fanning-out relays 15D1, 15D2 and 15D5 operate in accordance with the combination set up on the registering relays 15R1 to 15R5. Relay 15R6 operates to its marking position, while start magnet 150 is operated and thereby causes the operation of relay 17N, the circuit being traceable from grounded battery, through the winding of relay 17N, front contact and lower armature of relay 17M, conductor 1722, front contact and upper armature of relay 15K, marking contact and armature of relay 15R6, conductor 1513, back contact and upper armature of relay 17R, to grounded conductor 1702. Relay 17N, upon operating, (1) opens the circuit of the spacing contact of relay 16G to prevent any additional incoming pulses from being registered; (2) locks to ground on conductor 1702; (3) opens the operating path of relays 17M and 15H1 and prepares a path for the operation of relay 17N1. When relay 15R6 returns to its spacing, or left-hand, position, it causes the operation of relay 17N1. Relay 17N1, upon operating, closes a path extending from grounded battery, through the windings, in series, of out-of-order relay 17—OO and busy relay 17BY, front contact and lower armature of relay 17N1, back contact and outer lower armature of relay 17R, conductor 1607, middle lower armature and back contact of relay 16LU, conductor 1516, lower armature and contact of relay 15D5, outer upper armature and back contact of relay 15D4, outer upper armature and back contact of relay 15D3, outermost upper armature and front contact of relay 15D2, No. 3 armature and contact of relay 15D1, to conductor No. 2 of the conductors Nos. 0 to 9, armature No. 2 and contact of relay 15H1 which remains operated in its locking circuit, conductor 1545, normally closed contacts at the ring spring of jack 207, conductor 211, inner upper armature and back contact of relay 4C, conductor 253, through the winding of "hold" magnet 2H2, to grounded battery. "Hold" magnet 2H2 corresponds to the line extending to called subscriber station 102, the call number of which is assumed to be No. 12. Also, relay 17N1, upon operating, closes at its upper armature and contacts the operating circuit of slow-acting relay 17N2 which operates. It will be noted that as usual the registration relays 15R1 to 15R5 remain locked in the direction in which they were last operated.

Testing the called subscriber line

The connection of battery, through relays 17—OO and 17BY to the particular called subscriber line enables these two relays to determine if conductor 253 to the hold magnet of the called subscriber line is terminated in a direct ground, which causes the operation of both relays 17—OO and 17BY, 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 a jack, say jack 208, of the called subscriber line, which results in the operation of relay 17—OO only. In case no ground is available neither of the relays 17—OO and 17BY operate. This test takes place during the slow-operating time of relay 17N2, which, as indicated above, begins to operate when relay 17N1 operates. As soon as relay 17N2 operates, the off-normal ground on the front contact and outer upper armature of relay 16C1 is connected in a circuit extending over conductor 1702, armature and front contact of relay 17N2 to the armature of relay 17—OO. Assume that the called subscriber line is idle in which case ground is not connected to conductor 253, relay 17—OO will be unoperated and ground connected to its armature by the operation of relay 17N2 will cause the operation of relay 17R. Relay 17R, upon operating, (1) removes relays 17—OO and 17BY from conductor 253 of the called subscriber line and replaces them by relay 17S; (2) causes the release of relay 17N1 by removing ground, the ground being furnished over conductor 1702 which is connected to its upper armature; (3) prepares an operating circuit for relay 17U; and (4) locks to grounded conductor 1702. Relay 17N1, upon releasing, causes relay 17N2 to slowly release. During the time that relays 17N1 and 17N2 are releasing, ground at the outer right-hand armature and contact of relay 14D is connected to a circuit extending through resistance 1401, conductors 1402 and 1305, outer left-hand armature and contact of relay 15K1, conductor 1521, through the winding of relay 17S, front contact and outer lower armature of relay 17R, conductor 1607, middle lower armature and contact of relay 16LU, conductor 1516, lower armature and contact of relay 15D5, outer upper armature and back contact of relay 15D4, outer upper armature and back contact of relay 15D3, outermost upper armature and front contact of relay 15D2, No. 3 armature and front contact of relay 15D1 to conductor No. 2 of conductors Nos. 0 to 9, and as hereinbefore traced over conductor 253, through the winding of "hold" magnet 2H2 to grounded battery. Under the assumed condition of the called subscriber line being idle, grounded battery on the winding of "hold" magnet 2H2 of the cross bar switch in the link circuit permits relay 17S to operate but due to the high resistance of the circuit the "hold" magnet 2H2 remains unoperated. Relay 17S, upon operating, opens the operating circuit of relay 17U, and closes an operating circuit for relay 17S1 which operates in a circuit traceable over the armature and back contact of relay 17N2. Relay 17S1, upon operating, locks over grounded conductor 1702; (2) short-circuits the winding of relay 17S and (3) holds open the operating circuit for relay 17U. With the winding of relay 17S short-circuited the ground at the outer right-hand armature and contact of relay 14D which is connected to the circuit, hereinbefore traced, is now effective to cause the operation of hold magnet 2H2 which operates to move its vertical row of contact sets into engagement with their respectively associated sets of horizontal conductors, the set of horizontal conductors associated with the selected trunk 801 having already been moved into its operated position by the operation of selecting magnet 2SM—2, the called subscriber line will, therefore, be connected at contact set 255 to the trunk circuit 801 which will function to release the sequence circuit. The sequence circuit in turn will function to remove the ground from conductor 1304 to release relay 16A, upon releasing, removes ground from the various parts of the circuit including relays 16C and 16C1, and releasing relay 16A1 unless conductor 1608 is connected to ground at relay 13TA, indicating that another inward call is awaiting com-

pletion. Relay 16C1, upon releasing, removes locking ground from a considerable part of the director circuit. If relay 16A1 releases, the motor will be stopped and all remaining parts of the circuit will be deenergized. If, however, relay 16A1 is held operated, the motor is kept running and relays 15R1 to 15R5 and the associated fanning-out relays 15D1 to 15D5 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 16B now operates immediately since the motor is running at full speed and relays 16C and 16C1 follow in operating at once, upon receiving a closure of the "stop" pulse contact 1510 of the start-stop distributor. Before the stop pulse is received relays 15R1 to 15R5 may be operated to spacing through the back contacts of relay 16C, 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 16N1 connects relays 17—OO and 17BY to conductor 253 of the called subscriber line circuit. At this time, however, conductor 253 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 line, the jack corresponding to jack 208 of subscriber line circuit 202. The direct ground established by a busy condition may be traced over conductor 1545, normally closed contacts at the ring spring of jack 207, conductor 211, upper armatures and their respective contacts of relay 4C, conductor 405, sleeve contacts of the operated set 255, conductors 256, 257, and 820, through the winding of low resistance sleeve relay 8SL, conductor 821, to ground at the innermost upper armature and contact of relay H—ON. In either case of busy condition, relay 17—OO quickly operates but relay 17BY is marginal and operates only on direct ground. Relay 17—OO, upon operating, prevents relay 17R from operating and, therefore, relay 17N1 remains operated keeping relays 17—OO and 17BY connected to conductor 405. Relay 17—OO, therefore, remains operated along with relays 17N, 17N1 and 17N2 and also operates relay 16N3. Relay 16N3, upon operating, (1) applies at its upper armature and contact ground to start the production of "K" or "Q" characters by relays 16P and 16P1 as hereinafter described, (2) connects the contacts of relay 16P1 to the outward transmission path, the connection being established over its outer lower armature and front contact and extending over conductor 1303. Relays 16P and 16P1 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 1704, 1609 and 1610, relay 16P will operate to its spacing, or left-hand, contact due to current flowing in its upper winding. When the armature of relay 16P is in its left-hand position, the current in the upper winding of the relay is reversed but the discharging of condenser 1644, through the lower winding of the relay holds the relay to its spacing, or left-hand, contact 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, contact. Here the process is repeated, the upper winding of relay 16P tending to make the relay armature return to its spacing contact while condenser 1644, in charging, holds it to its marking, or right-hand, contact until their effect is overcome. The condenser and potentiometer resistances are so proportioned that relay 16P will pulse at about 9 cycles per second if resistance 1609 is in the circuit or 11 cycles per second if resistance 1609 is short-circuited. As will be seen hereinafter, if the line were busy, relay 17BY, upon operating, would cause "K" signals to be sent; if out of order the relay 17BY is released and "Q" signals will be sent.

When ground is connected by relay 16N3, relay 16P1 will operate to its marking, or left-hand, contact, 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 8G and 8G1, respectively. However, when relay 16P opens its marking, or right-hand, contacts condenser 1615 will charge through the lower winding of relay 16P1 to cause relay 16P1 to leave its marking, or left-hand, contact for one pulse length (approximately .022 second), the charging originating in grounded battery 1709 and extending through resistances 1710 and 1711 and over conductor 1716. Relay 16P1 then returns to its marking, or left-hand, contact and after relay 16P operates to its marking, or right-hand, contact, condenser 1615 is discharged through resistance 1616. Since relay 16P is pulsing continuously, relay 16P1 will send out a spacing pulse of .022 second every time relay 16P opens its marking, or right-hand, contact. In this way relay 16P drives relay 16P1 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 one 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 17S is connected to the circuit extending over conductor 1521, outer left armature and contact of relay 15K1, conductors 1305 and 1303 as hereinbefore traced when testing a particular called subscriber line for an idle condition, grounded battery on the winding of hold magnet, such as hold magnet 2H1, for a subscriber line station 101 is not available and relay 17S fails to operate. When, therefore, relay 17N2 releases, off-normal ground will be connected to the winding of relay 17U causing relay 17U to operate. Relay 17U, upon operating, closes at its inner lower armature and front contact an operating circuit for relay 16N3, causing ground through the operation of relay 16N3 to be connected to relays 16P and 16P1 and associated apparatus as hereinbefore described, and disconnects resistance 1713 which was in parallel connection with resistance 1714. Resistance 1704 is in the circuit inasmuch as its shunt around the outer lower armature and contact of relay 17U has been opened. Under these conditions relay 16P operates at approximately 6 cycles per second. When relay 16P operates to its spacing, or left-hand, position, relay 16P1 is operated to its spacing, or right-hand, position for two pulse lengths, that is, 0.044 second, by a charging condenser 1615. Relay 16P1 upon returning to its marking, or left-hand, position,

remains in that position until relay 16P again operates to its spacing, or left-hand, position. Thus, a "V" or ⅜ character is generated and transmitted to the operator's teletypewriter at the distant central office.

When the director circuit times out

When the director circuit was first seized the operation of relay 16A removed at the outer lower armature and back contact of the relay a ground connection from the grid of vacuum tube 1617 thereby permitting condenser 1618 to start charging from grounded battery 1619, through resistances 1620, 1621 and 1622. If a call is not completed and the director circuit dismissed within a ten-second period the charge on condenser 1618 and thus the voltage on the grid of vacuum tube 1617 is of such value that the plate current operates relay 16T which, in turn, operates relay 16T1. Relay 16T1, upon operating, (1) transfers transmission conductor 1603 from its back contact of No. 5 armature to its front contact of No. 4 armature so that the transmission conductor is now connected to the marking, or right-hand, contact of relay 16P, instead of to the marking, or left-hand, contact of relay 16P1; (2) operates relay 16N3; and (3) removes the shunt from resistances 1609 and 1611. Relay 16P with the resistance change in its upper winding operating circuit, pulses at approximately an eight-cycle rate, the charge and discharge of condenser 1614 holding the armature of relay 16P on its marking, or right-hand, contact 0.132 second and on its spacing or left-hand contact 0.110 second. Thus the signal generated by relay 16P 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 one second.

Signal limiting feature

Busy, or out-of-order, unassigned and director timed-out signals are all limited to one second as mentioned above. The operation is as follows: When relay 16N3 operates, ground is connected to a winding of relay 16TA which operates and locks to ground on a contact of relay 16TB. Relay 16TA, upon operating, (1) operates a relay 16TB which locks directly to ground at the inner lower armature and contact of relay 16N3; and (2) connects at its middle upper spring member which is normally open, a ground connection to the grid of vacuum tube 1617 to recycle the vacuum tube in case relay 16T1 has operated. Relay 16TB, upon operating, (1) opens the operating and locking circuits of relay 16TA, (2) removes resistance 1622 from the charging circuit of condenser 1618; and (3) transfers the armature and contact of relay 16T from the winding of relay 16T1 to the contact at the outer lower armature of relay 16TA. Relay 16TA, upon releasing, completes a circuit extending over the contacts and outer lower armature of relay 16TA, conductors 1623 and 1624, innermost left-hand armature and contact of relay 13DC, through the left-hand winding of relay 13B0 to grounded battery. At approximately one second relay 16T operates connecting ground to grounded battery through the left-hand winding of relay 13B0. Relay 13B0, upon operating, locks the trunk out until released at the distant central office and immediately releases the director circuit to restore all relays to normal.

With reference to the registering relays 15R1 to 15R5 being operated in different combinations in accordance with the pulse combination received from the distant central office for the establishment of connections to the local subscriber station lines, the following table shows the relative positions of each of the relays for each character received. "M" indicates marking; "S" indicates spacing.

Character, lower case	Character, upper case	Relay 15R1	Relay 15R2	Relay 15R3	Relay 15R4	Relay 15R5
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

CALL ORIGINATING AT THE CENTRAL OFFICE TO A SUBSCRIBER STATION ARRANGED ON A NON-CONFERENCE BASIS

Hereinbefore was described a connection to subscriber station No. 12 which is shown herein as a station arranged on a conference basis. Now it is assumed that a connection is desired with a station arranged on a non-conference basis, say station 101, the listed number of which is assumed to be No. 11. A call for station No. 11 incoming from the central office will be received by the register relay in accordance with the combinations of spacing and marking pulses corresponding to No. 11. The first and second digits are alike. Therefore, register relays 15R1 to 15R5 will be operated in the same combination for each digit, that is, they will be respectively operated to their marking, marking, marking, spacing and marking positions and accordingly fanning-out relays 15D1, 15D2, 15D3 and 15D5 will be operated. After the pulses of the second digit are received, grounded conductor 1516 will be extended by the fanning-out relays over a path which may be traced over the lower armature and contact of relay 15D5, outer upper armature and back contact of relay 15D4, outer upper armature and front contact of relay 15D3, innermost lower armature and front contact of relay 15D2, No. 5 armature and front contact of relay 15D1, to conductor No. 1. Inasmuch as subscriber line station, the listed call number of which is 11, is in the same group with the station having the listed call number 12, relays 15H and 15H1 will become operated to extend conductor No. 1 of conductors Nos. 0 to 9 over conductor 1546, normally closed contacts at the ring spring of a jack corresponding to jack 207 of subscriber line circuit 202, conductors 218 and 252 through the winding of "hold" magnet 2H1, to grounded battery. Hold magnet 2H1 operates to move the connector switch vertical individual to subscriber station 101 to which the listed No. 11 is assigned so that the contact set, such as set 260, may be moved into engagement with the trunk selected by the operator at the distant central office.

INCOMING CALL FOR THE ESTABLISHMENT OF A CONFERENCE CIRCUIT CONNECTION

The operator at the central office desiring to set up a conference circuit in the concentrating unit switching center uses a trunk extending to the switching center and in the normal way types the special number assigned to the conference. If the conference circuit is in use or, if some

patching cord circuits still remain in any of the subscriber conference branches, the director circuit at the switching center will report the conference circuit busy. If jack 601 of the trunk conference branch is patched to subscriber busy or subscriber out-of-order jacks the director circuit will so inform the operator. If the conference circuit is idle, the link circuit will be ordered to connect it to the trunk which, for purposes of identification, is called herein the conference trunk. By calling for the special number assigned to the conference circuit, the director circuit operates as hereinbefore described to direct the fanning-out relays 15D1 to 15D5 to operate in combinations corresponding to the pulse combinations of the two digits. The conference circuit is in a group with some of the subscriber lines and, therefore, the relays of the particular group, such as relays 15H and 15H1, are operated to extend grounded conductor 1516 over one of the conductors of conductors Nos. 0 to 9 to conductor 1547 terminated on a separate cross-connecting block 1548, inner lower armature and back contact of relay 6AL, conductor 605, normally closed contacts at the ring spring of jack 601, conductor 606, through the winding of "hold" magnet 2HC to grounded battery. The selecting magnet 2SM—2 having been operated in response to the selection of the trunk by the operator, the operation of "hold" magnet 2HC at this time connects conductors 608, 607 and 606 through to the tip, ring and sleeve conductors, respectively, of the selected trunk, say for purpose of illustration, trunk 801. The connection of the trunk is made at contact set 268. The ring conductor 822 of trunk 801 is connected over the operated contact set 268 and the middle armature of "hold" magnet 2HC to conductor 607 which is part of a circuit traceable over the normally closed contacts at the spring of jack 609, conductor 610, through the winding of relay 6R1, conductor 612, resistance 613, conductors 614 and 501, to grounded battery 502. Ground is connected to the upper winding of relay 8SP at the other end of the circuit just traced and, therefore, relay 6R1 operates to close an obvious operating circuit for relay 6—ON. Relay 6R1 operates in series with relay 8SP of the conference trunk, say trunk 801, but the high resistance of the path prevents the operation of relay 8SP. Off-normal relay 6—ON, upon operating, turns power on the conference circuit branches and the conference control circuit and at the same time causes all unlisted numbers to cease testing unassigned. With power on in the conference branches, a mark signal is prepared for transmission to the conference trunk when the tip conductor 266 of conference trunk 801 is closed through, but for the time being only a space signal is received by the conference trunk, which acts as if an ordinary called subscriber has not answered. In automatic ringing offices, ringing is sent out by the conference trunk but reaches nowhere.

Operator reaches a subscriber station by using the unlisted conference number of the desired subscriber station

In order to reach a subscriber station the line of which has been equipped for automatic connection to a conference for the specific purpose of alternately connecting the desired subscriber line to a subscriber conference branch, the operator must call over another trunk, referred to herein as an "order" trunk, typing the unlisted conference number associated with the desired subscriber line. If the desired subscriber line is busy or out of order because of cord circuit patches into jack 407 of the access circuit associated with the desired subscriber line, the director circuit will so inform the operator. If the desired subscriber line is idle, the director will place a resistance ground on a conductor of conductors Nos. 0 to 9, such conductor being that terminating at cross-connecting block 1548 and assumed herein to correspond to the desired subscriber line. The resistance ground is found in a circuit traceable from ground at the outer right-hand armature and contact of relay 14D, resistance 1401, conductors 1402 and 1305, contact and outer left-hand armature of relay 15K1, conductor 1521, through the winding of relay 17S, front contact and outer lower armature of relay 17R, conductor 1607, middle lower armature and contact of relay 16LU, conductor 1516, through the path established by a combination of operated fanning-out relays 15D1 to 15D5 in accordance with the directing pulses for the unlisted conference number of the desired subscriber line, a particular conductor of conductors Nos. 0 to 9 and cross-connected to conductor 1549, normally closed contacts at jack 407, outermost lower armature and back contact of relay 4C, outer lower armature and back contact of relay 4A, through the winding and the make-before-break contacts of relay 4B, conductors 408 and 409, outermost lower armature and back contact of relay 5ST, contact and outer upper armature of relay 5V, conductor 514, through the middle upper armature and contact of relay 6—ON to grounded battery. Relay 4B operates and locks up in its own operating circuit excepting for the outer lower armature and back contact of relay 4A. Relay 4B, upon operating, closes at its outermost lower armature and contact an obvious operating circuit for relay 4B1 which operates. Relay 4B1, upon operating, (1) splits the subscriber ring conductor 603 at its outermost upper armature to bring both ends of the conductor into the control circuit shown in Figs. 5 and 6; (2) extends the subscriber "tip" conductor 402 over the contacts and No. 4 armature of relay 4B1, over conductor 410, resistance 503, through the winding of relay 5T to ground at the upper armature and contact of relay 5H; (3) connects other control conductors from the access circuit to the conference control circuit shown in Fig. 5; (4) closes at its No. 6 armature and contacta circuit traceable over conductor 411, through the winding of relay 5ST, conductors 504 and 513, innermost upper armature and contact of relay 6—ON to grounded battery; (5) closes at its No. 8 armature and contact a circuit traceable from ground at the inner lower armature and back contact of relay 4A, contact and No. 8 armature of relay 4B1, innermost lower armature and front contact of relay 4B, conductors 412 and 413, through the winding of relay 5D, conductor 504, contact and lower armature of relay 5V, conductor 513 to grounded battery at the innermost upper armature and contact of relay 6—ON; (6) prepares at its No. 6 armature and contact a locking circuit for relay 5G. Relays 5ST and 5D operate. Relay 5ST, upon operating, (1) causes all other unlisted conference numbers to again test "unassigned"; (2) removes at its middle lower armature and back contact the ground from the grid element of vacuum tube 505 and at its front

contact and middle lower armature closes a circuit for energizing the filament of vacuum tube **505**; (3) closes at its innermost lower armature and contact a circuit extending from ground, conductor **506**, normally closed contacts of key **701**, conductor **702**, lower armature and back contact of relay **7SL1**, conductor **703**, through the winding of selecting magnet **7SM1** to grounded battery, and selecting magnet **7SM1** operates to prepare the first, or uppermost, idle level of the conference connector switch. Relay **5D**, upon operating, connects a resistance ground to the called subscriber line "hold" magnet, say magnet **2H2**, the operating circuit being traceable from ground at the inner lower armature and back contact of relay **5E**, armature and back contact of relay **5F**, resistance **507**, armature and contact of relay **5D**, conductor **508**, No. 3 armature and contact of relay **4B1** (assuming that subscriber station **102** is the first subscriber station desired in the conference), conductors **414** and **1545**, normally closed contacts associated with the ring spring of jack **207**, conductor **211**, inner upper armature and contact of relay **4C**, conductor **253**, through the winding of "hold" magnet **2H2** to grounded battery. "Hold" magnet **2H2**, upon operating, closes at its inner left armature and contact a circuit traceable from ground, conductor **269**, through the winding of relay **4A** to grounded battery, and relay **4A** operates. "Hold" magnet **2H2**, upon operating, locks over its sleeve conductor to the "order" trunk and connects the ring conductor of the "order" trunk to the conference control circuit. The locking circuit may be traceable from grounded battery, through the winding of "hold" magnet **2H2**, conductor **253**, contact and outer upper armature of relay **4C**, conductor **405**, sleeve conductor **254**, sleeve contact of the operated set, say set **255**, sleeve conductors **256** and **257** (assuming that the trunk shown in Figs. 8 and 9 is also the order trunk although in actual practice the order trunk must be different from the conference trunk). The ring conductor of the "order" trunk, say conductor **822**, is connected over conductor **258** through the ring contact of operated set **255**, conductor **259**, outer left-hand armature and front contact of "hold" magnet **2H2**, conductor **403**, front contact and armature No. 2 of relay **4B1**, conductor **415**, resistance **509** and front contact out of engagement with the upper armature of relay **5SP2** of the conference control circuit. Relay **4A**, upon operating, (1) connects the desired subscriber line tip conductor to the tip conductor of the "order" trunk; (2) causes at its outer lower armature and back contact the release of relay **5D** of the control circuit; and (3) while at the same armature supplies a locking ground for relay **4B** while it keeps a busy condition on the unlisted conference number associated with the called subscriber station.

The "order" trunk proceeds to discharge the director circuit and if so arranged begins to ring the called subscriber line; otherwise the operator may manually ring the subscriber station. Marking potentials supplied by the "order" trunk operate relay **5T** which, upon operating, connects ground at the outermost upper armature and contact of relay **6**—ON to the grid element of vacuum tube **505** thereby preventing the tube from acting. At this stage on the call, the desired subscriber line remains connected to the "order" trunk solely because the trunk holds the subscriber station "hold" magnet operated. The line can, therefore, be disconnected at the pleasure of the originating operator at the distant central office. If, therefore, the subscriber does not answer, the operator can withdraw from the "order" trunk which in turn will cause the trunk to release the "hold" magnet. The "hold" magnet, in turn, releases relay **4A** which, in turn, releases relays **4B**, **4B1**, **5T** and **5ST** and returns the circuit to normal.

The conference subscriber answers

When the conference subscriber answers, grounded battery on the ring conductor operates relay **5SPC** of the control circuit, which in turn operates relay **5SP2**. Relay **5SP2**, upon operating, greatly reduces the bias current in winding No. 1 of relay **5SPC**, connects grounded battery to the ring conductor of the "order" trunk operating relay **8SP** in the order trunk, and prepares an operating path for the "hold" magnet, say magnet **7H2**, associated with the desired subscriber line in the conference connector cross bar switch, the operating path being prepared at the inner lower armature and contact of relay **5SP2**. Relay **8SP** in the "order" trunk causes the trunk circuit to enter the transmission stage, and the operator communicates with the subscriber.

Conference subscriber refuses to accept conference call

If the conference subscriber, after answering, refuses to accept the conference call, relay **5SPC** of the conference control circuit releases as soon as the subscriber disconnects. The release of relay **5SPC** releases relay **5SP2** which, upon releasing, disconnects at its upper armature and front contact grounded battery **502** from conductor **415** which is connected over armature No. 3 and contact of relay **4B1** to the ring conductor of the calling trunk thereby releasing relay **8SP** of the calling trunk and registering a subscriber disconnect which is transmitted to the operator at the distant central office. When the disconnect signal is registered at the operator's switchboard at the central office, the operator withdraws the calling cord circuit from the "order" trunk, which finally results in the release of the subscriber station hold magnet **2H2**, causing in turn the release of relays **4A**, **4B**, **4B1**, **5ST** and **5T** thereby returning to normal the subscriber appliqué circuit for subscriber station **202** and the conference control circuit.

Transfer of a conference subscriber station to an idle conference subscriber branch

If the conference subscriber accepts the conference call the operator at the distant central office sends a two-second break signal. Transmission of the break signal to the subscriber station causes the release of relay **5T** which, upon releasing, removes ground from the grid element of vacuum tube **505**. After approximately 1.5 seconds having elapsed, the plate current is sufficient to operate relay **5T2** which, upon operating, causes in succession the operation of relays **5E** and **5F**. Relay **5E**, upon operating, operates **6SP3** which locks under control of relay **5ST** and closes the tip conductor of the conference trunk to the trunk conference branch and at the same time increases the potentials on the ring conductor of the conference trunk causing this trunk to act as if a subscriber had answered. This "trip" is advanced to trip the ringing in the automatic ringing offices so as to prevent the first conference subscriber station receiving a rem-

nant of the automatic ringing. Relay 6SP3 also supplies ground to the conductors respectively extending to the subscriber station conference branches.

At the conclusion of the break signal sent by the operator at the distant central office, relay 5T again connects ground to the grid element of vacuum tube 505 thereby causing the release of relays 5T2 and 5E. Relay 5F being of the slow-releasing type, remains operated until relay 5E is completely released, at which time ground is connected at the inner lower armature and back contact of relay 5E to a circuit traceable over the armature and front contact of relay 5F, through the winding of relay 5G, lower armature and contact of relay 5V, conductor 505, innermost armature and front contact of relay 6—ON to grounded battery. Relay 5G operates and locks under the control of armature No. 6 and contact of relay 4B1. When finally relay 5F releases a resistance ground is connected in the circuit traceable from ground at the inner lower armature and back contact of relay 5E, armature and back contact of relay 5F, resistance 507, conductor 510, contact and upper armature of relay 6S2, conductor 611, lower armature and contact of relay 5G, inner lower armature and front contact of relay 5SP2, conductor 511, No. 5 armature and contact of relay 4B1, conductor 416, through the winding of "hold" magnet 7H2 to grounded battery. "Hold" magnet 7H2 is associated with the first called conference subscriber station in the conference connector switch. This path for operating hold magnet 7H2 remains open until the conference trunk has sent a mark signal long enough to release relay 6S2 thereby insuring the operation of relay 5U, and precluding the possibility of ringing being sent to the first subscriber station to be added to the conference circuit. "Hold" magnet 7H2 operates and locks in series with relay 7SL of the first idle level on the conference connector switch, the first, or uppermost, idle level of the switch and relay 7SL being associated with the first subscriber station conference branch. The locking circuit of "hold" magnet 7H2 may be traced from ground at armature No. 7 of relay 6SP3, conductor 615, through the winding of relay 7SL, conductors 705 and 736, sleeve contact of operated set 726, conductor 727, through the winding of "hold" magnet 7H2, to grounded battery. The selecting magnet 7SM—1 of the connector switch level associated with the first subscriber station conference branch has already been operated in a circuit traceable from ground at the innermost lower armature and contact of relay 5ST, conductor 506, normally closed contacts of key 701, conductor 702, lower armature and back contact of relay 7SL1, conductor 703, through the winding of selecting magnet 7SM—1 to grounded battery 733. Relay 7SL of the first subscriber station conference branch operates but does not as yet operate relay 7SL1 though it lights busy lamp 707 in an obvious operating circuit extending over conductor 708 to ground at the middle lower armature and contact of relay 6—ON, busy lamp 707 being associated with the first subscriber station conference branch. Also "hold" magnet 7H2, upon operating, disconnects the subscriber station tip and ring conductors and connects them respectively to the corresponding conductors in the subscriber station conference branch associated with the seized level of the conference circuit connector switch. In other words the tip conductor 209 and ring conductor 210 of the called subscriber station are connected over the upper armatures and front contacts of hold magnet 7H2, conductors 728 and 729, tip and ring contacts of operated set 726 to conductors 730 and 731, respectively, conductor 730 being connected in a path extending over conductor 709, through the upper winding of polarized relay 7R1, retardation coil 710, armature and marking, or left-hand, contact of polarized relay 7S1 to grounded positive battery, and conductor 731 being connected in a path extending over conductor 711, through the Nos. 3 and 2 windings, in series, of polarized relay 7SP, to ground. The first subscriber station conference branch sends from the left-hand contact of relay 7S1, a marking signal to the subscriber station and which now forms a complete circuit including the windings Nos. 3 and 2, in series, of relay 7SP and relay 7SP operates. Relay 7SP, upon operating, closes an operating circuit for relay 7SP1, the circuit being traceable from ground at the armature and contact of relay 7SP, through the winding of relay 7SP1, conductor 712 to grounded battery at the outermost lower armature and contact of relay 6—ON. Relay 7SP1, upon operating, removes ground connected to the tip conductor of the first subscriber station conference branch, the path in which the resistance ground is removed may be traced over conductor 713, lower armature and contact of relay 7SP1, resistance 714, conductors 715, 716 and 627, resistance 628, to ground at the outermost upper armature and contact of relay 6—ON. This resistance ground normally had been creating a mark signal for the first subscriber station conference branch contribution to the conference transmission circuit, but now that the subscriber loop is attached, the loop performs that service. Relay 7SP1, upon operating, also operates relay 6SP4 in a circuit traceable from ground at its upper armature and contact, conductor 717, through the lower winding of relay 6SP4, conductor 513 to grounded battery at the innermost upper armature and contact of relay 6—ON. Relay 6SP4, upon operating, closes at its upper armature and front contact a locking circuit for relay 6SP3. Relay 6SP4, upon operating, places relay 6SP3 under control of relay 6RS which operates to its spacing, or right-hand, contact whenever the conference trunk transmits a space signal to the conference circuit.

Meanwhile, when "held" magnet 7H2 of the conference connector switch operated, it effectively transmitted a space signal to the "order" trunk because it opened the tip conductor and in opening the ring conductor it causes the release of relay 5SPC which, in turn, released relay 5SP2. Relay 5SP2, upon releasing, removes battery 502 from the ring conductor of the "order" trunk, resulting eventually in the registation of a disconnect signal in that trunk and finally in a disconnect signal before the operator at the distant central office. Relay 5SP2, upon releasing, also increases the bias on relay 5SPC, disconnects the resistance ground which operated the "hold" magnet 7H2 in the conference connector switch and applies it to a circuit extending through the winding of relay 5H which operates, the resistance ground herein referred to involving resistance element 507. Relay 5H, upon operating, opens the operating path of relay 5T which releases and again removes ground from the grid element of vacuum tube 505. After one and one-half seconds relay 5T2 again operates but this time relay 5H being operated, the operation of relay 5T2 results in the operation of relay 4C

of the first conference subscriber station appliqué circuit. Relay 4C upon operating (1) locks in parallel with "hold" magnet 7H2, through the operated contact set 726 of the conference connector switch; (2) opens at its outer upper armature and contact the holding path of subscriber "hold" magnet 2H2 which releases; and (3) places a busy indication on the selecting conductors of both the subscriber regular and unlisted calling numbers, namely, conductor 1545 for the subscriber regular calling number and conductor 1549 for the subscriber unlisted calling number. The release of "hold" magnet 2H2 causes the release of relay 4A which, upon releasing, releases, in turn, relays 4B and 4B1. Relay 4B1, upon releasing, releases relays 5ST and 5G in the control circuit. Relay 5ST reapplies ground to the grid element of vacuum tube 505, causing the release of relay 5T2. Relay 5G, upon releasing, releases relay 5H, returning this part of the circuit to normal, while it permits relay 7SL1 of the subscriber conference branch just selected, to operate, and also again causes all other unlisted calling numbers to again cease testing "unassigned." Relay 7SL1, upon operating, preselects the next idle level on the subscriber conference connector switch, permitting the selecting magnet, such as selecting magnet 7SM—2 (not shown), on the next idle level to operate when relay 5ST again operates. The relay corresponding to relay 7SL1 of the next subscriber conference branch (not shown) and associated with the next idle level will similarly be held from operating.

Addition of other conference subscriber stations

As hereinbefore described the operator receives a disconnect signal after the conference subscriber station is connected to a subscriber conference branch. Slightly later, the control circuit causes the release of the subscriber station "hold" magnet, such as "hold" magnet 2H2, which again permits the operator to reach the director circuit. When the director circuit is attached the operator receives a lamp indication, and if subscriber stations are to be automatically connected the operator repeats the routine hereinbefore described until all the desired subscriber stations have been added one to each of the subscriber stations conference branches available. The action of the conference circuit remains the same as when the first subscriber station was added except this time relay 5E does not operate relay 6SP3 and relays 6SP3 and 6SP4 remain operated. Each of the subscriber stations to be added is connected to an idle level of the subscriber conference connector switch.

Start of the conference and transmission

After the operator at the central office has added the last subscriber station to the conference, she awaits the reception of the disconnect signal over the "order" trunk and then disconnects from the "order" trunk, which returns to normal. The operator then turns to the conference trunk and sends a one-second break signal to the concentrating unit. This space signal causes the operation of relay 6RS to its spacing, or right-hand, contact and at the same time appears as a space signal in all conference subscriber loops. Relay 6RS causes the operation of relay 6S2 and the slow release of relay 5U. Relay 6S2, upon operating, closes at its lower armature and contact a holding circuit for relay 6SP3 the circuit being traceable over the outer lower armature and contact of relay 6SP4, No. 2 armature and contact and winding of relay 6SP3, to grounded battery at the innermost upper armature and contact of relay 6—ON. Relay 5U, upon releasing, closes an operating circuit from grounded battery at the innermost upper armature and contact of relay 6—ON, conductor 505, through the winding of relay 5V, contact and armature of relay 5U, to ground at the upper armature and front contact of relay 6SP4. Relay 5V operates and locks under control of relay 6—ON. Also 5V, upon operating, removes the grounded battery at the innermost upper armature and contact of relay 6—ON from the control circuit shown in Fig. 5 and from all remaining unlisted conference numbers making them test "unassigned" and thus preventing any further addition to the conference circuit. At the conclusion of the break signal relay 6RS operates to its marking, or left-hand, contact releasing relay 6S2. The operator then calls all subscribers, and orders the start of the conference. The transmission circuit of the conference circuit consists of two polar relays for each subscriber conference branch, such as relays 7S1 and 7R1 for the first subscriber conference branch, and three polar relays for the trunk conference branch, such as relays 6S, 6R and 6RS. Relay 6RS in the trunk branch is used for supervisory purposes. In general, the R relay of each subscriber conference branch, such as relay 7R1 of the first subscriber conference branch, transmits signals created by that branch into the conference as a whole, while the S relay of each branch, such as 7S1 transmits signals obtained from other branches into the particular branch. When the conference is marking, the lower winding of the S relay in each subscriber conference branch, such as relay 7S1, and the upper winding of relay 6S draw a series marking current causing the relays to remain on their marking contacts. This series circuit has a potentiometer arrangement on each end causing a 10-milliampere current to flow, the sources of current being the potentiometer comprising a path extending from grounded battery 718 at one end, through the lower winding of relay 7S1, through the upper winding of relay 6S, to the potentiometer at the other end formed by a ground connection at outermost upper armature and contact of relay 6—ON and extending through resistance 699, armature and marking contact of relay 6R, armature and marking contact of relay 7R1, to grounded battery 799. In the subscriber conference branches the S relay marking contacts supply current to operate all R relays to their marking contacts either because the attached subscriber loops are closed or because the resistances, such as resistance 714 in the first subscriber conference branch, is connected to the tip conductor by the unoperated SP1 relay, such as relay 7SP1 in the first subscriber conference branch. The upper winding of all S relays in the subscriber conference branches are short-circuited, that is, have no current at the time. In the trunk conference branch ground on the marking contact of relay 6S permits relay 6R to draw current from the conference trunk and to remain marking.

If a subscriber originates a space signal the R relay in the associated subscriber conference branch, such as relay 7R1 in the first subscriber conference branch, becomes spacing under the influence of biasing current in its lower winding. Relay 7R1, upon operating, to its spacing contact removes the short-circuit from the upper winding of relay 7S1 and by applying ground to the right

side of the upper winding of relay 6S permits a current to flow through this upper winding whereby relay 6S is held definitely in its marking position. This same ground which is connected to the outermost upper armature and contact of relay 6—ON also replaces one of the end potentiometers which comprised grounded battery 799, causing a reversal of current in the upper winding of relay 6S and the lower winding of the S relay in each of the subscriber conference branches, such as relay 7S1 of the first conference branch. Relay 6S and the S relay in each of the subscriber conference branches operate to spacing except the S relay in that subscriber conference branch that had created the space signal and such relay remains marking because of current in its upper winding. When the subscriber station again returns to the marking condition the R relay in its associated subscriber conference branch, such as relay 7R1 in the first subscriber conference branch, operates to marking thereby short-circuiting the upper winding of its associated S relay, such as relay 7S1 and removing the ground connection, which permits a 10-milliampere marking current to flow in all S relays which now operate to their respective marking contacts.

The same action as described above occurs if the conference trunk branch originates a space signal except in this case the trunk conference relay 6S remains marking because of current in its upper winding and all other relays such as those in the subscriber conference branches operate to their respective spacing positions.

Relay 6RS in the trunk conference branch monitors the signals received from the trunk. When a space is received relay 6RS operates relay 6S2 and holds relay 6SP3 operated, thus preventing the registration of a disconnect signal. The trunk circuit itself has a similar feature, but it must be used in the conference circuit because the disconnect signal arrangement once operated remains locked up.

Connection to the conference circuit of a subscriber station not arranged for automatic connection

If the operator at the distant central office requires the addition of a subscriber's station to the conference, for which the operator has no unlisted number and whose line is therefore not arranged for automatic connection, the operator must request the attendant at the concentrating unit switching center to add said subscriber station manually. The operator reaches the attendant in the usual way by selecting the station of the attendant and then transmits information of the connections required. The attendant tests the subscriber line and, if idle, calls the subscriber. If the conference is accepted the attendant patches a cord circuit between jacks of the desired subscriber's line, such as jacks 207 and 208 of subscriber's line 202, and corresponding jacks of the next idle conference branch, such as jacks 719 and 720, respectively, of the first subscriber conference branch. Jacks 719 and 720 are mentioned herein for illustration purposes only and because they are the only ones shown associated with a subscriber conference branch. When the first subscriber station is selected for connection to a conference, it is necessary to perform an additional function as compared with those subscriber stations that are added to the conference. In the case of the first subscriber station being added to the conference the attendant holds start key 512 operated for a second before and while he plugs into the jacks of the idle subscriber conference branch. Thus the tip and ring conductors of the subscriber line are connected to the subscriber conference branch causing the operation of relays 7SP and 7SP1. The ring conductor of jack 719 furnishes ground to the ring conductor of jack, say jack 207, a subscriber line 202 is selected as the first subscriber to be added to the conference, and this ground is extended over conductor 1545 to the contact at No. 2 armature of relay 15H1 so that any call for subscriber line 202 on the director circuit will find a busy condition. Jack 720 receives grounded battery through the winding of subscriber "hold" magnet 2H2 in a circuit traceable over conductor 253, contact and inner upper armature of relay 4C, conductor 211, operated off-normal contacts associated with the tip spring of jack 208, ring spring of jack 208, ring spring of jack 720, operated off-normal contacts associated with the tip spring of jack 720, through the winding of relay 7SL, to ground at the No. 7 armature and contact of relay 6SP3, relay 6SP3 having operated when start key 512 was operated to close a circuit from ground, through the winding of relay 6SP3, to grounded battery at the contact and innermost upper armature of relay 6—ON. Relay 7SL operates to close at its upper armature and contact an operating circuit for relay 7SL1, the circuit being traceable through the winding of relay 7SL1, conductor 712 to grounded battery at the front contact and outermost lower armature of relay 6—ON. Relay 7SL, upon operating, closes at its lower armature and contact an operating circuit for busy lamp 707 which lights, the lighting circuit extending over conductor 708 to ground at the middle lower armature of relay 6—ON. Relay 6—ON operated in response to the operation of relay 6R1 which in turn operated in a circuit traceable from ground, through the upper winding of relay 8SP, normally closed contact at tip spring of jack 836, ring conductor 822, operated ring contact of set 268, inner armature and contact of hold magnet 2HC, conductor 607, normally closed contact of jack 609, conductor 610, through the winding of relay 6R1, No. 1 armature and contact of relay 6SP3, conductor 614 to grounded battery 502. The operation of relay 7SL1 preselects the next idle subscriber conference branch.

Manual set-up of conference circuit

In case of failure of the automatic equipment, or if the concentrating unit is not arranged for automatic conference connections, the attendant, under instructions from the operator at the distant central office, can completely set up the conference manually. If the concentrating unit has failed the attendant first patches a cord circuit between the jacks of a trunk assigned as the conference trunk, say jacks 835 and 836 and jacks 601 and 602, respectively, of the trunk conference branch. In this circuit, completed by the patching cord, relays 6R1, 6S2 and 6—ON operate. The operating circuit for relay 6R1 is traceable from grounded battery 502, conductor 614, resistance 613, conductor 612, through the winding of relay 6R1, conductor 610, normally closed contacts of jack 609, tip spring of jack 602, tip spring of jack 812, through the upper winding of relay 8SP to ground. Relay 6R1, upon operating, closes an obvious operating circuit for relay 6—ON. Relay 6—ON, upon operating, closes a circuit from grounded battery, contact and innermost

upper armature of relay 6—ON, through the winding of relay 6S2, to ground at the armature and spacing contact of relay 6RS, relay 6RS having operated to its spacing contacts in a circuit traceable from ground at the outermost upper armature and contact of relay 6—ON, conductor 622, marking contact and armature of relay 6S, through the lower windings, in series, of relays 6R and 6RS, to grounded battery 624. The attendant then adds the subscriber stations to the idle branch as required. While plugging the first subscriber station into the first idle subscriber conference branch, the attendant holds start key 512 operated for approximately one second. The operation of start key 512 causes the operation of relay 6SP3 which, upon operating, connects the tip conductor 608 of the conference trunk to the trunk conference branch and causes the operation of relay 8SP in the conference trunk. The addition of the first subscriber station therefore finally ends in the operation of relays 6SP3 and 6SP4.

Relay 6—ON, upon operating, closes at its outermost upper armature and contact, a circuit extending from ground over conductors 622 and 625, through the upper winding of relay 7SP, to grounded battery which is common to the corresponding relay in each of the other subscriber conference branches. Relay 7SP operates to its right-hand position thereby connecting ground to the winding of relay 7SP1 which operates. Relay 7SP1, upon operating, takes over the function of holding relay 6SP3 operated. After all required subscriber stations have been added, who could be reached, the attendant notifies the operator at the distant central office who in turn arranges to start the conference over the conference trunk. If the unit is arranged for automatic conference connection operation but is temporarily being operated manually, the operator at the central office sends the usual one-second break signal before starting the conference. The attendant reaches the operator at the central office over the conference trunk by patching a cord circuit between the test jacks 1902 and 1903 of the test circuit and jacks 626 and 609, respectively, of the trunk conference branch. The test circuit is prepared by operating the trunk test answering key 1904 whereby the test circuit holds the conference circuit in its marking condition. The trunk test answering key 1904 is released and reoperated to send a recall signal over the conference trunk to the operator at the central office. When the operator answers, the attendant gives details of his accomplishment and disconnects from jacks 626 and 609 of the trunk conference branch.

A conference subscriber disconnects prematurely

If one or any number, but not all, of the subscribers whose station lines are connected to the conference circuit, disconnects the SP relay in each of the associated subscriber conference branches, such as relay 7SP in the first subscriber conference branch, releases, releasing the SP1 relay of the same branch, such as 7SP1 of the first subscriber conference branch. The SP1 relay in each subscriber conference branch, upon releasing, connects a resistance ground to the tip conductor of the subscriber conference branch, causing that branch to create a mark signal toward the conference circuit. Resistance 714 is employed for this purpose. The conference can therefore continue between the remaining subscribers. The telegraph signal may tap the bell at the prematurely disconnected station. All subscriber lines remain attached to the conference circuit until the operator at the central office disconnects. Any new call originated by any disconnected subscriber reaches the conference circuit.

Disconnection of a conference circuit containing automatically connected subscriber stations

When finally all conference subscribers have disconnected, relay 6SP3 releases. The release of relay 6SP3 effectively creates a disconnect signal in the conference trunk, which signal is sent to the operator at the central office. The release of relay 6SP3 in removing ground from conductor 615 releases all automatically connected subscriber lines and returns such lines to normal. The operator, upon receiving a disconnect signal, withdraws from the conference trunk causing it to release the hold magnet, such as magnet 2HC, which holds the conference circuit to the conference trunk. This releases relays 6R and 6—ON. Relay 6—ON, upon releasing, removes power from the conference branches and control circuits thereby releasing all operated relays and returning the circuit to normal.

Disconnection of conference circuit containing both automatic and manually operated subscriber stations

After all subscribers have disconnected from the conference the automatic subscribers are released and the circuit returns to normal as indicated in the immediately preceding paragraph. Relay 6SP3 being normal and a patching cord remaining in any of the jacks of the subscriber conference branches, such as jacks 719 and 720 of the first subscriber conference branch, causes the operation of relay 6AL which, upon operating, sounds an alarm and lights disconnect lamp 721 as a signal for the attendant to remove the patching cord. Relay 6AL also connects ground to the conference circuit conductor 1547 which is seized when the signal received from the operator at the distant station corresponds to the calling number of the conference circuit. Ground on conductor 1547 gives the conductor a busy condition. When all patching cords are removed, relay 6AL releases restoring the circuit to normal.

Disconnection of a conference circuit manually set-up

Regardless of the reason for the manual set-up removal of the patching cord between the jack of the subscriber line and the jack of the conference branches is caused as hereinbefore described. If the conference was manually set up because of failure of the concentrating unit, the operator at the central office after receiving a disconnect signal over the conference trunk informs the attendant and orders the removal of the patching cord between the trunk and the conference circuit. If the unit is so arranged, the withdrawal of the operator from the conference trunk lights a disconnect lamp which furnishes a signal for the attendant to remove the patching cord between the trunk and the conference circuit.

Busy key

Each subscriber conference branch is equipped with a busy key, such as key 701 of the first subscriber conference branch. This key, upon operation, can remove the branch from service. As soon as relay 6—ON operates, the busy lamp, such as lamp 707 in the first subscriber conference

branch, of the branch associated with the operator's key, lights. The busy key prevents the preselection of that branch for a subscriber connection.

Busy and out-of-order jack of unlisted conference numbers

Each subscriber conference access circuit is equipped with a jack, such as jack **407** of the access circuit for subscriber's station **102**, which as far as the unlisted conference number conductor, such as conductor **1549** of the access circuit of subscriber's station **102**, is concerned, functions the same as a jack of the subscriber line circuit, such as jack **207** of subscriber line **202**. When, therefore, an attendant wishes to manually make busy or out-of-order subscriber lines arranged for automatic conference connection, he connects by means of patching cords, both a jack of the access circuit, such as jack **407**, and a jack of the subscriber line, such as jack **207**, to either the subscriber busy or the subscriber out-of-order jack as desired. When the conference circuit is normal all unlisted conference numbers test "unassigned," to a testing director circuit but that the manual busy or out-of-order condition inserted into a jack of the access circuit, such as jack **407** of the access circuit for subscriber station 102, supplants the "unassigned" condition.

ALL-TRUNKS-BUSY CIRCUIT

When a subscriber, say at station 105, originates a call during the all-trunks-busy period the sequence circuit connects a ground connection to a circuit extending over conductor **1330**, No. 2 armature and contact of relay **18B**, through the winding of start relay **18ST** to grounded battery and relay **18ST** operates. Relay **18ST**, upon operating, permits relay **18PC** and **18—Sub. Off.** register to function. Relay **18ST**, upon operating, closes at its middle lower armature and contact a circuit extending from grounded battery, back contact and No. 5 armature of relay **18B**, conductor **1806**, through the winding of selecting magnet **2SM—0** to ground and the magnet **2SM—0** which is assigned to the uppermost, or all-trunks-busy, level of the link circuit operates. Selecting magnet **2SM—0**, upon operating, closes a circuit extending from ground at its armature, conductor **266**, through the winding of relay **14D**, to grounded battery. Relay **14D** operates and closes at its outer right-hand armature and contact a circuit extending from ground, resistance **1401**, conductors **1402** and **303**, through the operated outermost upper armature of one of relays **3U1** to **3U5**, for example, say, in the case assumed herein, the operated outermost upper armature of relay **3U5**, armature No. 9 of relay **3C** in operated condition, through the winding of subscriber "hold" magnet **2H5** to grounded battery. "Hold" magnet **2H5**, upon operating, connects the tip and ring conductors of subscriber station **105** over the operated contact set **270** to conductors **271** and **272**, respectively, which extend to the all-trunks-busy circuit. The link circuit hold magnet, say magnet **2H5**, corresponding to the calling subscriber station, upon operating, effects the release of the line relay in the calling subscriber line circuit, such as line **205** which, in turn, effects the release of calling-in relay **3SC**. Relay **3SC**, upon releasing, (1) causes relay **3GB** to release thereby connecting ground at its right-hand armature and contact to conductor **315** which extends over two paths, one of which extends to the all-trunks-busy circuit, and (2) removes ground at its No. 12 armature and contact from the circuit extending over conductor **313**, outer lower armature and contact of one of the relays **3U1** to **3U5**, contacts and outer left-hand armature of relay **3GD**, conductor **320**, through the winding of relay **14LS1** to grounded battery. Relay **14LS1** releases to remove ground from conductor **1404** in a circuit traceable over conductor **1329** of the trunk advance relay chain, conductor **1329** being an alternative of conductor **1311** when relay **13AD** is operated.

Relay **3GB**, upon releasing after the operation of start relay **18ST**, causes relay **18B** to operate. Relay **18B**, upon operating, locks momentarily in a circuit traceable over its No. 3 armature and contact, conductor **1807** to ground at the No. 6 armature and contact of relay **14H** but relay **14H** is quickly caused to release by the release of relay **14LS1**. Relay **18B**, upon operating, (1) connects at its No. 4 armature a ground connection to the upper winding of relay **18LN**; (2) operates relay **18D**; (3) connects the lower winding of relay **18LN** to the inner lower armature of relay **18E**; (4) connects ground at its No. 8 armature and contact through a circuit extending over conductor **1808**, sleeve conductors **273** and **274** now in mutual engagement through contact set, say set **270**, of the operated link circuit, to the winding of hold magnet **2H5** which was previously operated; (5) opens the operating circuit for the selecting magnet **2SM—0**; (6) opens the circuit including the conductors **304** and **1805** which extend to the sequence circuit; (7) transfers at its No. 2 armature and front contact, conductor **1330** to the start relay in another all-trunks-busy circuit if such is required and releases the start relay **18ST** of the all-trunks-busy circuit shown. Relay **18LN** also operates by means of its upper winding and supplies a holding ground for relay **18B**.

Relay **18D**, upon operating, connects ground to a circuit extending from ground at key **1809**, conductors **1819** and **1810**, contact and outer lower armature of relay **18D**, conductor **1812**, innermost lower armature and contact of relay **18L**, conductor **1813**, through the winding of relay **18L1**, to grounded battery and relay **18L1** operates during the "no circuit" condition. Also relay **18D**, upon operating, causes a circuit extending from grounded battery, through the winding of relay **18E**, contact and upper armature of relay **18D** to the interrupter **1814** which operates on a basis of two seconds on and four seconds off. Relay **18E** operates in accordance with the pulses obtained from interrupter **1814** and, on operating, (1) permits relay **18F** to operate, and (2) holds relays **18D** and **18L** operated. Relay **18F**, upon operating, produces a ground connection to operate stepper magnet **18A—MGT** during the "no circuit" condition and removes the ground connection from one side of condenser **1802** which side is then connected to the secondary, or upper, winding of relay **18P1**, at the same time placing ground on the armatures of relays **18—INT** and **18P**. Relay **18F**, upon operating, connects ground at its inner lower armature and contact to a path extending over conductor **1815** to the armatures of relays **18P** and **18—INT**. In the meanwhile the connection of the calling subscriber line through the tip and ring conductors has returned the sequence circuit to normal, removing ground from conductor **1330**.

Counting subscribers' calls during an all-trunks-busy period

When a subscriber calls during the all-trunks-busy period ground is connected to the winding of relay 18PC in a circuit traceable from the innermost lower armature and contact of relay 18ST, conductor 1816, through the windings, in series, of relay 18PC and register 18—Sub. Ofl. the latter, upon operating, (1) serving to register the call after relay 18PC operates and (2) supplementing the ground potential. Register 18—Sub. Ofl., when operated, locks to the ground on the armature and contact of relay 18PC, and remains locked through its own armature and contact until ground is removed at the innermost lower armature and contact of relay 18ST. Relay 18PC releases when register 18—Sub. Ofl. operates. The register therefore operates only once on any one single grounding of conductor 1330 by the sequence circuit. The function of relay 18PC is to insure the application of ground for a sufficient period to enable the slow-acting message register Sub. Ofl. to function. If the all-trunks-busy circuit, the line circuit and the sequence circiut function speedily and tend to remove the ground from conductor 1330 before the message register has operated, ground on relay 18PC will insure the operation of the message register. Therefore, as the signals are transmitted to each subscriber's line the subscriber call is registered.

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

When a subscriber is connected to the all-trunks-busy circuit during the "no circuit" period as hereinbefore indicated, relay 18—INT follows the sixty impulse per minute with interrupter 1801, and relay 18F follows two-second ground, four-second open from interrupter 1814. During the time that relay 18F is normal, condenser 1802 is charged and relay 18P1 is held marking and a marking signal is transmitted to the connected subscriber line. When relays 18F and 18—INT are operated, ground at the upper armature and contact of relay 18F discharges condenser 1802 via resistance 1817 and the contacts of relay 18—INT. The current of this discharge tends to hold relay 18P1 on its marking contact. As soon as relay 18—INT releases, condenser 1802 recharges, the current in this case operating relay 18P1 to its spacing contact. When the charging current has decreased sufficiently relay 18P1 again returns to its marking contact. On each subsequent operation and release of relay 18—INT during the operated period of relay 18F, this cycle is repeated producing a space signal of .022 second, once per second. When ground is removed from the interrupter ground conductor 1818 by interrupter 1814, relays 18E and 18F release. Relay 18F, upon releasing, opens the secondary or upper, winding of relay 18P1, allowing condenser 1802 to charge, definitely operating relay 18P1 to its marking contact. The different release times of relays 18E and 18F insure that ground will be connected to conductor 1819 for an interval after the last transmitted space signal. The 22-millisecond space signal which is equivalent to the "letters" character is thus transmitted to the subscriber, once per second during the "on" period of the interrupted relay circuit. Relay 18LN is held operated by relay 18E during the "on" period of the interrupter and by the marking condition of the line during the remainder of the interrupter cycle.

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

As soon as a trunk in the group involved becomes idle under this condition ground is removed from the all-trunks-busy conductor 1308 by the sequence circuit causing the release of the associated relay 18A and in turn the release of relay 18L provided that relay 18E is also released at that time. The release of relay 18L opens the contact and winding circuits of relay 18—INT causing its release and at the same time connects grounded battery to the winding of relay 18P. When relay 18F again operates and providing that relay 18P is not operated to its right-hand contact, current flows in both the primary and secondary windings of relay 18P, the current in the primary, or lower, winding tending to operate the relay to its right-hand contact and that in the secondary, or upper, winding tending to keep the relay on its left-hand contact. When the charging current flowing through the secondary, or upper, winding of relay 18P has decreased sufficiently, relay 18P operates on its primary, or lower, winding. As soon as relay 18P operates to its right-hand position the current is reversed in the primary, or lower, winding of the relay, tending to drive the armature to its left-hand position. The charge on ccondenser 1820, however, causes a current to flow through the secondary, or upper, winding in a direction tending to hold relay 18P in its right-hand position. When this discharge current has been sufficiently dissipated, relay 18P is driven to its left-hand position under the influence of the reversed current in the primary, or lower, winding. When the armature and right-hand contact of relay 18P are disengaged, the reversed current in the primary, or lower, winding ceases, and the current through the secondary, or upper, winding and the operating current through the primary, or lower, winding again begins to flow, causing a repetition of the complete cycle. Relay 18P therefore operates and releases at a rate of about nine cycles per second and the discharging and charging of condenser 1802 occurs nine times per second instead of once per second. Space pulses of 0.022 of a second, nine times per second, produce a "K" character on the subscriber's teletypewriter as an indication that a trunk is now available. These signals are, of course, produced only during the active period of the relay interrupter circuit. The subscriber disconnects and tries again. The disconnect of the subscriber station can take place only during the period in which relay 18E is released. If several subscriber stations have been waiting, only one will 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 wherein letters are being produced

When relay 18D operates during an all-trunks-busy period, relay 18L1 operates since relay 18L is operated. Each grounding of the interrupted ground conductor 1818 of the interrupter results as described in the immediately preceding paragraph, in the operation of relay 18F which, in turn, operates the rotary magnet 18A—MGT. In machine ringing systems the relay circuit places a ground on the interrupted ground conductor

1818 once every six seconds in accordance with the ringing machine interval. In systems not equipped with machine ringing, the relay circuit manufactures approximately the same cycle. In any case, if the all-trunks-busy condition persists, each grounding of the interrupted ground conductor 1818 causes the rotary magnet 18A—MGT to step a selector brush 1821 one terminal. On terminal No. 9 of the selector switch 18A—SW ground is connected to the winding of rotary magnet 18B—MGT causing it to step its brush 1822 up one terminal. When selector switch 18A—SW operates its brush 1821 to terminal No. 10, relay 18L2 operates energizing release magnet 18A—RLS. Selector switch 18A—SW is returned to normal and begins stepping around again. When selector switch 18B—SW reaches a predetermined terminal, relay 18LA operates and locks, causing the "letters" lamp 1823 to light and an audible alarm signal (not shown) to sound as an indication to the attendant that the all-trunks-busy condition has lasted too long. The attendant by operating key 1809 can release lamp alarm relay 18LA to silence the audible alarm, extinguish the lamp signal and return the selector switches 18A—SW and 18B—SW to normal. If at any time prior to the operation of lamp alarm relay 18LA a trunk becomes idle, relay 18L releases causing the release of relay 18L1. The release of relay 18L1 places ground on the release magnet of both selector switches causing the switches to return to normal.

Test circuit

When the trunk test equipment jack 1901 is patched to jack 930 in the trunk side of the trunk terminating equipment at the concentrating unit switching center the tip conductor 940 is included in a circuit traceable from ground at the left-hand normally closed spring of trunk test inward ring key 1905, sleeve of jack 1901, sleeve of the patching cord (not shown), sleeve of jack 930, conductor 941, contact and inner upper armature of relay 9TR, then over parallel paths, one extending through condenser 906 and the winding of relay 9R1 and the other extending through the winding of relay 9L, high resistance element 931, and then over a common conductor 948, outer lower armature and back contact of relay 9TR, conductor 940, tip spring of jack 930, tip conductor of the patching cord, tip spring of jack 1901, trunk test inward disconnect key 1906, potentiometer 1907, right-hand spring and its normally closed contact of key 1905, ring spring and the normally closed contact of jack 1908, through the milliammeter 1909, normally closed contact and tip spring of jack 1908, resistance 1910, over the spring member and its normally closed contact of trunk test inward spacing key 1911 to ground. An inward call may be simulated by operating trunk test inward ring key 1905 which, in its operated position, closes the circuit, just traced, through resistance 1912 to ground at its left-hand spring member and to a source 1913 of ringing current over conductor 1914 and through lamp 1915 at its right-hand spring member. The ringing current from source 1913 operates relay 9R1 to initiate a call as hereinbefore described, that is, seizes the director circuit, replacing the high resistance element 931 with the trunk repeater element, such as receiving relay 9R, in its marking position. By patching trunk test milliammeter jack 1908 to jack 918 of the trunk terminating equipment, potentiometer 1907 may be operated until the meter reading on milliammeter 1909 is zero, potentiometer 1907 adjusting the line current. The monitoring teletypewriter may now be patched to the test teletypewriter jack 1601 of the director circuit and the required subscriber station calling number pulses supplied by sending from the monitoring typewriter. When the link circuit has completed the connection to the called subscriber line, ground will be connected to the ring circuit of trunk test equipment jack 1901 to light lamp. The operation of trunk test inward ring key 1905 will ring the bell in the called subscriber station. When the call is answered milliammeter 1909 will indicate the condition, that is, marking current.

The operation of trunk test inward spacing key 1911 will place a spacing condition on the circuit toward the subscriber station or testing equipment connected in place of a subscriber station.

When the subscriber or test circuit disconnects, the condition is indicated by the milliammeter 1909 and the operation of trunk test inward disconnect key 1906 places a negative potential, say 130 volts, on the tip spring of jack 1901 to release the equipment in the trunk termination circuit. Resistance 1917 of relatively high value reduces the current from source 1918 to give a rough check of the operation of relay 9L in the trunk terminating equipment.

Subscriber side of trunk

Tests made at the subscriber side of the trunk mean those that are made looking toward the trunk terminating equipment from a subscriber loop. If jacks 1902 and 1903 are patched to jacks 207 and 208, respectively, of the subscriber line circuit, the sleeve circuits will be connected to the equipment side of the subscriber line circuit and the tip circuits to the subscriber loop. The keys associated with the line equipment are shown herein as keys 1904 and 1923. With these keys normal the tip circuit is terminated in a ringdown relay 19E which is of the alternating current type and the ring conductor circuit is open. A call for subscriber station such as station 102, will apply ringing current to relay 19E which will operate, lighting lamp 1921.

Operation of trunk test answering key 1904 in answering such a call will complete the circuit through the monitoring teletypewriter connected to jack 1922 through the ring circuit to operate the SP relay in the trunk, such as 8SP in trunk 801.

With no call awaiting the operation of the trunk test answering key 1904 will place a call condition as from a subscriber station on the trunk termination equipment under test.

Operation of the trunk test break key 1923 will simulate a break signal from a subscriber station and the SP relay in the trunk, such as 8SP in trunk 801, should not release.

Subscriber loops

As hereinbefore outlined when jacks 1902 and 1903 are patched to jacks 207 and 208 the jack tip springs are connected to the subscriber loop. The tip conductor of the loop is thus terminated in a source 1933 of positive potential, say 130 volts, via the monitoring teletypewriter, or contacts of jack 1924 and the ring conductor is terminated in a ground connection via the upper winding of relay 19L.

The closure of the loop at the subscriber station will operate relay 19L and thereby light lamp 1925. Communication with the station subscriber

is afforded by means of the monitoring teletypewriter connected to jack 1924.

Operation of subscriber line test padding adjusting key 1919 operates relay 19K which, upon operating, connects the subscriber loop into a Wheatstone bridge circuit which is balanced when the loop resistance is say about 4480 ohms. The four arms of the bridge arrangement are those which respectively comprise resistances 1926, 1927, 1928 and the subscriber's loop and the bridge itself comprises resistances 1929, 1930 and microammeter 1931, resistance 1930 and microammeter 1931 being shunted by varistor 1932. For a definition of the varistor and its purpose reference may be made to the copending application of L. A. Gardner et al., Serial No. 403,116, filed July 19, 1941. A balance is indicated by a zero reading on microammeter 1931. The loop resistance is adjusted by means of a potentiometer in the subscriber line circuit, such as potentiometer 243 in subscriber line circuit 202. A meter reading of one scale division on either side of the zero position will indicate a deviation of compensated loop resistance of approximately one-half of one per cent from the correct value of say 4480 ohms. The varistor 1932 is shunted across the microammeter to prevent the flow of excessive current in case the loop under test is open or short-circuited.

During periods when the test attendant is operating toward the subscriber station, relay 19K or springs of jack 1924 will be operated to interrupt the connection to conductors in the subscriber line circuit which correspond to conductors 1545 and 211 of subscriber line circuit 202, these circuits being carried through the ring spring of jacks 1902 and 1903. If the subscriber loop under test is selected by the director circuit, the originating operator will receive a busy signal because subscriber line test and selection conductor 1934 will be connected to ground through the winding of relay 19H. Relay 19H operates and lights trunk test inward call lamp 1921. If the attendant removes the monitoring teletypewriter from jack 1924 and restores key 1919 or removes the patching cord from the subscriber line jack, such as jacks 207 and 208 of subscriber line circuit 202, the operator will be able to complete on her reconnection for verification of the busy condition. If the patching cord has been removed from subscriber line jack the operator will complete to the subscriber station. If the patching cord is left up, that is, inserted in the subscriber line jack, and the monitoring set disconnected, the call will be completed to this test circuit, the ring signal operating relay 19E to again operate lamp 1921. The call may be answered by connecting the teletypewriter to jack 1922 and operating trunk test answering key 1904.

Milliammeter 1909 may be seized by a patching cord connected to jack 1908 and used with the line and balancing jack of the trunk terminating equipment to indicate current conditions, for trunk 801, line jack 917 and balancing jacks 918 and 919 may be used. Care should be taken to prevent patching the milliammeter into circuit with current higher than say 25 milliamperes unless the jack is equipped with the proper shunts.

Test attendant's line

A subscriber line circuit will be associated with the test circuit with an optional appearance at the testboard. When a call is completed to this circuit the ringing current will operate the subset, or ringer, 1938 directly, or in case the testboard appearance is supplied, will operate relay 19C which in turn will operate relay 19B. Relay 19B, upon operating, will lock to a back contact at the outer right-hand armature of relay 19A, supplying ringing current to operate the subset, or ringer, and supply battery to light a lamp at the testboard appearance. When the call is answered at either appearance relay 19A operates, (1) releasing relay 19B, (2) connecting, say 130-volt battery, to the ring conductor to operate the SP relay in the trunk terminating circuit, say trunk 8SP in trunk 801, and (3) disconnecting the ringing receiving equipment from the tip conductor 1935. By operating the attendant's line hold key 1936 it is possible to hold a connection even though the teletypewriter is disconnected from attendant's line teletypewriter jack 1937. In cases where it is desirable to furnish two-outlet operation, that is, with two groups of trunks, one group extending to each of two central offices, an additional Fig. 19 is required and will be used with two subscriber lines, one assigned to each outlet. In the case of two-outlet operations, a single subset, or ringer, 1938 will be used and a call lamp will be associated with each attendant teletypewriter jack appearance, such as jack 1937.

As used herein, a "half-duplex" line, trunk or channel is a line trunk or channel equipped and terminated so that sending contacts at one end may transmit to a receiving relay or instrument at the other and vice versa but in which transmission in both directions may not be accomplished at one and the same time; it is roughly synonymous with what is sometimes called "simplex" and is to be distinguished from "duplex" in which two oppositely directed transmissions and receptions are independent of each other.

What is claimed is:

1. A telegraph system including a central office, a satellite office, one or more two-way communication trunks extending therebetween, a plurality of outlying stations, a telegraph line extending between each said station and said satellite office, each of said trunks consisting of one transmission conductor only normally terminated in identical potentials during the idle condition, and means to automatically seize an idle one of said trunks upon a call from one of said stations and extend said call to said central office by applying a potential condition to the satellite office end of said trunk different from that applied in the normal idle condition.

2. A telegraph system including a central office, a satellite office, one or more trunks extending therebetween, a plurality of outlying stations, a telegraph line extending between each said station and said satellite office, each of said trunks consisting of one communication conductor only and an induction balancing conductor therefor normally interconnected and normally terminated in identical potentials at each end in the normal idle condition, means under control of a subscriber for seizing one of said trunks and associating it with the line from his station to the satellite office to extend a call to the central office, means at the central office for answering said call, said last-named means comprising means for establishing a half-duplex telegraphing condition upon said trunk upon answering.

3. A telegraph system including a central office, a satellite office, one or more conductive trunks extending therebetween and each consisting of one telegraph communication conductor only, a plurality of outlying stations, a telegraph line extending between each said station

and said satellite office, switching means operative under control of a branch station for extending a call over one of said lines through said satellite office to the central office via said one only conductor of one of said trunks, means for extending a call under control of said one of said trunks via one of said lines selectively to one of said stations, and means for answering either of said calls to set up a communication path over said one only conductor of the trunk chosen under either condition, said trunk comprising a section subjected to a variable leakage resistance, means for applying three signaling conditions thereto, and means for adjusting the potentials for causing said signaling conditions so that the potential across the effective leakage resistance of said line is of substantially the same magnitude for all of said signaling conditions.

4. A telegraph system including a central office, a satellite office, one or more trunks extending therebetween and each comprising one telegraph communication conductor only, a plurality of outlying stations, a telegraph line extending between each of said stations and said satellite office, means for establishing a calling condition at one of said stations, means operative under control thereof to seize an idle said one only conductor of one of said trunks and associate it with said line in a path of intercommunicative relation, call responsive means at said central office for extending said path to transmission and reception means in said central office, one only conductor of said trunk providing a single half-duplex channel of communication.

5. A telegraph system including two central offices, an interoffice trunk therebetween for telegraphic intercommunication, said trunk being exposed to interfering potentials of the class of induced or ground potentials, said trunk comprising one communicative conductive path only for intercommunication and having an idle condition and a call condition, one balancing conductive path only extending parallel to said one communicative path, said communicative path and said balancing path in the idle condition being interconnected and having grounded connections at their terminals, said communicative path in call condition being automatically separated from said balancing path, extended through appropriate current responsive means and impedances, and terminated by a source or sources of operating voltage, and switching means whereby said balancing conductive path is equally and oppositely under call condition extended through the same current responsive means, extended through substantially equal impedances, and terminated by ground connections.

6. A telegraph system including two central offices, an interoffice trunk interconnecting said offices for telegraphic intercommunication, said trunk being exposed to interfering potentials of the class of induced or ground potentials, said trunk comprising a communicative conductive path and having an idle condition and a telegraphing marking condition, a balancing conductive path extending parallel to said communicative path, said communicative path and said balancing path in the idle condition being interconnected and having grounded connections at their terminals, said communicative path in telegraphing marking condition being automatically separated from said balancing path and extended through appropriate current responsive means and impedances, and terminated by a source or sources of operating voltage, and switching means whereby said balancing conductive path is equally and oppositely under telegraphing marking conditions extended through the same current responsive means, extended through equal impedances, and terminated by grounds.

7. A telegraph system including two central offices, an interoffice trunk interconnecting said offices for telegraphic intercommunication, said trunk being exposed to interfering potentials of the class of induced or ground potentials, said trunk comprising one only intercommunicative conductive path and having a marking condition and conditions for spacing in each direction of communication, a balancing conductive path extending parallel to said one communicative path, said communicative path being in each condition extended through appropriate current responsive means and impedances, and terminated by a source or sources of operating voltage, and switching means whereby said balancing conductive path is equally and oppositely under said conditions extended through the same current responsive means, extended through equal impedances, and terminated by grounds.

8. A telegraph system including two central offices, an interoffice trunk interconnecting said offices for telegraphic intercommunication, said trunk being exposed to interfering potentials of the class of induced or ground potentials, said trunk comprising one only intercommunicative conductive path and having a communicative marking condition in each direction of communication and a disconnect condition, a balancing conductive path extending parallel to said communicative path, said one communicative path being in each condition extended through appropriate current responsive means and impedances, and terminated by a source or sources of operating voltage, and switching means whereby said balancing conductive path is equally and oppositely under both conditions extended through the same current responsive means, extended through equal impedances, and terminated by grounds.

9. A telegraph system including a central office, a satellite office, one or more trunks extending therebetween, a plurality of outlying stations, a telegraph line extending between said stations and said satellite office, means operable under control of one of said stations to seize an idle one of said trunks and connect it intercommunicatively to the line of said station to establish a telegraphic communication path to said central office, and means whereby the idle condition of said trunks includes a termination to ground through a relay winding at the central office and a termination to ground through a condenser and the winding of an alternating current relay at the satellite office.

10. A telegraph system including a central office, a satellite office, one or more trunks extending therebetween, each said trunk consisting of one only intercommunication path, a plurality of outlying stations, a telegraph line extending between each of said stations and said satellite office, means operable under control of one of said stations to seize an idle one of said trunks and connect it intercommunicatively to the line of said station to establish a telegraphic communication path to said central office, and means whereby the calling condition established upon said trunk by a call from one of said stations

comprises the application of marking battery at the satellite office and a termination to ground through a supervisory relay at the central office.

11. A telegraph system including an interoffice trunk having an idle condition and a communicating condition, said trunk consisting of a single wire provided for intercommunication and exposed to interfering potentials of a class of induced or ground potentials, said wire being paralleled by a balancing wire, both said wires in the idle condition being interconnected at one office and terminated at the other office in ground, said trunk wire during the communicating condition being terminated at said other office in battery through a path including current responsive relays and impedances, said balancing wire being switched under all supervisory and telegraphing conditions to extend oppositely through the same current responsive relays, through identical impedances and to ground terminations.

12. In a communication system, a central office, a switching center, a plurality of outlying stations, a local communication circuit connecting each of said outlying stations to said switching center, a plurality of single wire intercommunication circuits connecting said switching center to said central office, each of said single wire circuits comprising means for transmitting and receiving communications in opposite directions, and means at said switching center for automatically interconnecting any one of said single wire circuits and one of said local circuits regardless of the direction of the call to establish said connections.

13. In a communication system, a central office, a switching center, a plurality of outlying stations, a local communication circuit connecting each of said outlying stations to said switching center, a single wire communication circuit interconnecting said central office and said switching center, said single wire circuit comprising means for transmitting and receiving communications in opposite directions and non-locking through supervisory means in said single wire circuit, in combination with means for automatically extending a call from any one of said stations over said single wire communication circuit, and means for selectively extending over said single wire communication circuit a call to any one of said outlying stations.

14. In a communication system, a central office, a switching center, a plurality of outlying stations, a local communication circuit connecting each of said outlying stations to said switching center, a single wire intercommunication circuit connecting said switching center to said central office, said single wire circuit comprising means for transmitting and receiving communication over each of said local circuits in opposite directions, and an additional single wire of substantially zero potential for its entire length during normal operation, provided for each single wire intercommunication circuit between said center and said office for neutralizing electrical effects induced in its respectively associated intercommunication circuit, from extraneous sources of voltage.

15. In a telegraph system, a central office, a switching center, a plurality of outlying stations local to said switching center, a communication circuit connecting each of said outlying stations to said switching center, any suitable number including one or more single wire intercommunication circuits each arranged for transmission communication in opposite directions and connecting said switching center to said central office, an artificial line for each of said single wire circuits, a receiving relay for each of said single wire circuits having differentially arranged windings respectively connected to said artificial line and its associated single wire circuit, an additional single wire, grounded at each end, provided for each single wire intercommunication circuit of said plurality for neutralizing electrical effects induced in its respectively associated single wire intercommunication circuit, from extraneous sources of voltage, another artificial line for each of said additional single wires, each of said additional single wires and its associated artificial line being arranged differentially with respect to each other on said receiving relay.

16. In a telegraph system arranged to operate with spacing and marking signals, a central office, a plurality of subscribers' stations connected to said central office, a switching center, outlying stations connected to said switching center, single wire intercommunication circuits interconnecting said switching center and said central office, each of said single wire circuits comprising at the switching center end a normal ground connection and at each end means for repeating spacing and marking signals into the single wire circuits, relay means at said central office and said switching center responsive to a prolonged space signal of a predetermined duration transmitted from any one of said subscribers' stations to hold intact at said central office and said switching center an established connection between any one said subscriber's stations and any one of said outlying stations, a source of variable current at said central office, other relay means at said central office responsive to a space signal of greater duration than that of said prolonged signal for causing a current from said source to be transmitted to said one outlying station, and a signal element at said one outlying station responsive to the variable current from said source for furnishing an indication at said outlying station to disconnect the established connection.

17. In a telegraph system arranged to operate with spacing and marking signals, a central office, a plurality of subscribers' stations connected to said central office, a switching center, a plurality of outlying stations connected to said switching center, a plurality of single wire communication circuits interconnecting said switching center and said central office, each of said single wire circuits comprising at the switching center end a normal ground connection and at each end means for repeating both spacing and marking signals into said circuits, a link circuit at said central office connectable to any one of said single wire circuits, a supervisory signal, a source of current for conditioning said supervisory signal when said cord circuit is connected to said one single wire circuit, transmitting means operable through said cord circuit for sending permutation code signals, a director circuit at said switching center for translating permutation code signals into an identifying designation of one of said outlying stations, a source of periodically fluctuating current at said central office automatically connectable to one of said single wire circuits incident to the connection of said cord circuit thereto, a source of potential at said switching center automatically connectable to said one single wire circuit and arranged when so connected to produce a steady marking signal condition on said one single wire circuit, means at said switching center responsive to the ringing

current from said source and effective to cause (1) said director circuit to be receptively associated with said one single wire circuit, and (2) said source of potential to be connected to said single wire circuit in place of said normal ground connection to produce in said single wire circuit a steady marking condition to uncondition said conditioned supervisory signal as an indication that said director circuit is ready to receive permutation code signals from said central office.

18. A telegraph system including a central office, a satellite office, one or more trunks extending therebetween, a plurality of outlying stations, a telegraph line extending between each of said outlying stations and said satellite office, an array of coordinately arranged series of contacts having rows respectively associated with said lines and crossing rows respectively associated with said trunks, another crossing row being associated with a source of "all-trunks-busy" signals, means for automatically extending under control of one of said outlying stations a call through said satellite office via an idle one of said trunks, and means operative under the condition of none of said trunks being idle to close a set of said coordinate contacts individual to said one calling outlying station and said other crossing row.

19. A system including a cross bar switch having holding magnets and selecting magnets, a plurality of teletypewriters individual to the holding magnets, telegraphic impulse trunks individual to certain of the selecting magnets, a source of telegraphic code signals, individual to other of said selecting magnets and means responsive to the operation of one of said holding magnets and one of said other selecting magnets for connecting said source to the teletypewriter individual to said one holding magnet.

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