Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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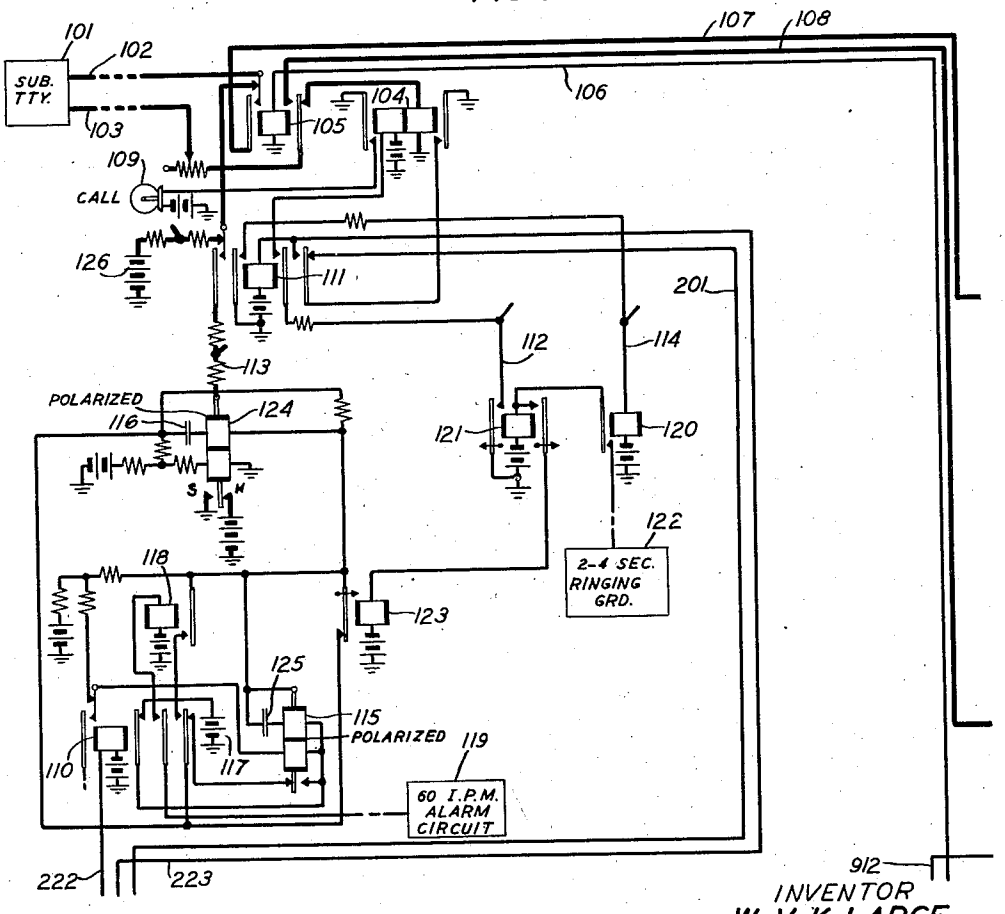
FIG. 21

FIG. 1	FIG. 5	FIG. 7	FIG. 9	FIG. 11	FIG. 13	FIG. 15	FIG. 17
FIG. 2	FIG. 6	FIG. 8	FIG. 10	FIG. 12	FIG. 14	FIG. 16	FIG. 18
FIG. 3							FIG. 19
FIG. 4							FIG. 20

FIG. 1



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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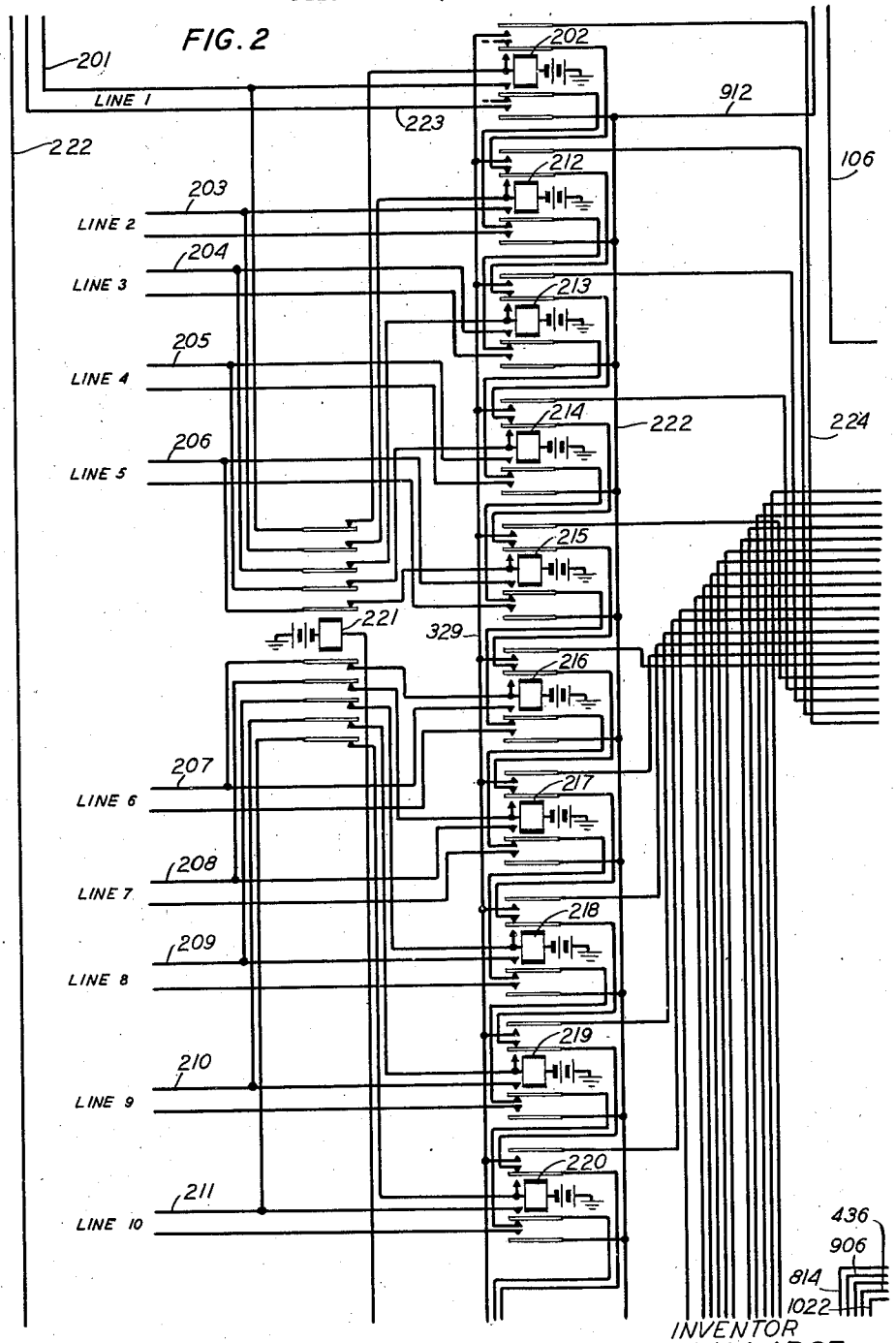
FIG. 2



INVENTOR
W. V. K. LARGE

BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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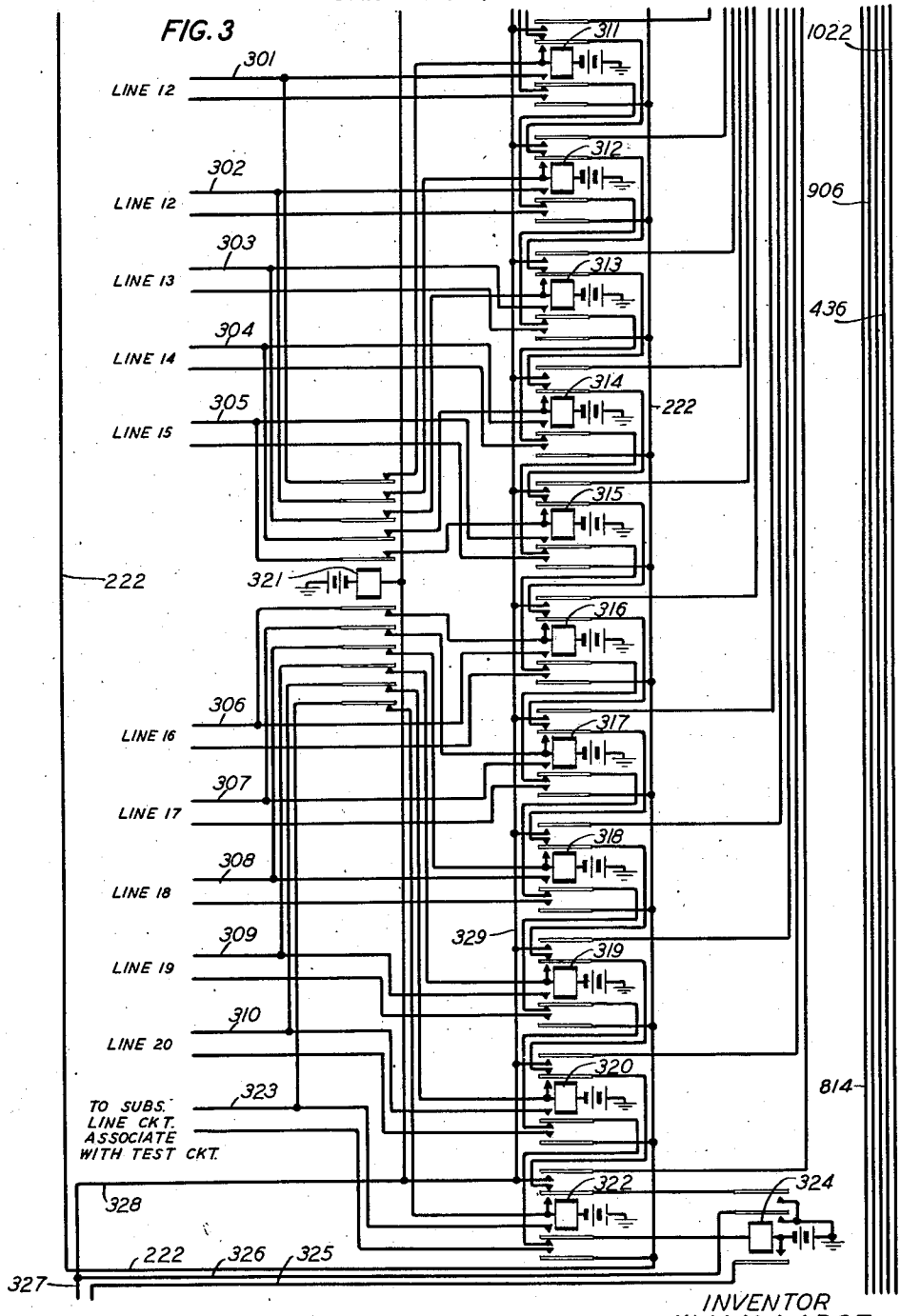
FIG. 3



INVENTOR
W. V. K. LARGE

BY

J. W. Schmied

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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FIG. 4

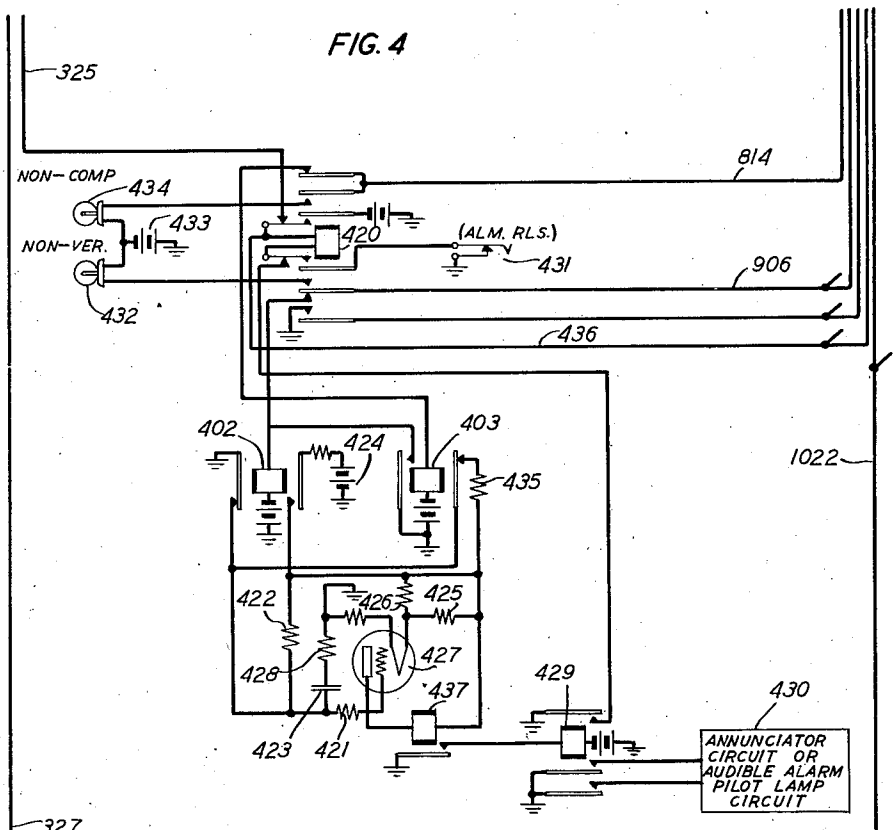


FIG. 4-A

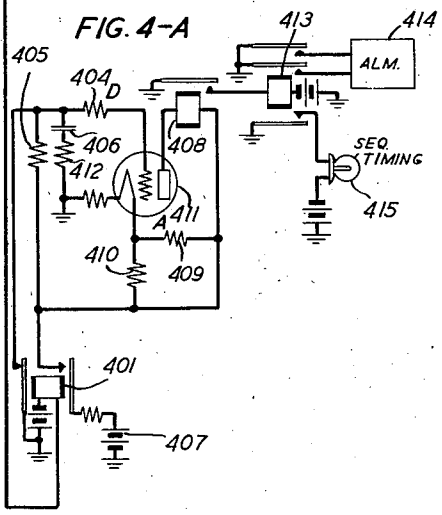
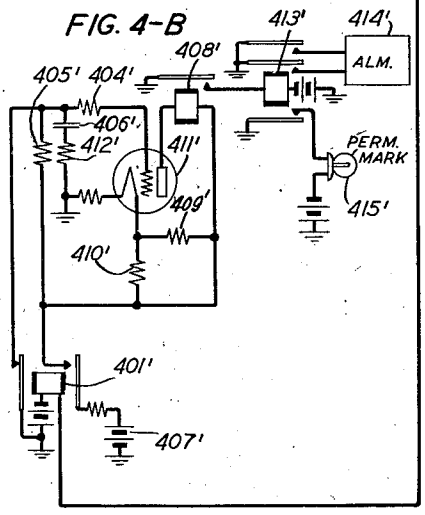


FIG. 4-B



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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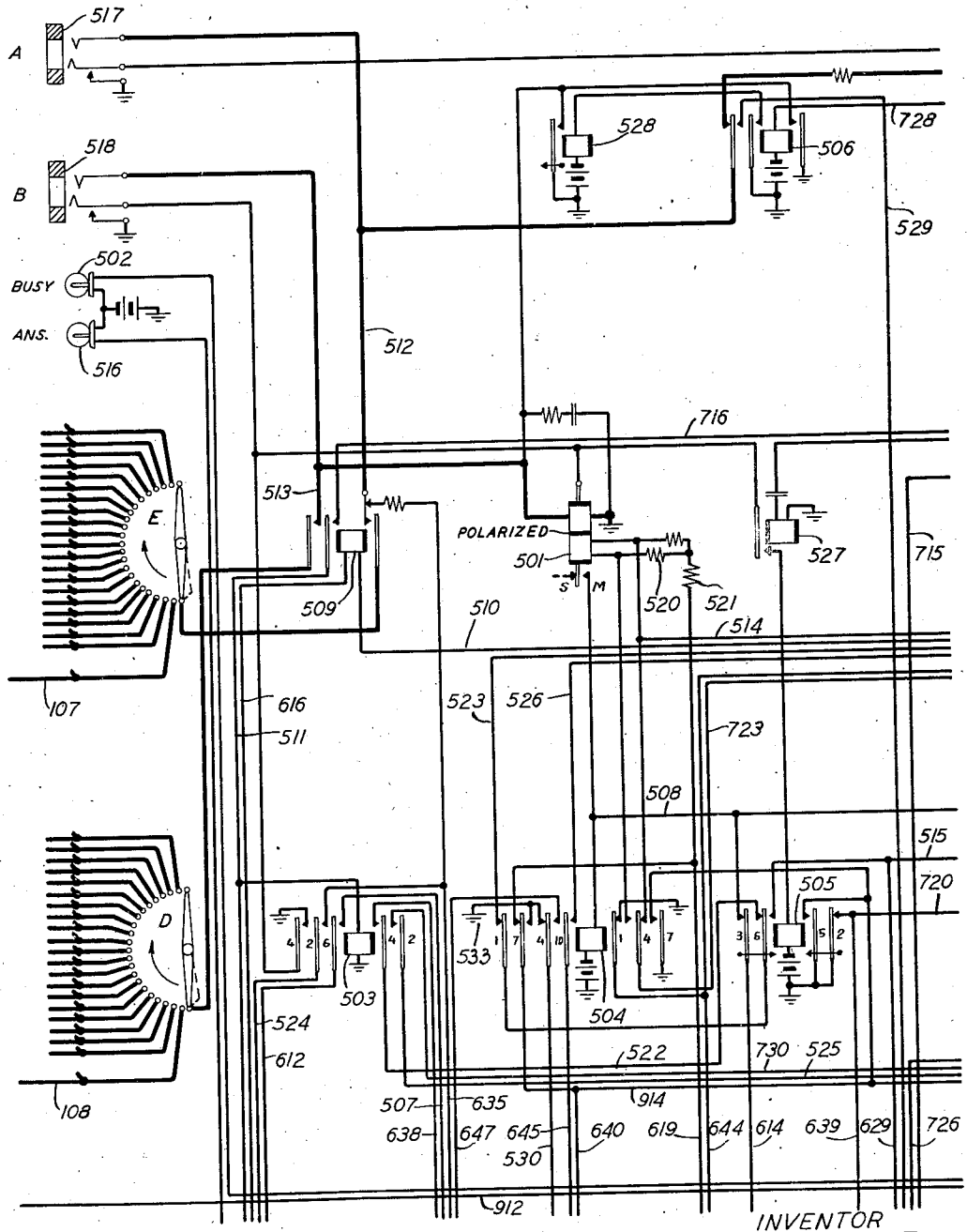
FIG. 5



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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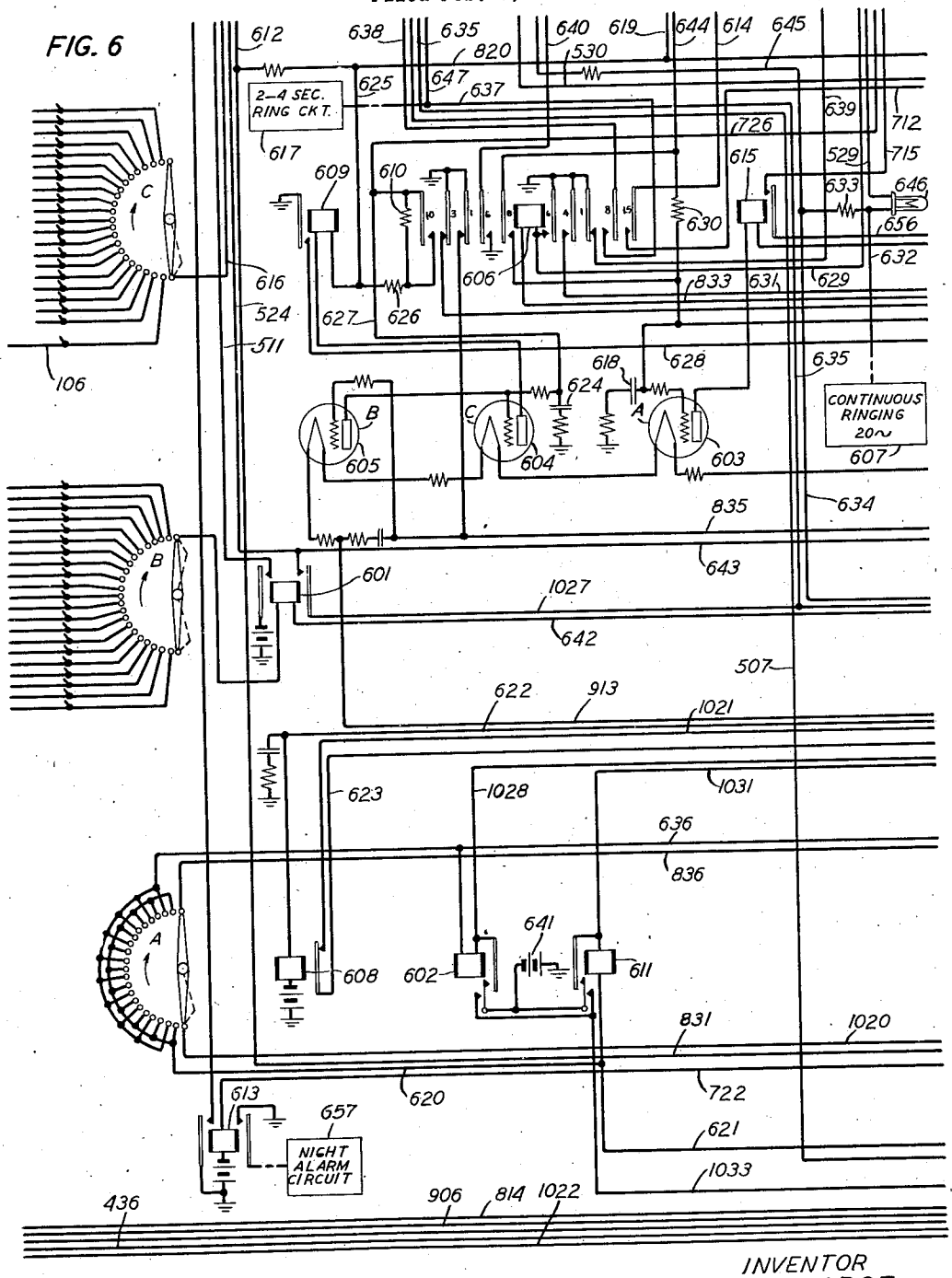
FIG. 6



INVENTOR
W. V. K. LARGE

BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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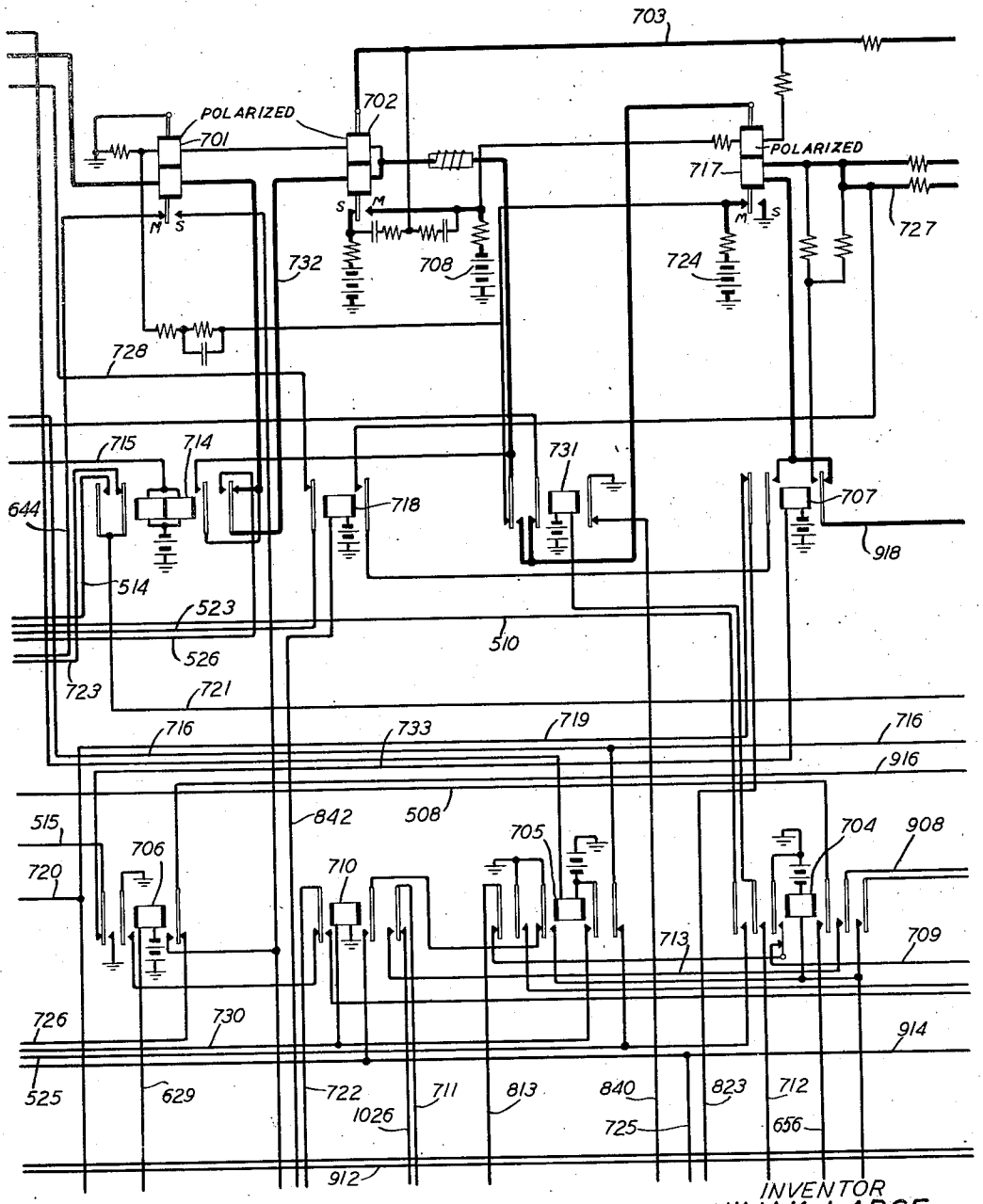
FIG. 7



INVENTOR
W. V. K. LARGE

BY

J. W. Schmied

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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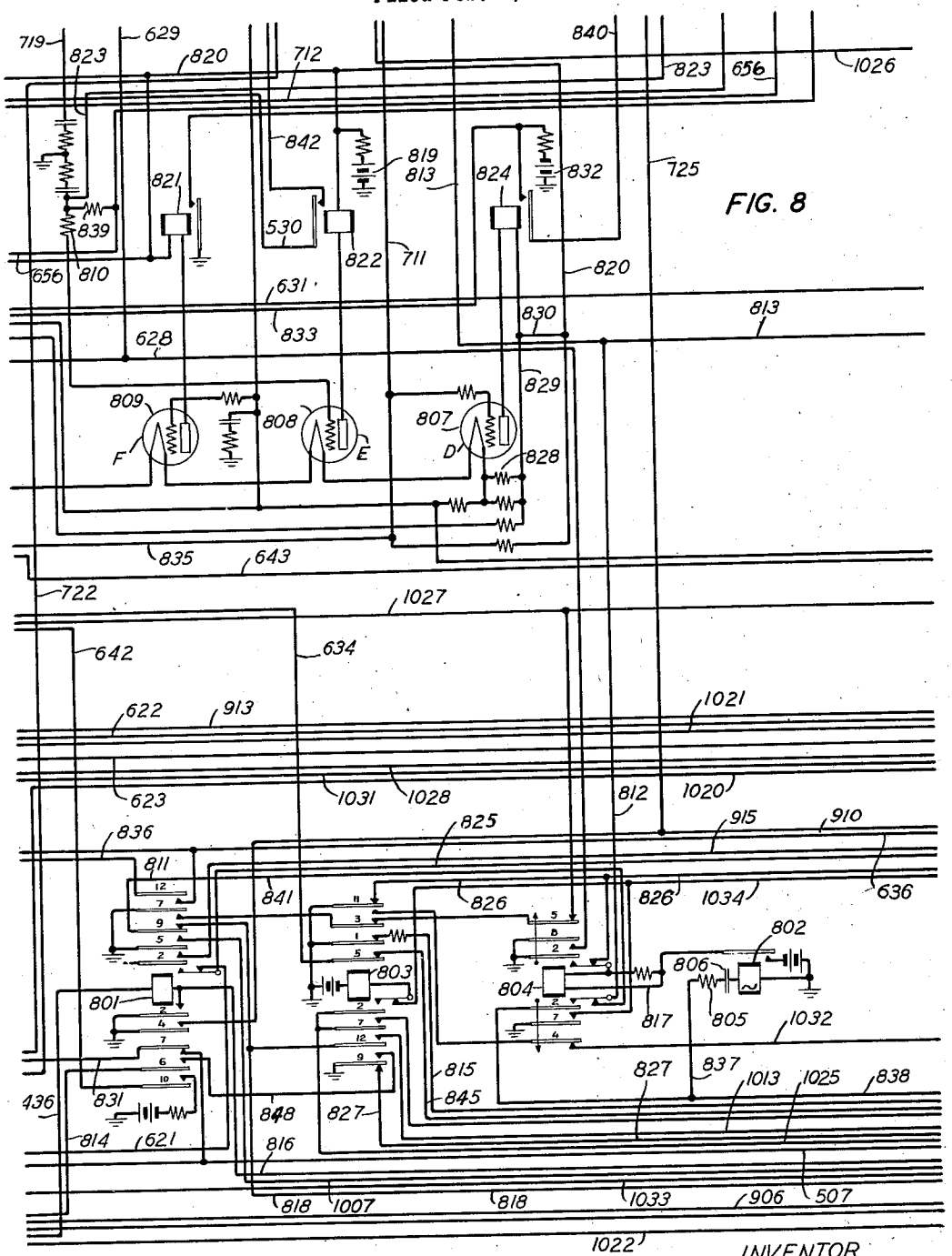

FIG. 8

INVENTOR
W. V. K. LARGE

BY

J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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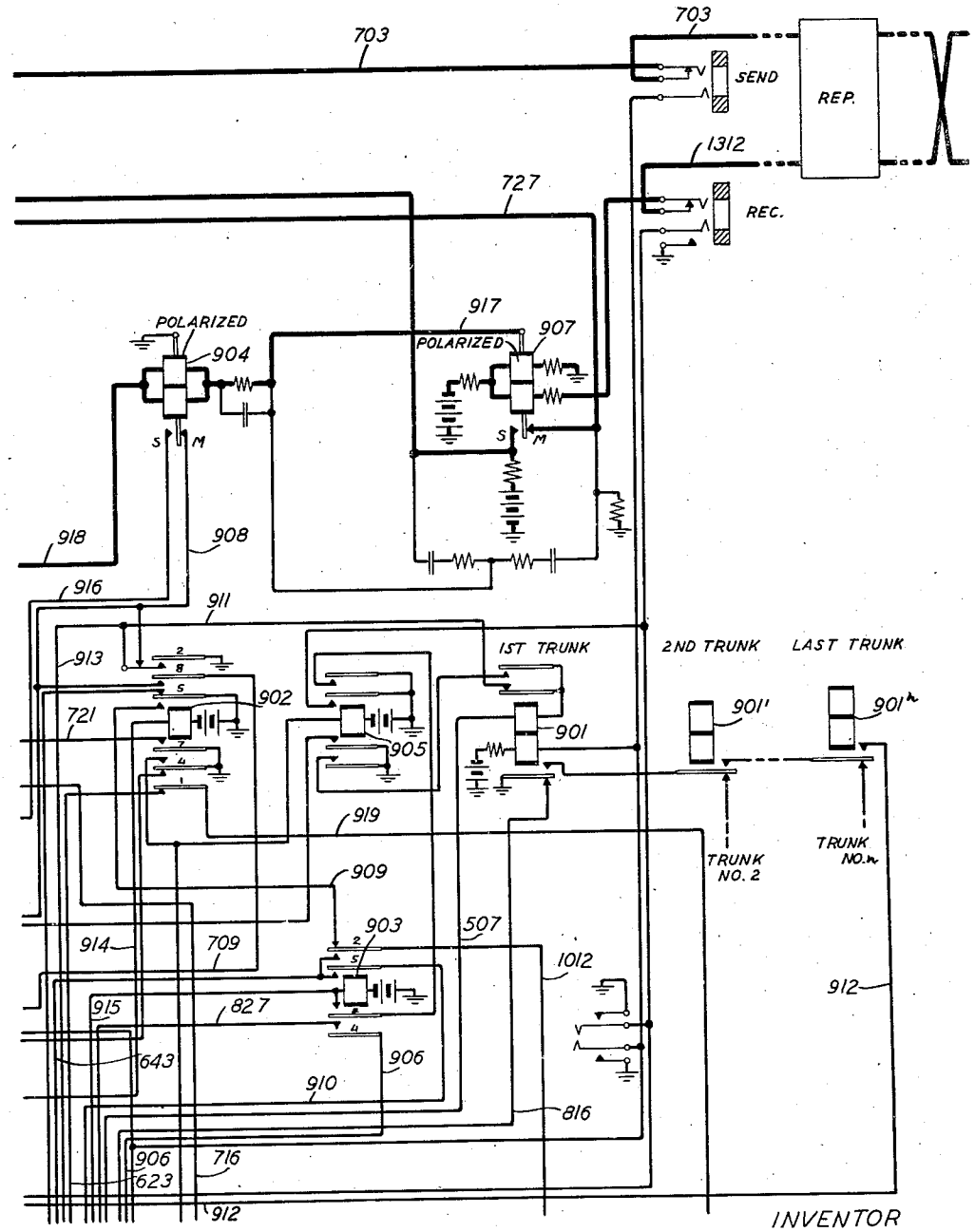
FIG. 9



INVENTOR
W. V. K. LARGE

BY

J. W. Schmied

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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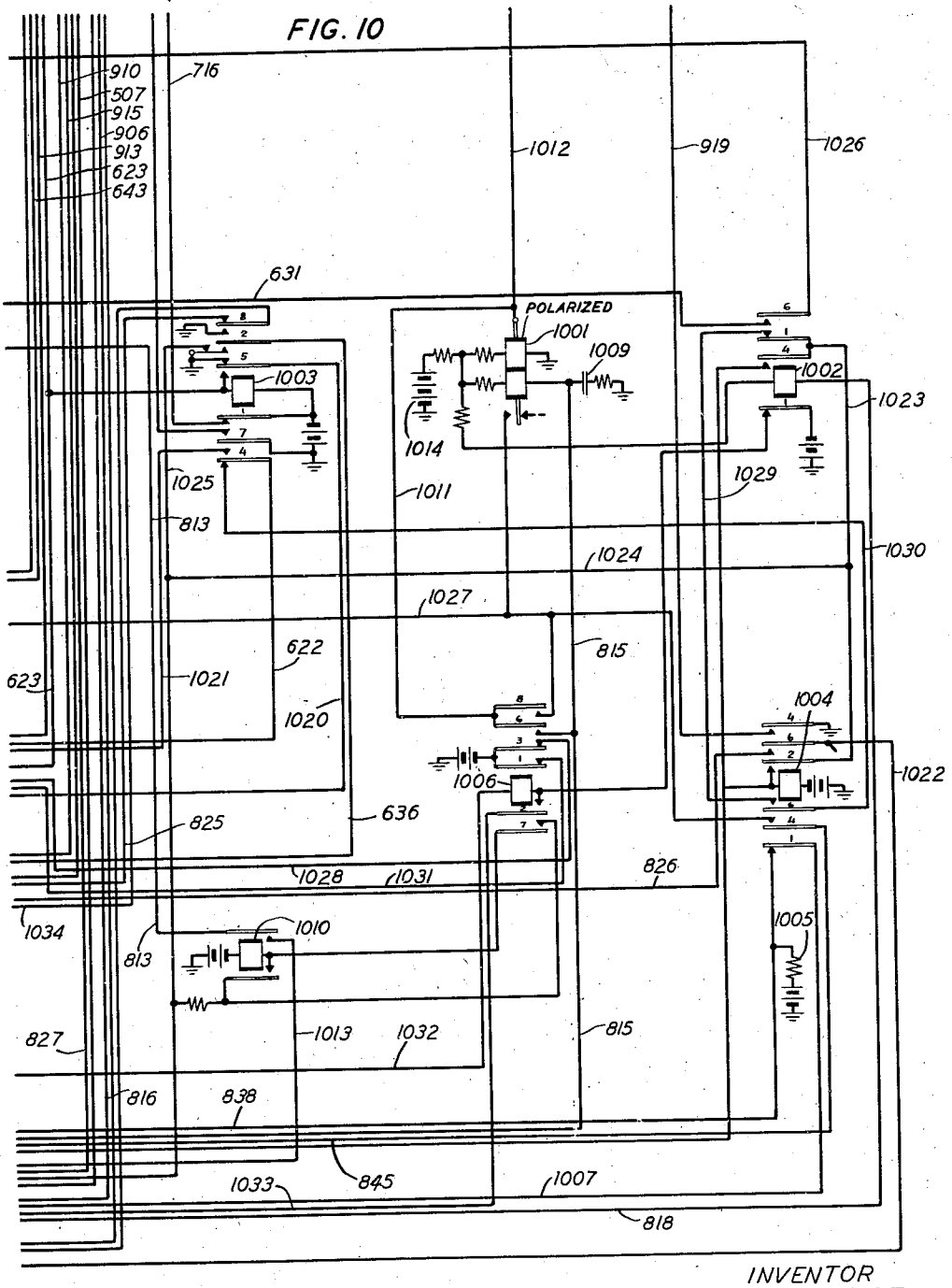
FIG. 10



INVENTOR
W. V. K. LARGE

BY

J. W. Schmidt

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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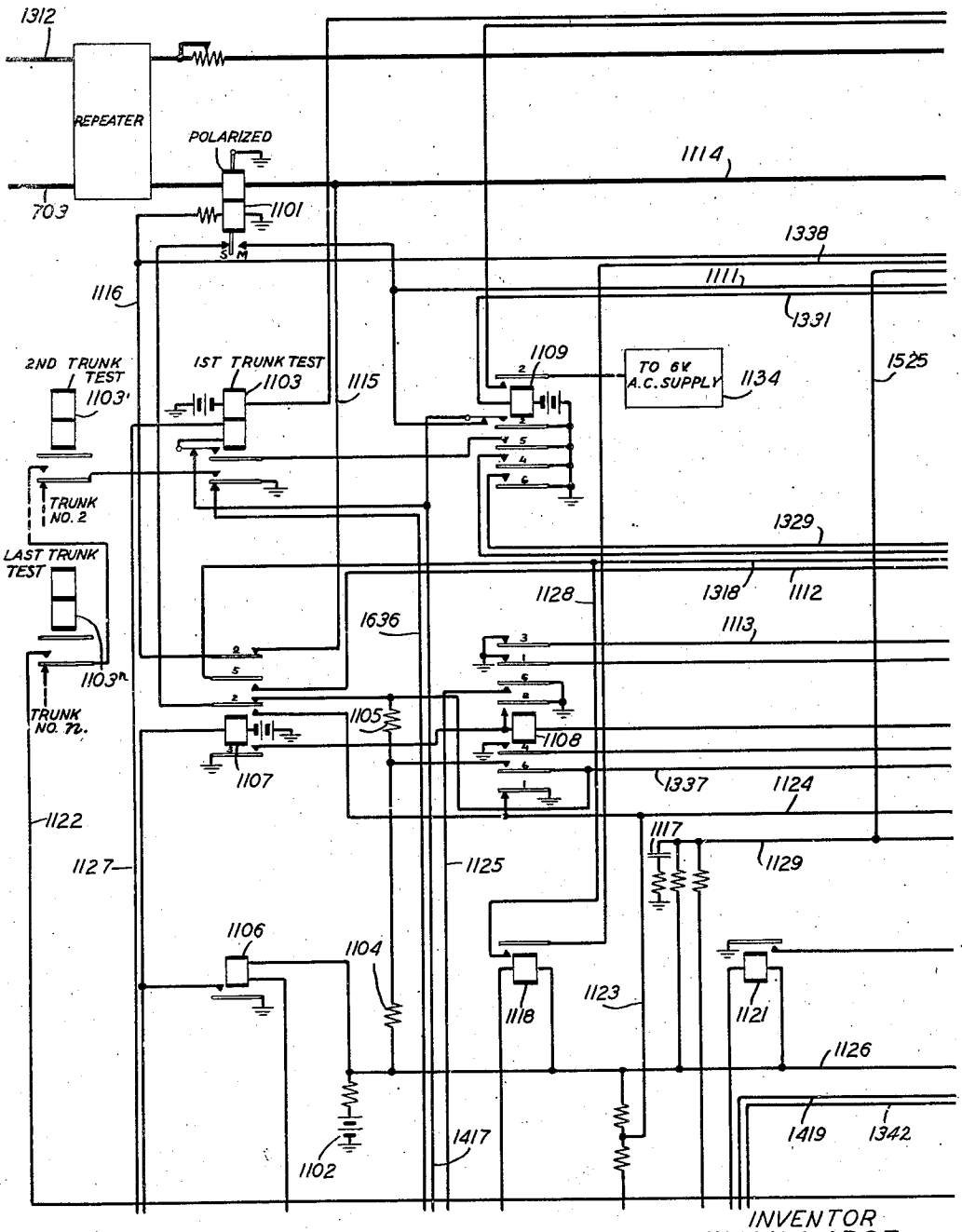
FIG. 11



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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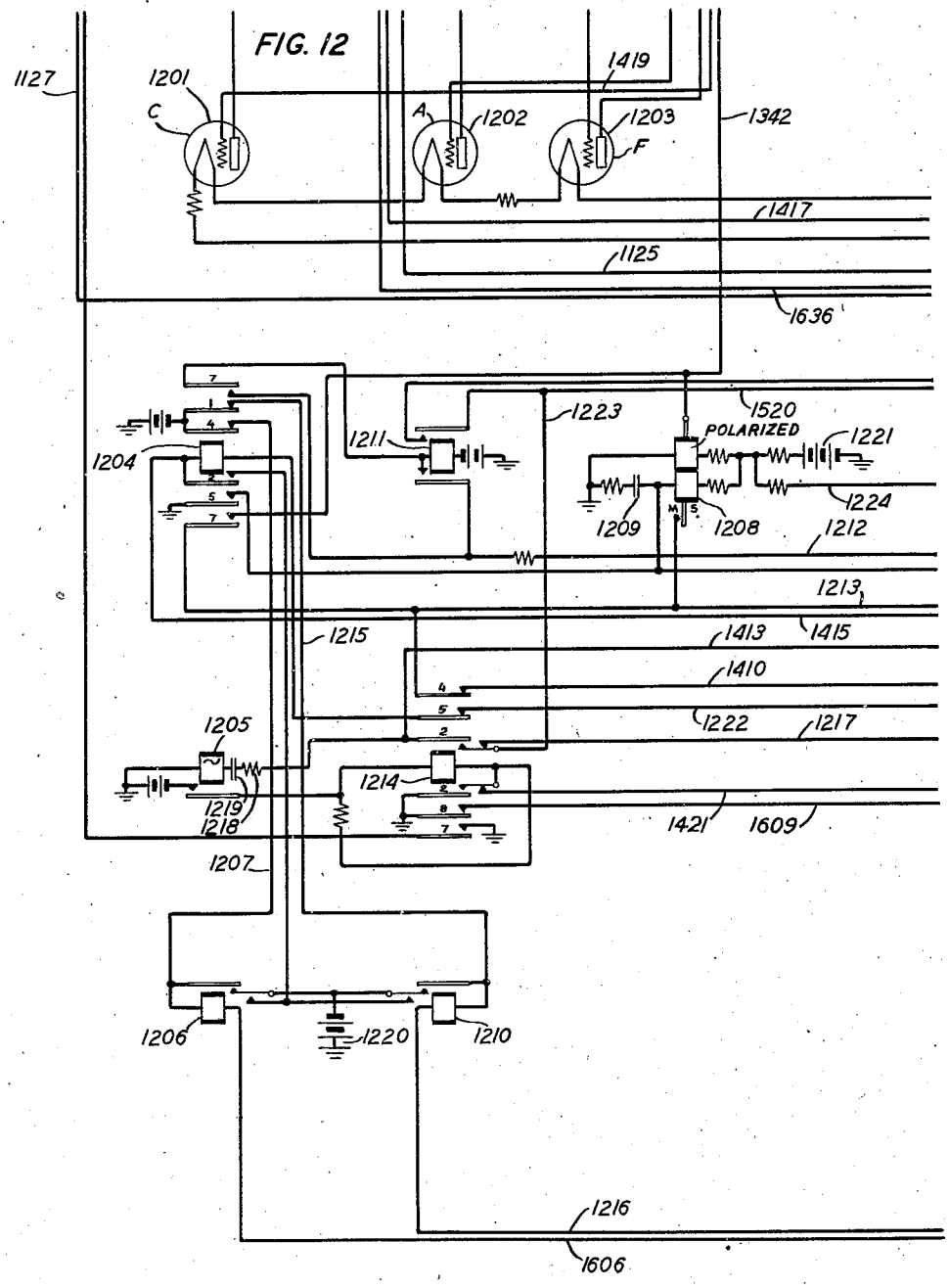
FIG. 12



INVENTOR
W. V. K. LARGE
BY
J. W. Schmeck
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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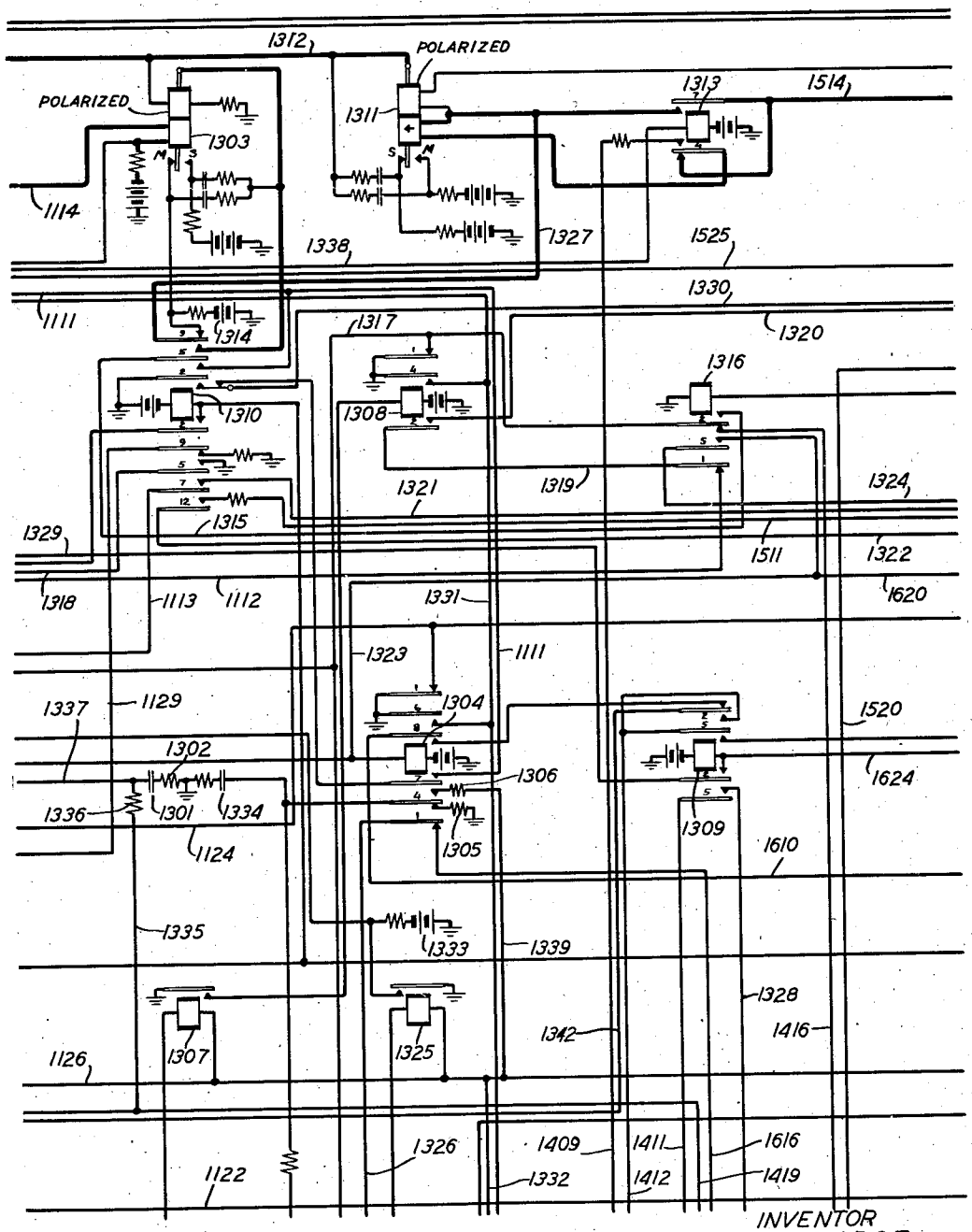
FIG. 13



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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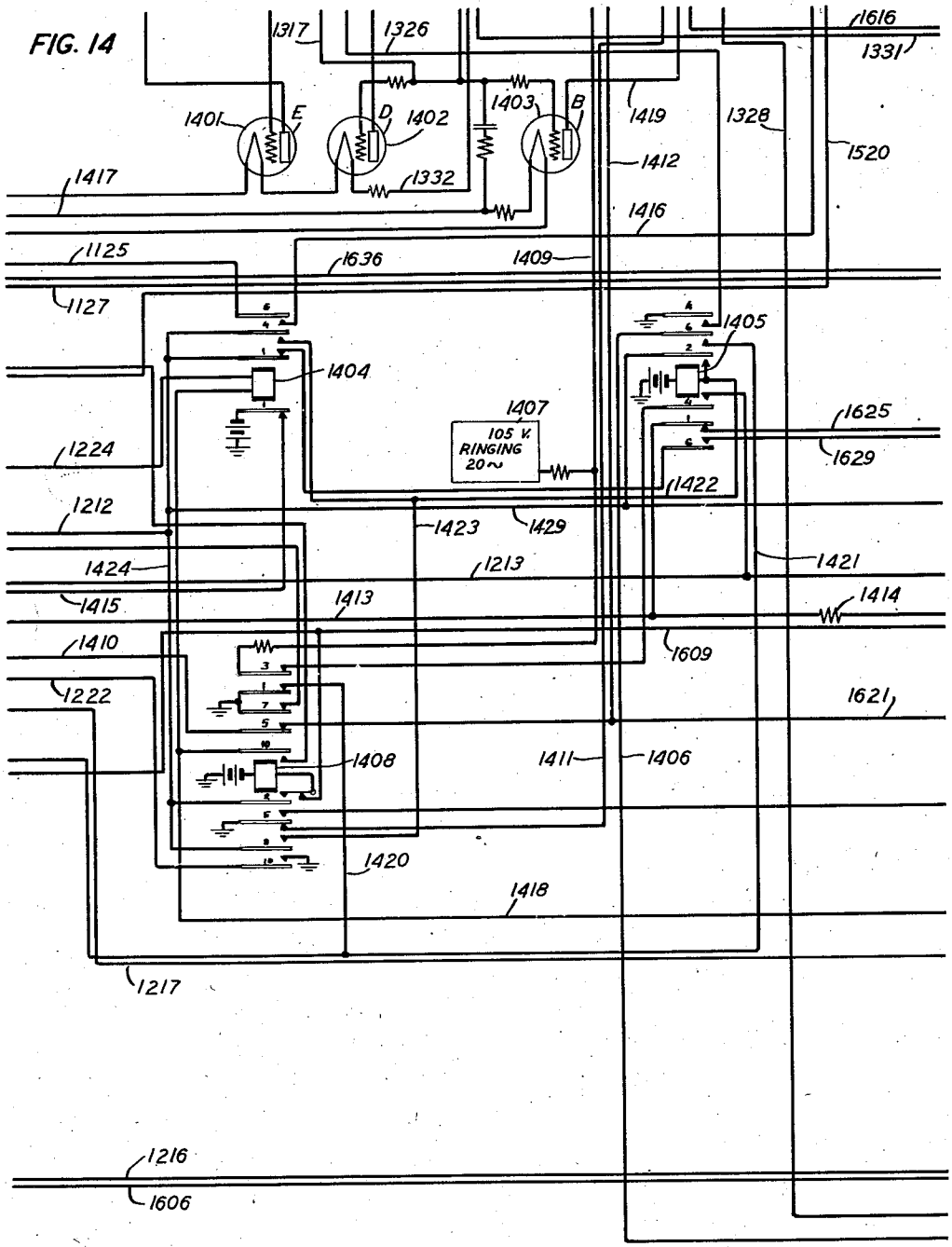
FIG. 14



INVENTOR
W. V. K. LARGE

BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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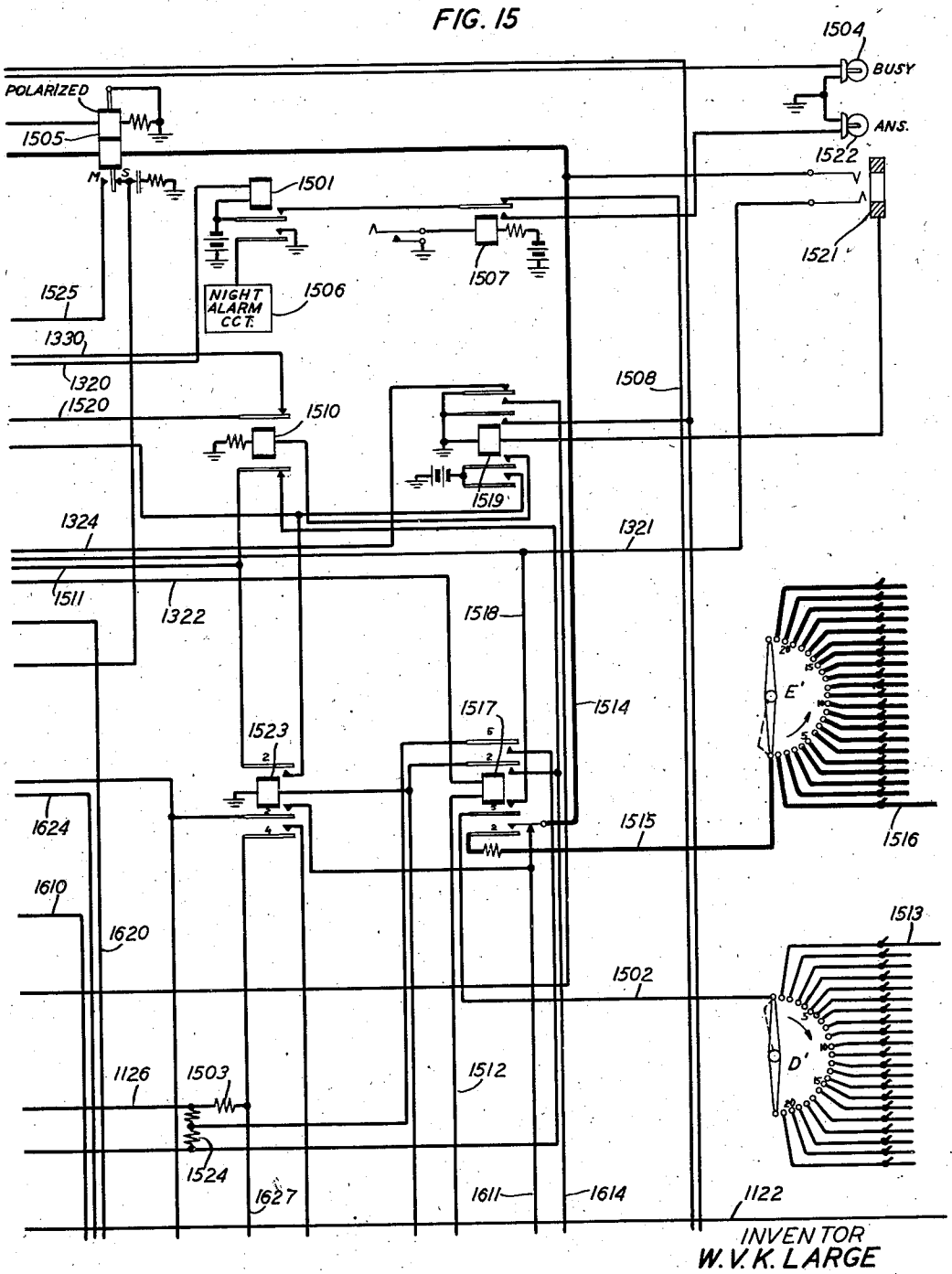
FIG. 15



INVENTOR
W. V. K. LARGE

BY

J. W. Schmied

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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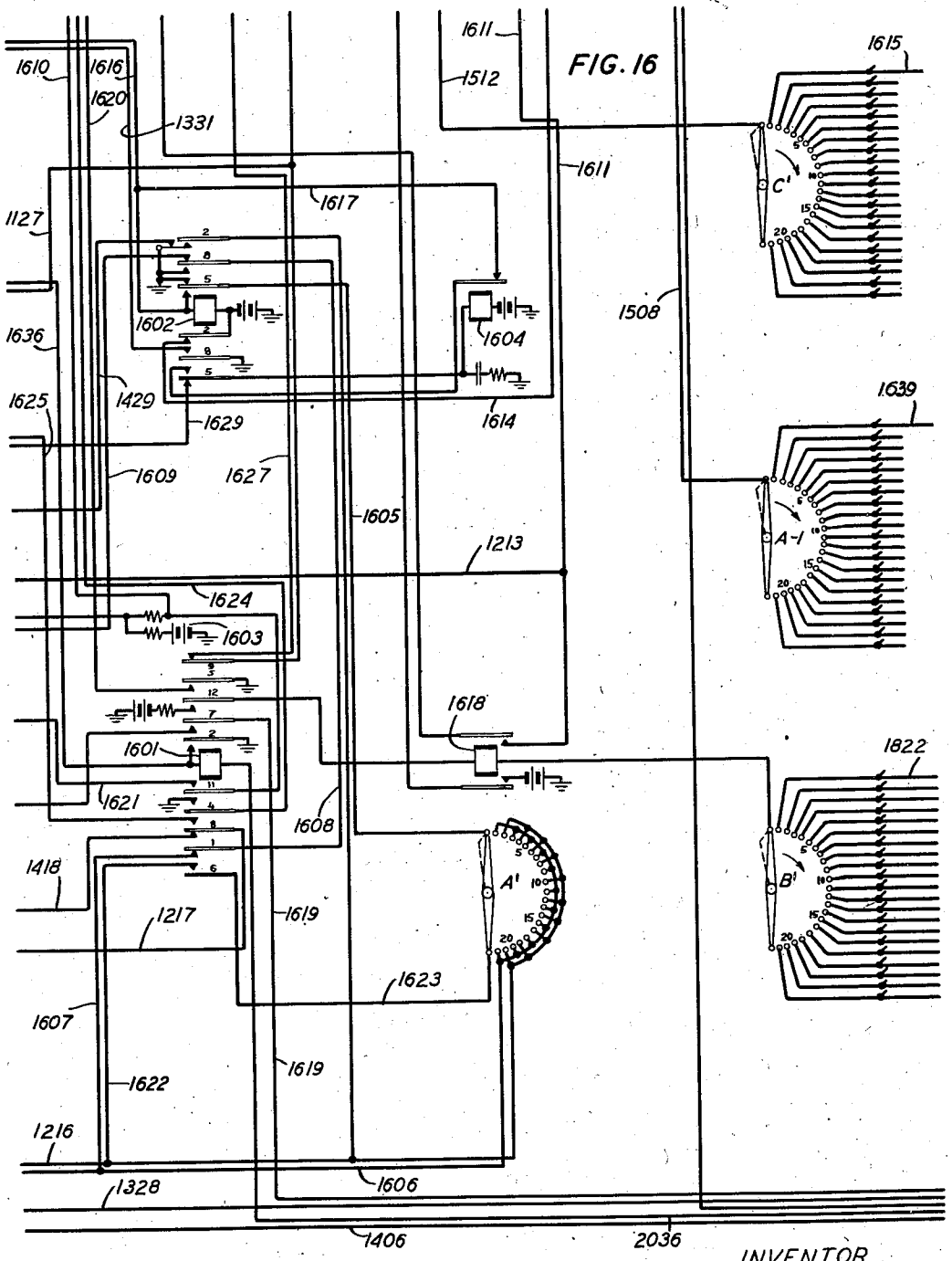
FIG. 16



INVENTOR
W. V. K. LARGE
BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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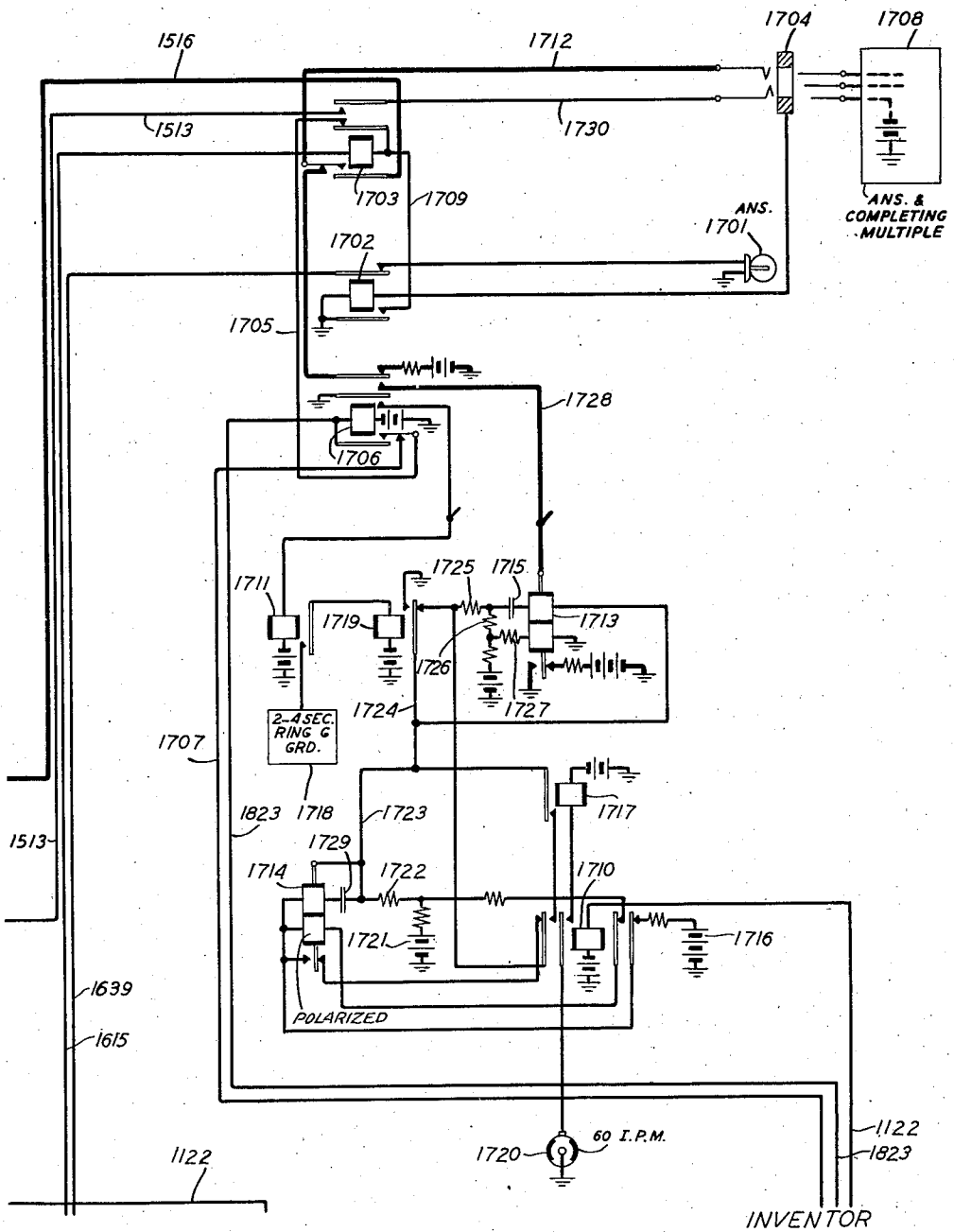
FIG. 17



INVENTOR
W. V. K. LARGE

BY

J. W. Schmeid

ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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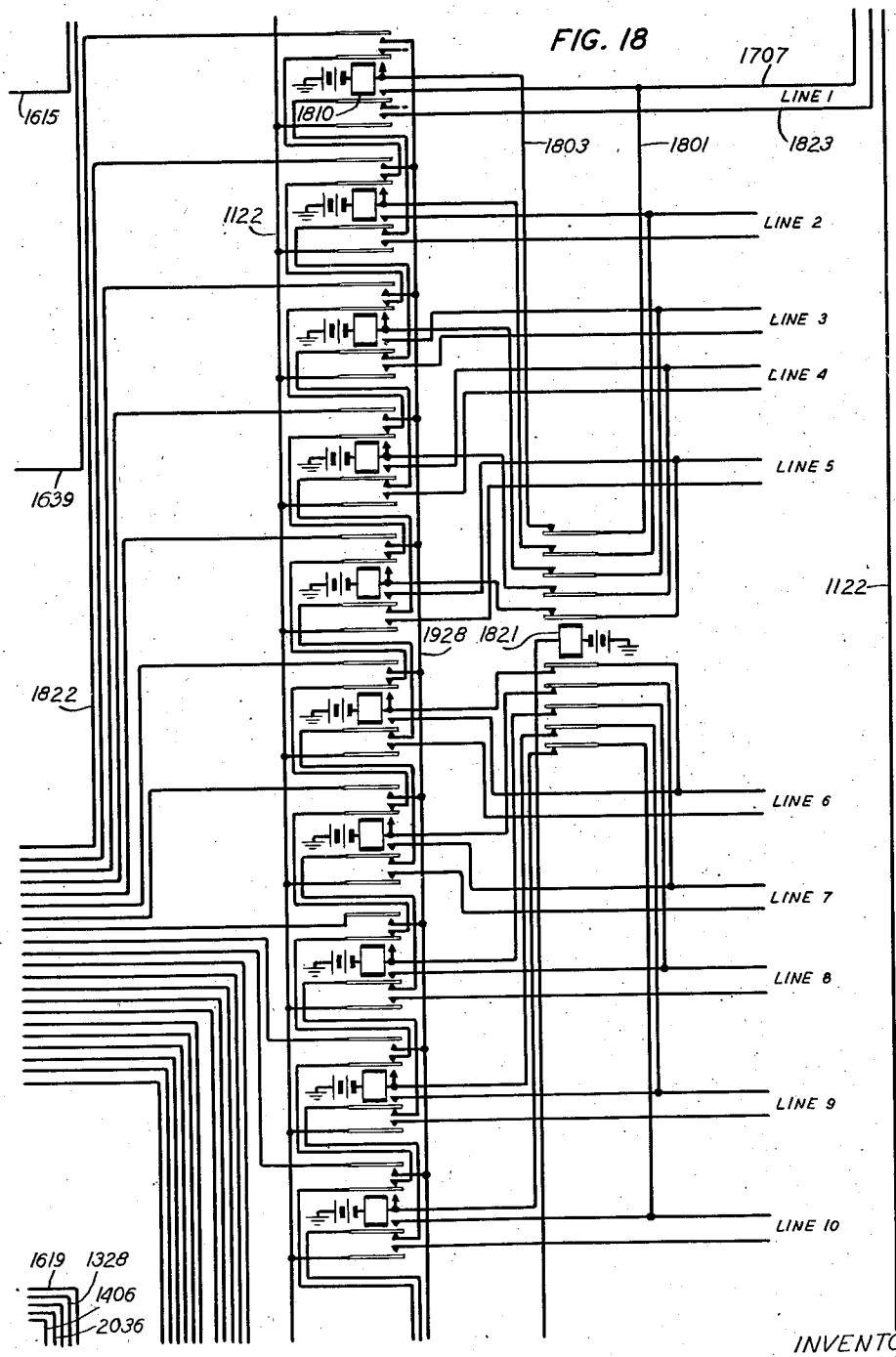
FIG. 18



INVENTOR
W. V. K. LARGE

BY J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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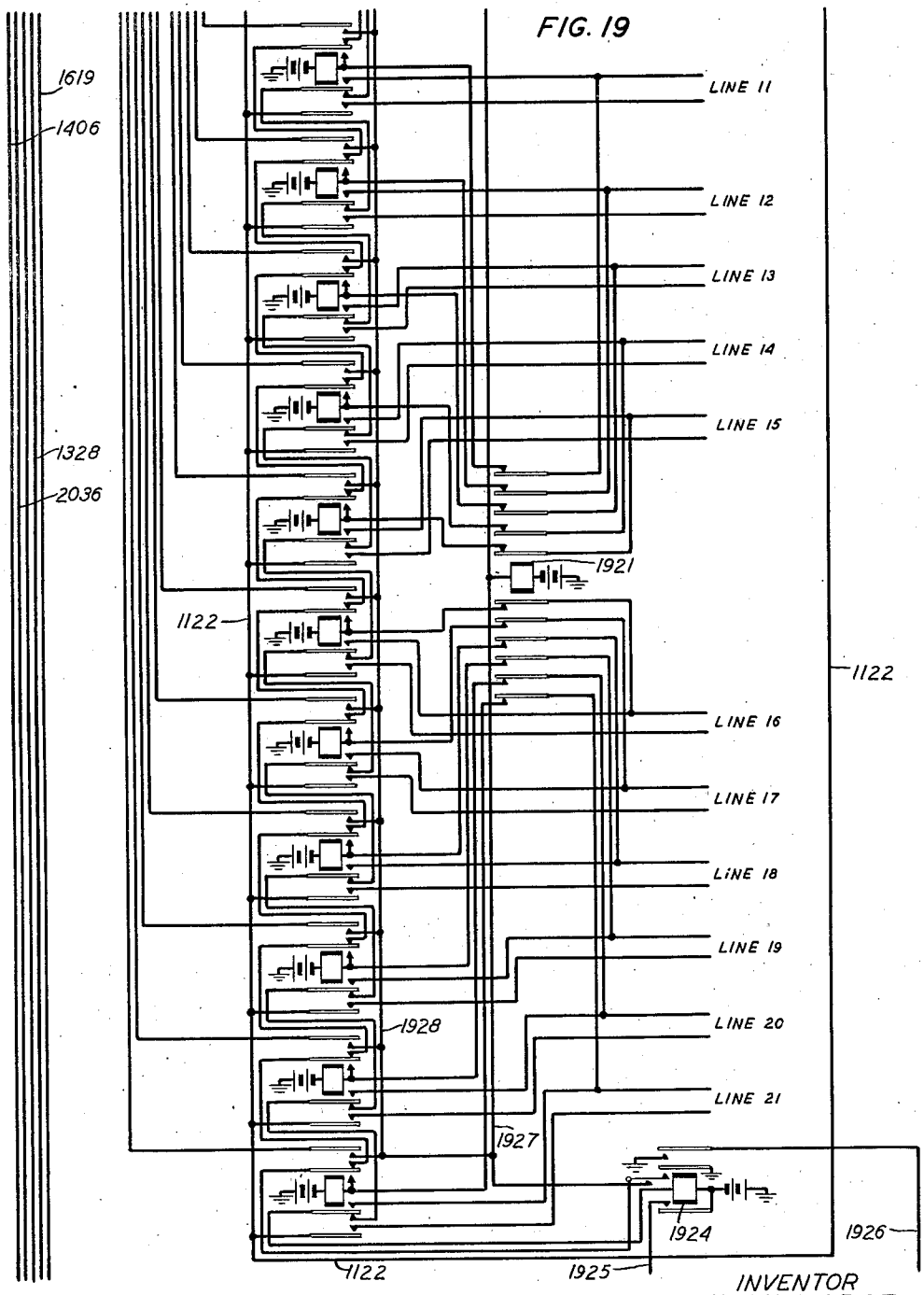
FIG. 19



INVENTOR
W. V. K. LARGE

BY
J. W. Schmied
ATTORNEY

Aug. 15, 1944. W. V. K. LARGE 2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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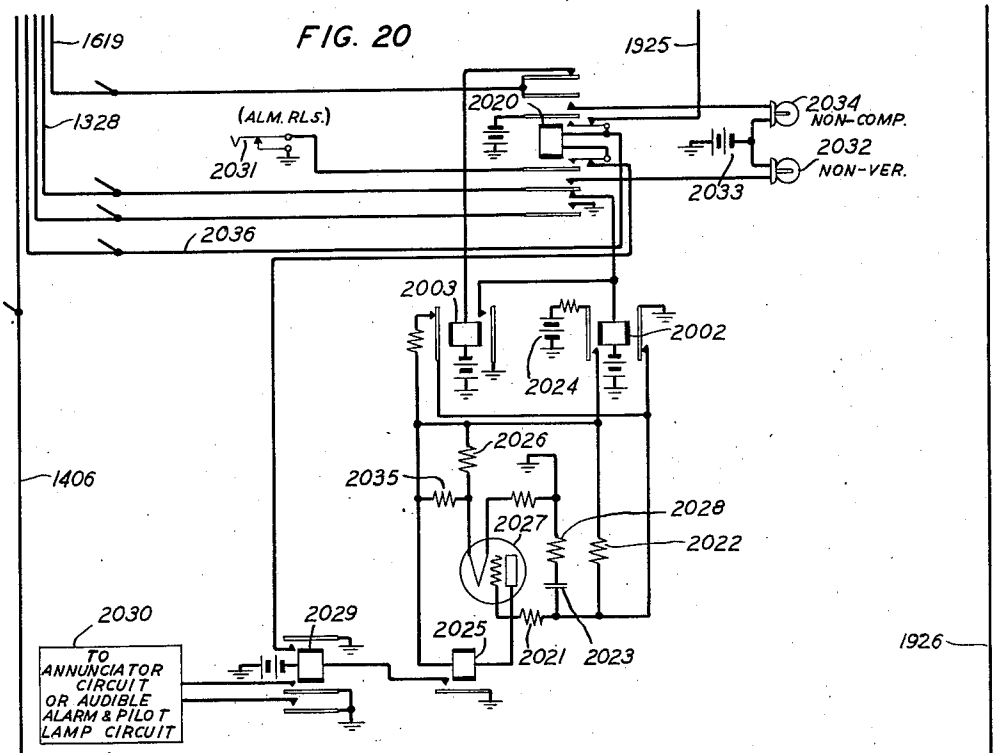
FIG. 20



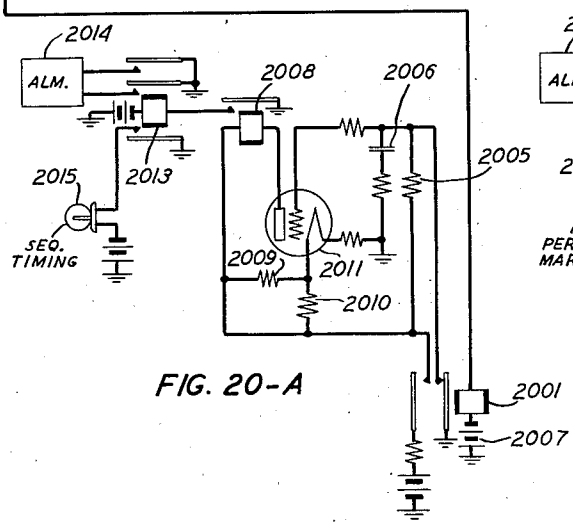


FIG. 20-A

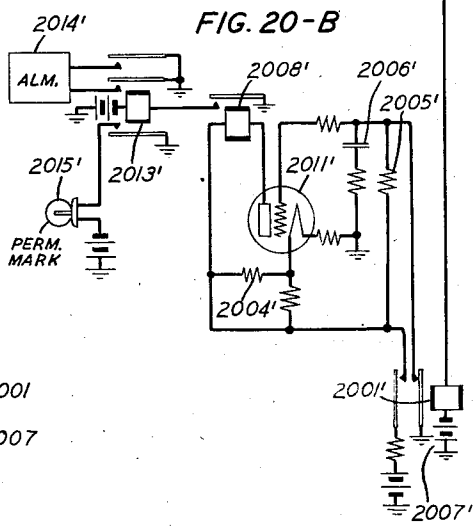


FIG. 20-B

INVENTOR
W. V. K. LARGE

BY J. Wolchmiel

ATTORNEY

Patented Aug. 15, 1944 2,356,067

UNITED STATES PATENT OFFICE

2,356,067

SATELLITE OFFICE TELEGRAPH SWITCHING SYSTEM

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

Application February 7, 1941, Serial No. 377,805

20 Claims. (Cl. 178—2)

The present invention relates to a teletypewriter or printing telegraph exchange system of the type which may be designated an automatic line concentration system or satellite exchange.

The nature of the system in its operational aspects as a whole may be gathered from the operating problem which it is designed to solve. The problem is this: A number of teletypewriter subscribers' stations are located in a region in which the traffic and the number of subscribers does not justify a manual exchange for the reason that to keep the exchange manned with operating personnel for twenty-four hour service and sufficient operating personnel to meet load conditions would not be economically justifiable. The alternative method of extending individual trunks to the nearest central office would require long line equipment and would also not be economically justifiable.

Systems suitable for giving a service of this kind have heretofore been proposed and designed. Among these are the systems disclosed in the application for United States Letters Patent of Fitch et al. Serial No. 173,958, filed November 11, 1937, and Lucek Serial No. 262,158, filed March 19, 1939, now Patent No. 2,228,279, granted Jan. 14, 1941.

These and other previous systems are relatively complex and could not be justified economically for giving service in a region in which only a small number of subscribers' stations is located. One object of the present invention is to provide a simplified arrangement involving less total apparatus and less expensive apparatus for giving service to a still smaller number of subscribers' stations by permitting their extension to a central office over a limited number of trunks from the central office to the satellite switching point. The satellite switching point is located geographically as nearly as may be in the central part of the region to be served thereby.

Although designed for a relatively small number of subscribers' stations and a still smaller number of trunks, a system according to the present invention is not necessarily limited to any exact lower or upper limit of subscribers or trunks and these may be provided or added as the demand for service necessitates. In the disclosed embodiment a limit of twenty subscribers is imposed by the use of a standard type of twenty-step switch.

The system to be described, therefore, involves a teletypewriter central office which may be variously referred to herein as the master office, the central office, TWX board or switchboard; a satellite office which may be referred to at times as a concentrating office; and subscribers' stations.

As will be seen from what follows, a fundamental feature of this present system is that each subscriber's line is represented at the central office by a jack multiple individual to that line and equipment is provided whereby all calls from a particular line terminate at the central office in the jack multiple individual to that line and all calls from the central office initiated by plugging into a jack multiple of an individual line are routed to that line automatically. This eliminates the necessity on the part of the operators at the central office of sending line selecting impulses toward the satellite office to select any particular subscriber's line because this function is performed automatically. Not only is the selective equipment at the satellite office eliminated but the operating procedure on the part of the operators is caused to be substantially identical to the procedure followed in extending a call directly to a subscriber's line which terminates directly at the central office.

The system, which the features of the present invention embody, consists in general of:

1. Subscriber stations

2. A master, or central, office with long telegraph lines or trunks arranged thereat to be automatically switched to circuits respectively terminated at switchboard jacks individual to the subscribers' lines connected at an outlying switching office.

3. An outlying switching office at which a concentrating unit is located for the purpose of terminating a plurality of subscribers' line circuits. The switching at the concentrating office is automatically accomplished to connect said trunks to the subscribers' stations over subscribers' loops or vice versa.

The subscribers' lines disclosed herein are simple local loops but from a more comprehensive viewpoint the principles of the invention may be applied in connection with subscribers' lines of the long line type including telegraph repeaters.

An object of the present invention is to make positive and automatic the selection of any one of a plurality of subscribers' stations at one end of the system and its corresponding jack at the other end.

Heretofore in teletypewriter exchange systems wherein concentrating units are included, there are provisions for automatically connecting at the concentrating office any one of a plurality of local subscribers' stations connected thereto to any one idle trunk of a group which extends to

a remote master office whereat each of said trunks may be terminated at a jack in the operator's switchboard. In these systems a call directed from the master office to a subscriber's station is completed by the following operations; first, an operator seizes a trunk to the satellite office; second, the trunk seizes a director at the satellite office; and, third, the director sends back a director ready signal to the operator, the operator sends selecting codes identified with the particular subscriber's line which seize the line and cause its connection to the trunk and thereupon ringing signals are caused to go out over the line under the control of the central office. It will be noted that these operations involve the seizing and operation of a director and the sending by the operator of line selecting code combinations.

In the present system the director is eliminated and the necessity of sending line selecting codes is avoided. This is accomplished by having at the central office one jack corresponding to each subscriber's line and one set of terminals at the satellite office corresponding to each jack. Stepping switches at each end of the trunk system operate so that upon every subscriber's call the trunk which is assigned to the call associates itself at its two ends or terminii with identical contacts. Thus if subscriber 10 makes a call and trunk 1 is assigned to handle this call, trunk 1 assigns itself to subscriber 10 and to the corresponding jack 10 at the central office. The central office operator is thereby enabled to deal with each jack more or less in the same manner as though it were directly connected to the subscriber's line corresponding to that jack by an individual trunk.

Consequently, according to the present invention the concentrating unit at the outlying office is connected by a comparatively small group of trunks to a single master office. Sequence circuit arrangements are provided at both ends of the trunk circuit group. The sequence circuit at the concentrating unit is adapted to connect any one of the local subscribers' stations to an idle trunk of a group and vice versa and that at the master office is capable of connecting a trunk to any one of a plurality of switchboard jacks which are individual to the subscribers' stations connected to the concentrating unit or vice versa. Should a call originate at a subscriber's station connected to the concentrating unit or at the master office, the sequence circuit at the originating end of the trunk sends a "mark" signal to the opposite end. From the opposite end is transmitted a 20-cycle verification signal. Upon receipt of the verification signal at the originating end the seized trunk at the originating end sends to the opposite end a pair of stepping impulses (timed space followed by a mark) to step a rotary selector switch at the opposite end to the first contact of each of its banks. Identical stepping pulses are received from the opposite end to cause a similar selector switch at the originating end to step to the first contact on each of its banks and again send new stepping pulses to the opposite ends. This operation continues at both ends of the seized trunk until the stepping brushes of the selector switch at the originating end arrive on contacts corresponding to the particular subscriber's station at which the call originated and the stepping brushes of the selector switch at the terminating end arrive on the contacts corresponding to the switchboard jack individual to the calling subscriber's station. No more pulses are sent from either end and the trunk terminating station at each end, recognizing a mark condition on both the sending and receiving conductors of the trunk, locks out its own stepping circuit, connects the trunk through to its destination (for example, at one end the line is connected to the switchboard jack corresponding to the subscriber's station at which the call originated and at the other end the line is connected through to the subscriber's station) and releases to normal its sequence circuit for the next call.

A feature of the invention is a new sequence circuit arrangement wherein a sequence circuit is provided at each end of a trunking system.

Another feature is the provision of transmitting from the receiving end of a seized trunk a verification signal and then transmission from both the sending and receiving ends of the seized trunk identical stepping impulses for making the desired selection whereby the seized trunk is connected at both ends to the calling and the called line to complete the connection.

In the drawings:

Fig. 1 shows one of a group of subscribers' stations connected to a subscriber's line circuit terminating at the concentrating unit and a trunk busy circuit for informing the subscriber when all trunks of a group are busy.

Figs. 2 and 3 show at the concentrating unit office a sequence circuit whereby only one subscriber's line circuit at a time is enabled to be in the process of connection from the subscriber's station to the master office over an idle trunk of the group, there being in the sequence circuit shown one relay for each of the twenty subscribers' circuits arranged in two subgroups of ten each.

Figs. 4, 4A and 4B show at the concentrating unit office the miscellaneous alarm circuits arranged to give, on an outward call from the local subscriber's station, visual and audible alarm indications under three different conditions, namely, (1) when the time interval in which the sequence switch is used is equal to or in excess of ten seconds, shown in Fig. 4A; (2) when the time interval in which the permanent mark condition in a trunk circuit should be removed is equal to or in excess of ten seconds, shown in Fig. 4B; and, (3) when the time interval in which a verification and a completion indication should be received in the trunk circuit, for example, when the verification indication is not received within about one second or the completion indication is not received within about ten seconds, shown in Fig. 4.

Figs. 5, 6, 7, 8, 9 and 10 show at the concentrating unit office the termination of one of a group of trunks extending to the master office. The trunk circuit may be arranged to operate either between a toll line and a subscriber's loop or between a line terminating repeater and a subscriber's loop.

Figs. 11, 12, 13, 14, 15 and 16 show at the master office the termination of the trunk shown in Figs. 5, 6, 7, 8, 9 and 10.

Fig. 17 shows at the master office the switchboard appearance of the subscribers' lines which are physically terminated at the concentrating unit office as shown in Fig. 1, in order to facilitate automatic selection on the subscriber's line at the switchboard in the master office. An all-trunks-busy circuit is also shown common to the lines of the group corresponding to the subscrib-

ers' lines terminating at the concentrating office and shown in Figs. 1, 2 and 3.

Figs. 18 and 19 show at the master office a sequence circuit whereby only one line at a time terminating at the switchboard is enabled to be in the process of connection from the master office to the concentrating unit office.

Figs. 20, 20A and 20B show at the master office the miscellaneous alarm circuit arranged to give on an outward call from the switchboard visual and audible alarm indications under the conditions as set forth above for Figs. 4, 4A and 4B.

Fig. 21 shows the relative arrangement of Figs. 1 to 20.

General Description

The system herein described, for calls to be established in one direction, comprises essentially twenty subscribers' stations respectively connected by means of metallic line circuits to line circuit terminating equipment at a concentrating unit office whereat a sequence circuit is provided for connecting by means of a five-bank rotary selector switch any one of the group of twenty subscriber line circuits to one of a group of trunk circuits extending to a master office, each trunk circuit being connected to the brushes of the selector switch, and two or more trunk circuits may be available to the twenty subscribers' lines. At the master office each trunk of a group terminates at the brushes of a six-bank rotary selector switch. To the contacts of certain of the selector switch banks at the master office are respectively connected line circuits terminating in jacks at the operator's switchboard, the jacks being individual to the subscribers' lines terminating at the concentrating unit office.

For calls to be established in the opposite direction, the system comprises the individual jacks over which the operator may originate calls through the sequence circuit at the master office to the group of trunk circuits for an automatic connection to any subscriber's station connected to the concentrating unit office.

An all-trunks-busy circuit is provided at both the concentrating unit office and the master office for transmitting to the calling party, as long as the calling line is closed, a distinctive signal, such as "letters" ("no circuit signal") when all trunks of a group are busy and another distinctive signal such as repeated "K" signals when one of the trunks of the group is idle after an all-busy condition. These signals or code combinations are transmitted in standard start-stop codes. A sequence circuit is provided at both offices and is adapted for use with twenty subscribers' lines divided into two subgroups of ten each because of the limitation of multicontact relays to ten armatures for satisfactory operation. "Miscellaneous alarm" circuits are also provided at both offices for furnishing to the calling party, supervisory information over connections that are being established. The operation of the sequence circuit, all-trunks-busy circuit and miscellaneous alarm circuit at the concentrating unit office respectively operate in a manner similar to the corresponding circuits at the master office.

A subscriber's line terminating circuit is arranged to register the subscriber's calling by means of a call lamp at the concentrating unit office and starts the sequence circuit operating to permit routing of the call to a manually operated switchboard at the master office. The subscriber's line circuit lights the call lamp when the subscriber calls and maintains the lamp lighted until the call is routed to the master office. This may serve as an indication to a service attendant at the satellite office, if and when such service attendant is present. When all available trunk circuits are busy, the subscriber's line circuit is arranged to release the sequence circuit and to attach itself to the all-trunks-busy circuit at the concentrating unit office for the purpose of transmitting to the subscriber information concerning the availability of trunk circuits. Connection to the all-trunks-busy circuit is maintained until the subscriber disconnects or another trunk circuit becomes available, and then the all-trunks-busy circuit returns to normal. When the subscriber's line on an outgoing call is connected to a trunk circuit the subscriber's line terminating circuit returns to normal thereby releasing the sequence circuit for a call from another subscriber.

The sequence circuit permits only one subscriber to have access to itself at any one time and disconnects all other subscribers' line circuits from itself after it has been seized by any one subscriber. It provides connections to the all-trunks-busy circuit to permit the proper signal generation in case all trunks are busy and provides connection to the miscellaneous alarm circuit to provide for an alarm signal in case the sequence circuit has not been released within a predetermined time interval.

The miscellaneous alarm circuit on an outward call from the local subscriber times the intervals in which various functions required in establishing a connection occur. If the time in which the sequence switch is engaged is equal to or in excess of ten seconds, visual and audible alarm indications will be given. If the sequence circuit is released at any time, these alarms will be released. If the duration of a marking signal transmitted over a trunk circuit is equal to or in excess of ten seconds, visual and audible alarm indications will be given. If the marking signal, or condition on the trunk circuit is removed at any time, these alarms will be released. If the verification signal indication is not received within about ten seconds, visual and audible alarm indications will be given. The visual alarm indications for the non-verification and non-completion functions will be locked in under control of an alarm circuit release key.

A trunk circuit, on an outward call from a calling party, is seized by the sequence circuit from a group of trunks and a "mark" signal is sent to the distant office. Upon receipt of a 20-cycle verification signal from the distant office, the trunk circuit at the local office sends a pair of stepping impulses consisting of a timed "spacing" and a "marking" interval to step the rotary selector switch brushes at the distant office to the first contacts on their respective banks. The trunk circuit at the distant office upon being connected to the first contacts of the selector switch at that end transmits to the trunk circuit at the local end two corresponding stepping impulses which in turn cause the selector switch brushes at the local end to step to the first contacts on their respective banks. Upon reception of a timed spacing and a marking signal, or stepping pulses, from the distant office which indicates that the selector brushes at that end are on their respective first contacts, the trunk circuit steps the selector switch brushes at the local end to their respective first contacts and in return sends new stepping pulses to the distant end.

This operation continues until the brushes at the local end arrive on the contacts corresponding to the line of the calling party. At this time no more stepping impulses are transmitted and the trunk circuit recognizes a marking condition on both sending and receiving conductors of the trunk circuit line to lock out the stepping circuits, connect the trunk circuit to the called line and release the local sequence circuit. The alarm circuit guards the steps taken from the time the sequence circuit is seized to that when the calling line is connected through to the trunk circuit. At the time a trunk circuit line is connected through to the called line, the equipment at the distant end lights the line lamp in the switchboard to indicate that an incoming call is desired at the operator's switchboard.

If the calling party abandons the call before the called party answers, a spacing condition is placed on the trunk circuit line toward the distant office to cause the trunk circuit at the local end to release. When a prolonged space impulse is received from a calling party the trunk circuit at the local end transmits a spacing signal to the distant office and after approximately three-quarters second the party at the distant office ascertains if the calling party has disconnected. If so the trunk circuit at the local end continues to send out the space signal but remains in condition to permit a rering of the calling station.

If the space signal from the local office resulted from the transmission of a "break" signal, the trunk circuit at the local end replaces the spacing signal sent to the distant office with 20-cycle pulses for the remainder of the break period. When a prolonged space signal is received from the distant office, the trunk circuit at the local end continues to send a spacing signal to the calling party. After three-quarters second has elapsed followed by the reception of 20-cycle pulses from the distant office, the trunk circuit continues to send a space signal to the calling party. After approximately 5 seconds of spacing interval to the calling party, the trunk circuit sends a periodic mark and space signal to the calling party as long as the reception of 20-cycle signals are being received from the distant office.

Under the condition outlined above, if the spacing signal from the distant office is not followed by 20-cycle pulses the trunk circuit recognizes this condition as a disconnect from the distant office, but awaits until the calling party has disconnected before taking final action.

When the trunk circuit is seized at the distant end for completion of the connection, a continuous mark is received by the trunk circuit at the local end which prepares to receive stepping pulses and sends 20-cycle signals back to the distant office as verification and at the same time withdraws from the sequence circuit so that the sequence circuit may be ready for another outward call. The reception and transmission of stepping pulses takes place until the receive conductor of the trunk circuit line becomes permanently marking to indicate that the circuits are connected to the contacts of the called line. The trunk circuit then recognizes this condition, locks out the stepping mechanism and connects the trunk circuit to the required line at the same time sending a spacing condition to the distant office to indicate that the called party station may be rung or in case of trunks equipped for automatic ringing that the called party's station is being rung.

After a subscriber has disconnected the operator can rering the subscriber's station by operating her cord ringing key (not shown) which either rings the station by repeated ringing or by starting the automatic ringing circuit.

Detailed Description and Method of Operation

Referring to Fig. 1, a local subscriber's station **101** is connected by means of the normally open line consisting of conductors **102** and **103**, to its terminating circuit at the concentrating unit office. The line circuit upon being closed by the subscriber at station **101** is effective to operate line relay **104** in a terminating circuit and, in turn, to light call lamp **109** and to operate the start circuit over conductor **201** extending through the winding of subscriber's start relay **202** in the sequence circuit shown in Figs. 2 and 3.

Other subscribers' stations arranged in the same group as subscriber's station **101** are similarly effective to close respective terminating circuits and, in turn, their respective start circuits **203** to **211** and **301** to **310**, these start circuits upon being closed being effective to operate their respectively associated relays **212** to **220** and **311** to **320**. Subscriber's start relays **202** and **212** to **220** of the sequence circuit are under the control of group relay **221** and start relays **311** to **320** are under control of group relay **321**. An additional start relay **322** which is operated in response to a closure of start circuit **323** and which is provided for connection to a test board (not shown) is also controlled by group relay **321**. A start relay in the sequence circuit and associated with a calling subscriber's station, such as relay **202** associated with station **101**, upon being operated closes at its inner lower armature and front contact an operating circuit for relay **324** which operates to: (1) close at its outer upper armature and contact a locking circuit for the subscriber's start relay, such as relay **202**, in the sequence circuit; (2) close at its inner upper armature and contact an operating circuit for group relays **221** and **321**; (3) closes at its inner upper armature and contact another circuit which operates relay **401** to start the miscellaneous alarm circuit functioning; and (4) closes at its lower armature and contact an operating circuit for a trunk start relay, such as **801**, in the first idle trunk circuit; the operating circuit for relay **801** being traceable over conductor **325**, upper make-before-break contacts of relay **420**, conductor **436**, through the winding of start relay **801**, conductor **816**, to ground at the back contact and lower armature of trunk test relay **901**. Relay **801** operates.

Assuming that subscriber's start relay **202** in the sequence circuit is operated, it is maintained locked until the connection to a jack at the distant switchboard is completed or until the calling subscriber at station **101** abandons the call. Relays **221** and **321**, upon operating, prevent any other subscriber in the group from originating a call while a connection is being established for the subscriber at station **101**. Relay **401**, upon operating, causes the operation of the visual and audible alarm when the time interval in which the sequence switch is used is equal to or in excess of 10 seconds. Relay **401'**, upon operating, causes the operation of the visual and audible alarm. When the time interval, in which the permanent mark condition in the trunk circuit line

should be removed, is equal to or in excess of 10 seconds.

Trunk start relay **801**, upon operating, (1) connects at its outermost lower armature and contact grounded battery to the winding of relay **601**; (2) opens at its middle lower armature and contact an operating circuit for trunk test relay **901** which, when operated, serves to transfer the calling line to successive trunks in search of an idle trunk; (3) closes at its outermost upper armature and contact an operating circuit for relay **602** which operates but serves no purpose at this time, the circuit being traceable from grounded battery at the next to the innermost upper armature and contact of relay **1006**, conductor **1028**, through the winding of relay **602**, conductor **636**, contact and outermost upper armature of relay **801**, conductor **836**, normal contact, brush, strap and zero contact of selector switch bank A, conductor **1020**, to ground at the innermost armature and back contact of disconnect relay **1003**; (4) provides at its innermost lower armature and contact a locking circuit for itself; (5) closes at its middle upper armature and front contact a future operating path for relay **802** which is of the alternating current type and at the same time opens the operating circuit for relay **1002**; (6) connects ground at its next to the outermost upper armature and contact to a circuit extending through the normal contacts, in series, of relays **803** and **804**, to the left-hand contact of relay **1001** and also over a parallel path extending through the line windings, in series, of send relays **701** and **702** whereby relays **701** and **702**, which are of the polarized type, are operated to their respective spacing and marking contacts, relay **702** to place a marking condition on send conductor **703** which extends to the distant master office, the marking condition being of negative polarity at the concentrating unit office; (7) closes at its next to the innermost lower armature and contact an operating circuit for relay **902** which operates in a circuit traceable from grounded battery, through the winding of relay **902**, conductors **914**, **725** and **910** to ground at the contact and the next to the innermost armature of relay **801**; (8) closes at its next to the innermost upper armature and contact an operating circuit for relay **903**, and relay **903** operates in a circuit that may be traced from grounded battery, through the winding of relay **903**, conductor **915**, contact and next to the innermost upper armature of relay **801**.

Relay **902**, upon operating, (1) opens at its outermost lower armature and contact the operating circuit for disconnect relay **1003**; (2) closes at its middle upper armature and contact a circuit extending from the marking, or right-hand, contact of polar relay **904**, make-before-break contacts of relay **704**, contact and outermost left-hand contact of relay **705**, conductors **813** and **812**, lower make-before-break contacts of relay **804**, middle upper armature and front contact of relay **801**, conductor **1007**, outermost lower armature and contact of relay **1004**, resistance **1005** to grounded battery. Resistances **1005** and **805**, together with condenser **806**, form an alternating current operating bridge for alternating current relay **802**; (3) connects at its outermost upper armature and contact, ground to energize the filament circuits of vacuum tubes **807**, **808**, **809**, **603**, **604** and **605** which light in a circuit traceable from ground at the outermost upper armature and contact, conductor **913**, through the filaments, in series, of vacuum tubes **605**, **604**, **603**, **809**, **808** and **807**, resistance **828**, conductors **829**, **830** and **820** to grounded battery **819**; (4) connects ground at its innermost lower armature and contact, to the lower winding of polar relay **501** to hold that relay on its left-hand contact, the circuit being traceable from ground at the innermost lower armature and contact of relay **902**, conductor **721**, inner left armature and contact of relay **714**, conductor **723**, middle right armature and contact of relay **504**, through the lower winding of relay **501**, resistances **520** and **521**, conductors **619** and **820** to grounded battery **819**; (5) closes at its middle lower armature and contact an operating circuit for busy relay **905** which operates to light busy lamp **502**; (6) removes at its innermost upper armature and contact a holding ground for the grid element of vacuum tube **809**.

Relay **903**, which is a call directional relay, upon operating, (1) locks in a circuit extending to ground over the outer upper armature and front contact of busy relay **905**; (2) connects at its inner upper armature and front contact the telegraph ground at the next to the innermost lower armature and contact of relay **801** to springs on relays **503** and **601** and the armature of relays **1001** and **1006**; and (3) connects at its outer lower armature and contact the ground at the outermost lower armature and contact of relay **803**, over the contact and outer lower armature of relay **903**, to conductor **906** which extends to the miscellaneous alarm circuit.

At this time vacuum tube **603** is held inactive by grid element ground at the innermost right armature and contact of relay **504** and at the left-hand, or marking, contact of relay **701** when the latter relay is subsequently operated to its marking position. Vacuum tubes **605** and **807** are held inactive from grid element ground at the middle left-hand armature and contact of transfer relay **606**. Vacuum tube **604** is held inactive from grid element ground at the armature and marking, or left-hand, contact of relay **904**, over conductor **916**, right-hand armature and back contact of relay **706** and conductor **726**. Vacuum tube **808** is held inactive from the grid element ground at the middle right-hand armature and contact of relay **606** and the outer right-hand armature and contact of relay **505**, in a circuit traceable over conductors **720** and **719**, over the contact and outer left-hand armature of relay **707**, conductor **823** and resistance **810**. Vacuum tube **809** is held inactive on the grid element ground at the contact and the next to the outermost left-hand armature of relay **606**.

Reception of marking signal at distant master office

The marking signal transmitted from the grounded negative battery **708**, when send relay **702** was operated to its marking, or right-hand, position, is received by relay **1101** at the distant master office. Negative polarity being connected to opposite ends of the line, receive relay **1101**, under the influence of the biasing current in its lower winding, is operated to its marking, or right-hand, position. Relay **1101**, upon operating to its marking position, or contact, connects ground at its armature to a circuit extending from grounded positive battery **1102**, over two parallel paths, one path extending over conductors **1126** and **1332**, through the filaments, in series, of vacuum tubes **1402**, **1401**, **1203**, **1202**, **1201** and **1403**, conductor **1417**, make-before-

break contacts of relay 1109 to ground at the armature and marking, or right-hand, contact of relay 1101 and the other extending over conductor 1126, resistance 1503, conductor 1627, back contact and outermost upper armature of trunk start relay 1601, conductors 1628 and 1127, through the lower winding of and make-before-break contacts of trunk test relay 1103, to ground at the marking contact and armature of relay 1101. Relay 1103 operates to free this particular trunk from seizure by an operator for calls to the concentrating unit office and to provide an operating circuit for the trunk start relay of the next idle trunk, the start relay for the next idle trunk corresponding to relay 1601 of the trunk circuit shown.

Relay 1103, upon operating, (1) closes at its inner lower armature a future locking circuit for itself to ground at next to the innermost lower armature and contact of busy relay 1109 and (2) connects ground at its outer lower armature and front contact to a future operating circuit for the trunk start relay of the next trunk circuit. Relays 1103' and 1103nth, respectively, represent the trunk test relays for the second and the last trunks of the available group and correspond to trunk test relay 1103 for the first trunk circuit which is shown herein in detail.

Receive relay 1101, upon operating to its marking, or right-hand, position, also removes the holding ground from the grid element circuit of vacuum tube 1201 so that condenser 1301 starts charging from grounded positive battery 1102, through resistances 1104 and 1105. As soon as the charge reaches a certain potential the grid element of tube 1201 permits sufficient plate current to operate relay 1106, in approximately 0.5 second, and relay 1106, upon operating, operates cut-through relay 1107. In other words, for cut-through operation the duration of the incoming calling mark signal will be of sufficient length, say 0.5 second, to operate vacuum tube 1201, relay 1106 and finally cut-through relay 1107, thereby preventing a fortuitous circuit change such as a "hit" from operating the cut-through relay. The incoming calling mark signal persists long enough to characterize it as a genuine signal and the communication trannsmission circuit is cut through to a proper transmission condition and so held thereafter under control of the vacuum tube 1201.

Cut-through relay 1107, upon operating, (1) opens at its outermost upper armature and contact a shunt circuit extending through the lower winding of relay 1101, thereby permitting relay 1303 to follow the received signals; (2) closes at its lower armature and contact an obvious operating circuit for transfer relay 1108 extending to grounded battery 1333; (3) prepares at its middle upper armature and contact a future operating circuit for relay 1501; and (4) transfers its innermost upper armature from the back to the front contact whereby the connection of the spacing contact of relay 1101 is transferred from the grid element of vacuum tube 1201 to the grid element of vacuum tube 1203. Relay 1108, upon operating, (1) opens at its outermost upper armature and contact a circuit which will subsequently include the ring conductor 1502 and the first terminal of selector switch bank D'; (2) connects ground at its next to the innermost upper armature and contact to the outermost upper armature of relay 1404; (3) locks itself at its innermost upper armature and contact; (4) closes at its middle lower armature and contact a shunt path around resistance 1105 in the grid element circuit of vacuum tube 1201, thereby reducing the resistance from 1.1 megohms to 0.1 megohm and thus reducing the tube operating time from 0.5 second to 0.04 second; (5) closes at its innermost lower armature and contact an operating circuit for relay 1304 which operates; (6) removes at its next to the outermost upper armature and contact the holding ground for vacuum tubes 1402 and 1403; and (7) removes at its outermost lower armature and contact a holding ground for vacuum tube 1203. Relay 1304, upon operating, (1) opens at its outermost lower armature and contact the operating circuit for disconnect relay 1602; (2) connects at its innermost lower armature and contact the marking, or right-hand, contact of relay 1101 to the winding of relay 1404 which operates in a circuit traceable from grounded battery 1221, through the winding of relay 1404, conductor 1418, back contact and middle lower armature of start relay 1601, conductor 1217, upper make-before-break contacts of relay 1214, conductors 1223 and 1520, upper armature and contact of relay 1510, conductor 1330, make-before-break contacts of relay 1310, innermost lower armature and contact of relay 1304, conductor 1111, to ground at the mark contact and armature of relay 1101 to operate relay 1404; (3) transfers by means of its middle lower armature the grid element of vacuum tube 1401 from holding ground at its back contact, to its front contact, through resistance 1306 over conductors 1339 and 1126 to grounded positive battery 1102, thus permitting vacuum tube 1401 to operate from condenser 1334 in approximately 0.4 second and the plate current in vacuum tube 1401 causes relay 1307 and, in turn, relay 1308 to operate; (4) connects at its innermost upper armature and contact grounded positive battery 1603 in a circuit traceable over conductor 1610, innermost upper armature and contact of relay 1304, back contact and outer upper armature of relay 1309, conductor 1342, armature and marking, or left-hand, contact of polarized relay 1208 which is, at this time, in its left-hand position, conductors 1213 and 1611, make-before-break contact of relay 1517, conductor 1514, through the winding of polarized relay 1505, back contact and lower armature of relay 1313, through the lower winding of polarized send relay 1311, conductor 1327, outermost upper armature and back contact of relay 1310 to grounded negative battery 1314, which circuit will later be used to place a marking condition on send conductor 1312 of the trunk circuit line towards the concentrating unit office; (5) closes at its middle upper armature and contact an operating circuit for busy relay 1109 which operates; (6) removes at the outermost upper armature and contact a holding ground from the grid element of vacuum tube 1203, which, however, remains inoperative.

Relay 1308, upon operating, (1) removes ground at its outer upper armature and contact from the grid element of vacuum tubes 1402 and 1403 which remain inoperative under control of the operated outermost upper armature and contact of relay 1404 which is now operated as hereinbefore described; (2) closes at its inner upper armature and contact a holding ground for operated busy relay 1109; (3) closes at its lower armature and contact a future operating circuit for relay 1501. Busy relay 1109, upon operating, (1) completes at the next to the innermost lower armature and contact the locking circuit for trunk test relay 1103 which now locks through

its lower winding; (2) establishes at its outermost lower armature and contact and at the next to its outermost lower armature and contact future locking circuits for relays 1309 and 1310, respectively; (3) closes at its upper armature and contact a circuit for connecting source 1124 of alternating current for lighting busy lamp 1504 associated with both the manual trunk jack 1521 and automatic trunk jack 1704 appearing at the switchboard, the manual trunk jack being utilized by the operator in the event that the automatically operated rotary selector switches fail to operate; (4) supplies at its innermost lower armature and contact a substitute ground in place of that at the marking contact of receive relay 1101 to maintain filaments of the vacuum tubes 1201, 1202, 1203, 1401, 1402 and 1403 lighted.

Relay 1404, upon operating, (1) opens at its lower armature and contact the future operating circuit for relay 1204; (2) connects at its outermost upper armature and contact holding ground to the grid element of vacuum tubes 1402 and 1403 which remain inoperative under the control of the operated upper armature and contact of relay 1404, as hereinbefore stated, the grounded circuit being traceable from ground at the next to the innermost upper armature and contact of relay 1108, conductor 1125, outermost upper armature and front contact of relay 1404, conductor 1416, back contact and innermost lower armature of relay 1316, conductor 1317 to the grid elements, in parallel, of vacuum tubes 1402 and 1403; (3) closes at its middle upper armature and contact a circuit extending to ground at the make-before-break contacts of disconnect relay 1602 for operating relay 1405 which operates; (4) opens at its innermost upper armature and contact the future operating circuit for selector switch stepping magnet 1604.

Relay 1405, upon operating, (1) opens at its middle lower armature and contact the future operating circuit for relay 1205 which is not used in a connection of this direction of establishment; (2) connects at its innermost lower armature and contact a source 1407 of 20-cycle pulses to the winding of send relay 1311 which repeats these signals over conductor 1312 to the concentrating unit office, the circuit being traceable from grounded source 1407, outermost upper armature and contact of relay 1408, innermost lower armature and contact of relay 1405, conductors 1213 and 1611, make-before-break contacts of relay 1517, conductor 1514, through the lower winding of relay 1505, back contact and lower armature of relay 1313, through the lower winding of send relay 1311, outermost upper armature and back contact of relay 1310 to grounded negative battery 1314; (3) closes at its outermost lower armature and contact the future operating circuit for selector switch stepping magnet 1604; (4) closes at its innermost upper armature and contact a locking circuit for itself extending to ground at the make-before-break contacts of disconnect relay 1602; (5) supplies ground at its outermost upper armature and contact for the future operating circuit for disconnect relay 1602; (6) closes at its middle upper armature and contact a circuit extending from ground at the next to the outermost upper armature and contact of relay 1408, conductors 1420 and 1421, middle upper armature and contact of relay 1405, conductor 1406 which extends through the winding of relay 2001 in the miscellaneous alarm circuit shown in Fig. 20A.

Reception of verification 20-cycle pulses at concentrating unit office verifying connection at the master office

In the subscriber's call hereinbefore described as originating at the concentrating unit office the sequence switch at the concentrating unit office selects an idle trunk circuit extending to the master office, and over the selected trunk circuit is transmitted from the concentrating unit office a mark signal which prepares the equipment at the master office to transmit back to the concentrating unit office a 20-cycle alternating current from source 1407, the 20-cycle current being applied to the trunk circuit approximately 0.4 second after condenser 1334 begins to charge to a positive potential to operate vacuum tube 1401. The 20-cycle current is received at the concentrating unit office as a verification signal, verifying, in this case, the connection at the master office. The equipment at the master office, at the time that the 20-cycle current is applied to the trunk circuit, also prepares itself to receive from the concentrating unit office a timed spacing signal immediately followed by a marking signal which serves as stepping pulses for operating the rotary selector switch at the master office.

Send relay 1311 transmits from the master office to the concentrating unit office the 20-cycle current, as pulses, over the send conductor 1312, through the lower winding of the polarized receive relay 907 to grounded negative battery. Relay 907 operates in response to the 20-cycle pulses and, in turn, causes another receive relay 904 of the polarized type to likewise respond, the circuit for operating relay 904 being traceable from grounded battery at the spacing, or left-hand, contact and armature of relay 907, through the windings, in parallel, of relay 904, right-hand armature and back contact of relay 707, through the lower winding of auxiliary receive relay 717, conductor 727, to ground. Thus the marking, or right-hand, contact of relay 904 is alternately connected to ground and disconnected therefrom thereby causing an alternating current to flow in a circuit extending from grounded battery 1005, outermost lower armature and contact of relay 1004, conductor 1007, middle upper armature and front contact of start relay 801, conductor 811, lower make-before-break contact of relay 804, conductors 812 and 813, outermost left-hand armature and contact of relay 705, make-before-break contact of relay 704, conductor 709, middle upper armature and contact of relay 902, conductor 908 to the marking contact and armature of relay 904. Grounded battery 1005 also serves when the marking contact of relay 904 is opened, to charge condenser 806 and operate alternating current relay 802. During the vibratory operation of relay 904 in response to the pulses received from the master office, relay 802 likewise operates in response to the 20-cycle pulses. The grounded winding of relay 802 is, during the interval when 20-cycle pulses are being received, connected in a circuit extending through condenser 806, resistance 805, conductors 837 and 838 to grounded positive battery 1005. Condenser 806 is normally charged to a value approximately that of battery 1005. Every time that relay 904 operates to its marking, or right-hand, position in response to the incoming 20-cycle pulses, the normally energized circuit extending through the winding of relay 802 is shunted by a path extending over the back contact and outermost lower armature of relay 1004, conductor 1007, front con-

tact and middle upper armature of start relay **801**, conductor **811**, lower make-before-break contacts of relay **804**, conductors **812** and **813**, outermost left-hand armature and contact of relay **705**, make-before-break contacts of relay **704**, conductor **709**, middle upper armature and contact of relay **902**, conductor **908** to ground at the marking contact and armature of relay **904**. The shunting of the normally energized circuit causes condenser **806** to discharge and the direction of the discharge current causes relay **802** to operate and relay **802** continues to operate as long as the 20-cycle pulses are being received by relay **904**. Relay **802**, upon operating, closes an operating circuit for relay **804**, the circuit being traceable from grounded battery at the contact and armature of relay **802**, conductor **817**, through the winding and the upper make-before-break contacts of relay **804**, conductor **826**, back contact and outermost upper armature of relay **803** to ground. Relay **804** which is of the slow-to-release type so as to hold up during the 20-cycle pulses, operates and locks to ground at its innermost upper armature and front contact. Relay **804**, upon operating, also (1) opens at its outermost lower armature and contact the future operating circuit of relay **1006**, (2) completes at its innermost lower armature and contact a substitute operating path for alternating current relay **802**, (3) completes at its middle lower armature and contact an operating path for relay **803**, which operates, (4) closes at its middle upper armature and contact an operating circuit for cut-through relay **706** which operates, and (5) opens at its outermost upper armature and contact the operating circuit for send relay **702** thus changing the condition of send conductor **703** of the trunk circuit to spacing under the influence of the current in the upper winding.

Relay, **706**, upon operating, (1) opens at its outer left-hand armature and back contact the future operating circuit for relay **707**, (2) closes at its outer left-hand armature and front contact an operating circuit for operating transfer relay **606** which operates, the circuit being traceable from ground at the front contact and outer left armature of relay **706**, conductors **515** and **629**, through the winding of relay **606**, conductor **833**, to grounded battery **832**, (3) transfers at its right-hand armature the spacing contact of relay **904** from the grid of vacuum tube **604** to the grid of vacuum tube **809** which, however, remains non-conductive, (4) closes at its inner left armature and contact an operating circuit for relay **613** which operates, the circuit being traceable from ground at the inner left armature and contact of relay **706**, back contact and left armature of relay **710**, conductor **722**, through the winding of relay **613** to grounded battery and relay **613** operates to light answering lamp **516** to thereby indicate that the trunk circuit is cut through. Relay **606**, upon operating, (1) locks to ground on its inner right-hand armature and front contact, (2) closes at its outermost right-hand contact a future operating circuit for relay **731**, (3) closes at its next to the outermost right-hand armature and contact a point in a circuit extending from source **617** of grounded 2 second-4 second ringing current for operating relay **506**, the circuit being traceable from grounded source **617**, conductor **637**, next to the outermost right-hand armature of relay **606**, conductor **638**, contact and inner right-hand armature (now open) of relay **503**, conductor **522**, inner left-hand armature and back contact of relay **505**, outermost left-hand armature and contact of relay **504**, conductor **523**, left-hand armature and contact of relay **718**, conductor **728**, through the winding of ringing relay **506** to grounded battery, (4) removes a holding ground at the middle right-hand armature and contact from the grid circuit of vacuum tube **808**, the circuit being traceable from the contact now out of engagement with the middle right-hand armature of relay **606**, conductors **639**, **720** and **719**, contact and outer left-hand armature of relay **707**, conductor **823**, resistance **810**, and grid element of vacuum tube **808**, which, however, remains inactive at this time under control of relay **505**, (5) short-circuits at the outermost left-hand armature and contact a charging resistance **610** in the grid circuit of vacuum tube **604** thereby reducing the resistance of the grid circuit from 1.1 megohms to 0.1 megohm to reduce the firing time of the tube from approximately 0.5 second to 0.04 second, (6) placing a holding ground on next to its innermost left-hand armature for holding relay **902** operated, the circuit being traceable over conductors **640** and **914**, through the winding of relay **902** to grounded battery, (7) shunting at its innermost left-hand armature and contact resistive element **630** of the timing resistance from the grid circuit of subscriber break vacuum tube **603** to reduce the interval of operating time for the tube from approximately three seconds to 0.5 second, (8) removes a holding ground at the middle left-hand armature and contact from the grid of vacuum tubes **605** and **807** and (9) removes at the next to the outermost left-hand armature and contact a holding ground from the grid of vacuum tube **809**. All the vacuum tubes at the concentrating circuit office, however, remain non-conductive at this time.

Relay **803**, upon operating, (1) opens at the next to its outermost upper armature and contact another point in the operating circuit for send relay **702** which caused the original "mark" to be sent to the master office, (2) transfers at its outermost lower armature the ground connection from the path extending over conductor **827** to closed contacts at the outer lower armature of relay **903**, conductor **906** to the miscellaneous circuit, to a path extending over conductor **838**, closed contact at the next to the outermost lower armature of relay **801**, conductor **814** to the miscellaneous circuit which will be hereinafter described, (3) removes at its next to the innermost upper armature of relay **803** a holding ground from a circuit extending over conductor **815** through the lower winding of relay **1001** to grounded battery thereby permitting condenser **1109** to start charging, (4) replaces its original operating ground with ground at the make-before-break contacts of disconnect relay **1003** which ground is connected in a path extending over conductor **1025** to the innermost lower armature of relay **803**, (5) removes at its outermost upper armature and back contact the ground connection from the original operating circuit for relay **804**, (6) connects the ground at its outermost upper armature and associated front contact to a future operating circuit for relay **1006**, (7) closes at the next to its innermost lower armature an operating circuit for relay **1004** which operates, the ground connection being at the make-before-break contact of disconnect relay **1003**, (8) closes at the next to the outermost lower armature and front contact a point in a circuit for the future operation of "mark" relay **1002**, directly from the marking contact of relay **904** and (9) opens at its innermost upper armature and

contact a circuit which supplies 20-cycle pulses to the line when calls originate at the other end of the circuit, that is, at or through the switchboard at the master office, the circuit, when closed, extending from source **607**, conductor **632**, resistance **633**, conductor **634**, innermost upper armature and contact of relay **803**, conductor **845**, operated middle lower armature and contact of relay **1004**, conductors **1027** and **635**, make-before-break contacts of relay **509**, conductor **512**, outer left armature and back contact of relay **506**, through the lower winding of relay **701**, back contact and outer right-hand armature of relay **714**, through the lower winding of send relay **702**, outer left armature and contact of relay **731** to grounded battery **724**.

Relay **1004**, upon operating, (1) closes at its middle upper armature a point in a circuit which is now open at both relays **804** and **803** and which extends over conductor **1022** to the miscellaneous alarm circuit, the circuit not being used at this time; (2) establishes at its innermost upper armature a locking path for itself under the control of disconnect relay **1003**; (3) completes at its innermost lower armature an operating circuit extending from the make-before-break contact of disconnect relay **1003**, conductors **1025**, **1024** and **1023**, middle upper armature and contact of relay **1002**, conductor **1029**, innermost lower armature and contact of relay **1004**, conductor **1030**, outermost lower armature and contact of relay **1003**, conductor **622**, through the winding of selector switch stepping magnet **608** to grounded battery, and magnet **608** operates; (4) closes at its middle lower armature and contact a point in the circuit hereinbefore described in connection with the operation of the innermost upper armature of relay **803**, which extends to source **607** of 20-cycle pulsing current, this pulsing circuit as hereinbefore stated is not used in this direction of call origination; (5) opens at its outermost lower armature and contact the original shunting path for alternating current relay **802**, relay **802** continues operating, however, in response to the 20-cycle pulses received from the master office and retransmitted by relay **904** over the innermost lower armature and front contact of operated relay **804** and (6) closes at its outermost upper armature and contact a future operating path for disconnect relay **1003**. Thus at this time the concentrating unit office is sending to the master office, a spacing signal over conductor **703** and is receiving from the master office a 20-cycle signal over conductor **1312**. After approximately 0.05 second condenser **1009** becomes charged to a voltage of such value whereby relay **1001** will operate to its marking, or left-hand, contact and thereby replaces the "spacing" signal with a "marking" signal on conductor **703** of the trunk circuit line extending to the master office, the duration of the "spacing" signal being approximately 0.05 second. The new "marking" signal circuit may be traced from ground at the next to the innermost lower armature and contact of start relay **801**, conductor **910**, inner upper armatures and front contacts of relay **903**, conductor **1012**, armature and left-hand contact of relay **1001**, conductors **1027** and **635**, make-before-break contacts of relay **509**, conductor **512**, through the lower winding of relay **702** to grounded positive battery **724**, and relay **702** operates to its marking position.

The reception of the spacing and marking signals at the distant end causes the selector switch at that point, that is, the master office, to advance to the first step and to replace the 20-cycle pulses sent out, with a spacing signal which eventually is also changed to a "marking" signal in approximately 0.05 second as will now be described.

Reception of first stepping pulses at the master office

As hereinbefore stated, the reception of the 20-cycle verification pulses over conductor **1312** at the concentrating unit office caused the equipment at the concentrating unit office to replace the marking condition first sent over conductor **703** to the master office, with a spacing signal of approximately 0.05 second duration followed by another marking signal. The reception of the spacing signal of 0.05 second duration at the master office operates receive relay **1101** to its spacing, or left-hand, position thereby releasing "mark" relay **1404** when its operating circuit is opened at the marking, or right-hand, contact of relay **1101**, the circuit, hereinbefore traced, extending over conductor **1111**, front contact and innermost lower armature of relay **1304**, make-before-break contacts of relay **1310**, conductor **1330**, contact and upper armature of relay **1510**, conductors **1520** and **1223**, upper make-before-break contacts of relay **1214**, conductor **1217**, middle lower armature and back contact of relay **1601**, conductor **1418**, through the winding of "mark" relay **1404**, conductor **1224**, to grounded positive battery **1221**. Relay **1404**, upon releasing, completes a circuit for energizing rotary selector stepping magnet **1604**, the circuit being traceable from grounded battery through the winding of stepping magnet **1604**, outermost lower armature and back contact of disconnect relay **1602**, conductor **1629**, front contact and outermost lower armature of relay **1405**, back contact and innermost upper armature of "mark" relay **1404**, conductor **1429** to ground at the make-before-break contacts of disconnect relay **1602**. The reception of the timed marking signal which follows the space signal over conductor **703** of the trunk circuit line operates relay **1101** to its marking, or right-hand, position and reoperates "mark" relay **1404**, which in turn causes stepping magnet **1604** to release. The release of magnet **1604** permits the selector brushes to step to the first station contacts on banks A', B', C', D', E' and A—1, respectively. This operation connects ground through the contact on bank A'. The brush at bank A' upon moving to its first contact connects ground at the innermost upper contact of disconnect relay **1602** over conductor **1605**, the multiple connection of the odd-numbered contacts of bank A', conductor **1606**, through the winding of relay **1206**, conductor **1207** to grounded battery at the contact and innermost upper armature of relay **1204**, and over conductor **1607**, contact and next to the outermost lower armature of relay **1601**, conductor **1608**, middle upper armature and back contact of relay **1602**, conductor **1609**, make-before-break contacts and winding of relay **1408** to grounded battery. Relay **1206** operates to close at its armature and inner front contact an obvious future locking path for relay **1204**. Relay **1408** operates and thereby (1) opens at its outermost upper armature the circuit which has been sending 20-cycle signals from source **1407** over the trunk circuit line to the concentrating unit office, the 20-cycle signals being replaced with a spacing condition when send relay **1311** operates to its spacing, or left-hand, position due to the biasing current in its

upper winding only, (2) closes at its innermost upper armature a part of the circuit not now used but extending through the winding of "mark" relay 1404, (3) closes at its next to the outermost lower armature a second operating circuit for relay 1405, also not used with this call origination but traceable from grounded battery through the winding of relay 1405, conductors 1422 and 1423, contact and next to the outermost lower armature of relay 1408, conductors 1424 and 1419 to ground at the make-before-break contacts of disconnect relay 1602, (4) provides at its outermost lower armature a ground which will be used to operate relay 1204 when "mark" relay 1404 again releases on the next incoming marking signal over conductor 703, (5) locks at its innermost lower armature to ground at the make-before-break contact of disconnect relay 1602, and (6) removes at its middle upper armature the ground from the left-hand terminal of the lower winding of relay 1208 to permit condenser 1209 to start charging in the relay timing circuit. After an interval of approximately 0.05 second, relay 1208 operates to its left-hand, or marking, contact to replace the spacing condition on conductor 1312 of the trunk circuit line with a marking condition, send relay 1311 again being operated to its marking, or right-hand, position by the circuit traceable from grounded positive battery 1603, conductor 1610, innermost upper armature and front contact of relay 1304, back contact and outer upper armature of relay 1309, conductor 1312, armature and left-hand contact of relay 1208, conductors 1213 and 1611, make-before-break contacts of relay 1517, conductor 1514, through the lower winding of send relay 1311, and as hereinbefore traced over conductor 1327, outermost upper armature and back contact of relay 1310 to grounded negative battery 1314. Send relay 1311 operates to its marking, or right-hand, contact to impress the "mark" signal on conductor 1312.

Reception at the concentrating unit office of the space signal of the first pair of stepping pulses transmitted from the master office

At the originating end which is the concentrating unit office, the incoming spacing signal which was substituted at the master office for the 20-cycle pulses is received over conductor 1312 and impressed on the lower winding of receive relay 907 which now operates to its spacing, or left-hand, contact. Relay 907, upon operating, to its spacing contact, closes a circuit extending from grounded battery at the left-hand contact and armature of relay 907, conductor 917, through the windings of relay 904, conductor 918, back contact and right-hand armature of relay 707, through the lower winding of relay 717, conductor 727 to ground. Relay 904 operates to its spacing, or left-hand, contact and thereby opens the circuit that, when closed, may be traced over conductor 908, contact and middle upper armature of relay 902, conductor 709, make-before-break contact of relay 704, contact and outermost left armature of relay 705, conductors 813 and 812, front contact and innermost lower armature of relay 804, conductors 838 and 837, resistance 805, condenser 806, through the winding of the alternating current relay 802 to ground. Alternating current relay 802, which was responsive to the 20-cycle pulses received over conductor 1312, now releases thereby releasing relay 804, although the latter relay does not release immediately because of its slow-to-release character. Relay 804, upon releasing (1) completes at its outermost lower armature an operating circuit for relay 1006 which operates, (2) completely opens at its innermost lower armature in conjunction with relay 1004 in operated position, the alternating current operating circuit for alternating current relay 802, (3) opens at its middle lower armature the original operating circuit for relay 803 which, however, it held operated by a circuit extending over conductor 1025 to ground at the make-before-break contacts of disconnect relay 1003, and (4) opens at its middle upper armature, the original operating circuit for relay 706 which is now held operated from ground at relay 609, the operation of which will now be explained. At the time relay 706 was first operated, the grid circuit of vacuum tube 604 was opened and the operation of relay 606 which followed immediately, further reduce the time required for the operation of tube 604 by removing a part of the grid charging resistance, such as resistive element 610, from the operating circuit for relay 609. Thus before relay 804 releases, the plate current in the vacuum tube 604 has operated relay 609 so that relay 706 does not release with the release of relay 804.

Relay 1006, upon operating, (1) opens at its next to the innermost upper armature and back contact the original operating circuit for relay 602 and at its innermost upper armature the operating circuit for relay 611, relay 602 remaining operated to grounded battery 641 on its own outer front contact and relay 611 has not operated at this time, (2) closes at its outer lower armature an operating circuit for a relay 1010 which operates and locks under the control of disconnect relay 1003, (3) closes at its outermost upper armature a path leading from signaling conductor 1027 to a substitute ground over conductors 1011 and 1012, the upper armatures, in series, of relay 903, conductor 910 to ground at next to the innermost lower armature of relay 801, to retain the marking condition on conductor 703 of the trunk circuit line extending towards the master office, (4) places the same ground, that is, that connected to the next to the innermost lower armature of relay 801, over the next to the outermost upper armature of relay 1006, conductor 815, to the right-hand terminal of the lower winding of relay 1001 which immediately operates to its spacing, or right-hand, contact to replace the marking signal on conductor 703 with a timed spacing signal as will be hereinafter described, and (5) completes at its inner lower armature and contact a locking circuit path for itself extending to grounded battery 641 at the operating contacts of relay 602.

Reception of the marking pulse of the first pair at the concentrating unit office

When the timed spacing signal of the first pair of pulses received from the master office, changes to a marking signal, the receive relay 904 operates to its marking, or right-hand, position thereby connecting ground over conductor 908, contact and middle upper armature of relay 902, conductor 709, make-before-break contacts of relay 704, contact and outermost left-hand armature of relay 705, conductor 813, upper armature and contact of relay 1010, conductor 1013, front contact and next to the outermost lower armature of relay 803, conductor 818, through the winding of "mark" relay 1002 to grounded battery 1014, to operate relay 1002. Relay 1002, upon operating, (1) opens at its middle upper armature, the

operating circuit for rotary switch stepping magnet 608 which deenergizes thus permitting the brushes on the selector switch comprising banks A, B, C, D and E to step to their respective first contacts, (2) opens at its lower armature and contact the operating circuit for relay 1006 which remains locked under control of relay 602, and (3) grounds at its outermost upper armature the grid circuits of vacuum tubes 605 and 807, the grounding circuit being traceable from ground at the next to the innermost right-hand armature and contact of transfer relay 606, conductor 631, contact and outermost upper armature of relay 1002, conductor 1026, back contact and outer right armature of relay 710, conductor 711, first, to grid element of vacuum tube 807 and then, over conductor 835 to grid element of vacuum tube 605. The stepping of the brush to the first contact on bank A of the selector switch, however, causes relay 602 to release, which opens the locking circuit for relay 1006 and relay 1006 releases. Relay 1006 upon releasing, (1) connects grounded battery at its innermost upper armature to the operating circuit for relay 611, which operates, the circuit being traceable from ground, battery at the innermost upper armature and contact, conductor 1031, through the winding of relay 611, conductor 620, first contact, brush and strap to the zero contact of bank A, conductor 1020, innermost upper armature and back contact of disconnect relay 1003 to ground, (2) disconnects at its outermost upper armature and contact, ground conductor 1011 from the lower winding of send relay 702 which operates to place a timed spacing condition on conductor 703 of the trunk circuit line, (3) disconnects at its next to the outermost upper armature and contact, ground conductor 1011 whereby ground is removed on the right-hand terminal of the lower winding of relay 1001 to start the timing circuit including condenser 1009. After the 0.05 second interval, the time for charging condenser 1009, relay 1001 operates to its marking, or left-hand, position and thereby causes relay 702 to operate to its marking, or right-hand contact to send over conductor 703 a marking signal, the circuit being traceable from ground at the next to the innermost lower armature and contact of start relay 801, conductor 910, upper armatures and contacts, in series, of relay 903, conductor 1012, armature and left-hand contact of relay 1001, conductors 1027 and 635, make-before-break contacts of relay 509, conductor 512, outer left armature and back contact of relay 506, through the lower windings, in series, of send relays 701 and 702, to grounded positive battery 724. In other words, as hereinbefore stated, a timed space signal followed by a mark signal is now sent back to the master office over conductor 703. It will be noted in connection with the operation of the rotary selector switch that relays 602 and 611 operate alternately as the brush on bank A moves over its successive contacts, relay 602 operating when the brush is on zero or an even-numbered contact and relay 611 operating when the brush is on an odd-numbered contact.

Reception of a second set of stepping pulses at the master office

The reception of the timed spacing signal operates relay 1101 to its left-hand, or spacing, contact, thereby opening at the right-hand, or marking, contact the operating circuit for relay 1404 which now releases. Relay 1404, upon releasing, (1) closes at its innermost upper armature the operating circuit for rotary selector switch stepping magnet 1604, (2) removes at its outermost upper armature and contact the ground connection at the next to the innermost upper armature and contact of relay 1108 from the grid circuit which extends over conductor 1125, outermost upper armature and contact of relay 1404, conductor 1416, back contact and innermost lower armature of relay 1316, conductor 1317, and grid elements, in parallel, of vacuum tubes 1402 and 1403, thereby causing the tubes to operate and (3) closes at its lower armature and contact the operating circuit for relay 1204 which operates. Relay 1204, upon operating, (1) closes at its innermost lower armature and contact a locking circuit for itself extending to grounded battery 1220 at the operated contact and armature of relay 1206, (2) opens at its innermost upper armature and contact and at next to the outermost upper armature and contact the operating circuits for relay 1206 and 1210, relay 1206 remaining operated through its locking circuit extending over conductor 1606, the first contact, brush and strap of bank A', conductor 1605 to ground at the innermost upper armature and back contact of disconnect relay 1602, and relay 1210 which was in an unoperated position at the time is not affected inasmuch as the selector switch brush at bank A is not in an even-numbered contact, (3) closes at its outermost upper armature and contact an operating circuit for relay 1211 which circuit extends over conductors 1212 and 1419 to ground at the make-before-break contact on disconnect relay 1602, relay 1211 operates and locks, performing no useful function at this time, (4) connects at its outermost lower armature and contact grounded battery 1603 to the winding of send relay 1311 which operates to continue the marking condition on conductor 1312 of the trunk circuit line towards the concentrating unit office, the circuit being traceable from grounded battery 1603, conductor 1610, innermost upper armature and contact of relay 1304, back contact and outer upper armature of relay 1309, conductor 1312, contact and outermost lower armature of relay 1204, conductors 1213 and 1611, make-before-break contacts of relay 1517, conductor 1514, and as hereinbefore described, through the lower windings, in series, of send relays 1505 and 1311 to grounded negative battery 1314, and (5) connects at its middle lower armature, a grounded connection to the left-hand terminal of the lower winding of relay 1208 whereby relay 1208 operates to its right-hand, or open, position.

When the spacing signal from the concentrating unit office changes to marking, relay 1101 operates to its marking, or right-hand, position and thereby causes relay 1404 to operate and, in turn, stepping magnet 1604 to deenergize. The deenergization of stepping magnet 1604 permits the selector brushes to move into engagement with their respective second contacts. In the new setting of the selector switch, the locking circuit for relay 1206 is opened causing it to release. The release of relay 1206 opens the locking circuit for relay 1204 which also releases. Relay 1204, upon releasing, opens at its outermost lower armature and contact, the operating circuit for send relay 1311 thereby again placing a spacing condition on the line conductor 1312 of the trunk circuit line to the concentrating unit office and disconnects at its middle lower armature the ground connection from the lower winding of relay 1208

to permit the charging of condenser 1209 whereby the timing circuit is started in measuring time. After the 0.05 second interval, relay 1208 operates to its left-hand, or mark, position and a marking condition is thereby placed on conductor 1312 extending to the concentrating unit office. Relays 1311 and 1505 then operated to their marking positions, right and left positions, respectively, the operating circuit extended from grounded positive battery 1603, conductor 1610, innermost upper armature and contact of relay 1304, back contact and outer upper armature of relay 1309, conductor 1342, armature and marking, or left-hand, contact of relay 1208, conductors 1213 and 1611, make-before-break contacts of relay 1517, conductor 1514, through the lower windings, in series, of relays 1505 and 1311, outermost upper armature and back contact of relay 1310, to grounded negative battery 1314.

Reception on the second set of stepping pulses at the concentrating unit office

When a timed space signal followed by a mark transmitted from the master office for the second time is received during the establishment of the connection, receive relay 904 operates to its spacing contact in response to the spacing signal and "mark" relay 1002 thereby releases. Relay 1002, upon releasing, causes stepping magnet 608 to reenergize and relay 1006 to reoperate which, upon operating, locks in a circuit extending over the operated contact of relay 611 to grounded battery 641. When the timed space signal being received by receive relay 904 is followed by the mark, relay 904 operates, first, to its spacing contact and then to its marking contact and the "mark" relay 1002 reoperates. Stepping magnet 608 deenergizes to step the brushes of the selector switch to their respective second contacts and relays 611 and 1106 release. These functions are hereinbefore described in connection with the reception of the first set of stepping pulses.

At concentrating unit office immediately after the transmission of stepping pulses over transmission line is completed to the selector switch contacts associated with the calling station

When the selector switch brush on bank B arrives at a contact which is grounded by the sequence circuit shown in Figs. 2 and 3, a relay, such as relay 601, operates to place a ground immediately on the circuit which holds a send relay, such as relay 702, on its marking contact and thus insures that no more stepping pulses are transmitted to the receiving station which in this case is the master office.

In the system shown on the drawings and described herein, it is assumed that the idle trunk circuit selected for the purposes of the description is the trunk circuit shown in Figs. 5 to 16, inclusive. The contact grounded in this case at bank B by the sequence switch is the lowermost, or first, contact which is shown connected to the outer upper armature of relay 202 which corresponds to subscriber's teletypewriter station 101 shown in Fig. 1, the circuit being traceable from ground at the front contact and the inner upper armature of relay 324, conductors 326, 328 and 329, contact and outer upper armature of relay 202, conductor 224, first contact, brush and strap of bank B, through the winding of relay 601, conductor 642, outermost lower armature and contact of start relay 801 to grounded battery. Relay 601 operates as hereinbefore referred to, and closes at its right armature and contact a circuit extending from ground positive battery 724, back contact and outer left armature of relay 731, through the lower winding of relay 702, outer right armature and back contact of relay 714, through the lower winding of relay 701, back contact and outer left armature of relay 506, conductor 512, make-before-break contacts of relay 509, conductor 635, right armature and contact of relay 601, conductor 643, contact and inner upper armature of relay 903, conductor 910, contact and next to the innermost lower armature of start relay 801, to ground. Send relay 702 is thus held at its marking, or right-hand, contact to prevent the sending of any more stepping pulses to the master office. At this time the trunk circuit line recognizes a marking condition on the sending conductor 703 at the concentrating unit office and on the sending conductor 1312 at the master office. Accordingly, receive relay 904 at the concentrating office and receive relay 1101 at the master office are in their respective marking positions to keep their respectively associated "mark" relays 1002 and 1404 energized. The stepping magnet at each office cannot operate when its associated "mark" relay is operated. The stepping circuit at the concentrating unit office is therefore locked at this time. The trunk circuit at the concentrating unit office is now connected through to the teletypewriter subscriber station 101 and the sequence circuit at the same office is released as will be hereinafter described.

Relay 601, upon operating, closes at its left armature and contact an operating circuit for relay 503 which operates. Relay 503, upon operating, (1) places a ground at its middle left-hand armature and contact to the holding circuit for send relay 702, the circuit being traceable from grounded battery 724, back contact and outer left armature of relay 731, through the lower winding of send relay 702, outer right armature and back contact of relay 714, through the lower winding of relay 701, back contact and outer left armature of relay 506, conductor 512, make-before-break contacts of relay 509, contact and middle left armature of relay 503, conductors 524 and 643, contact and inner upper armature of relay 903, conductor 910, contact and next to the innermost lower armature of start relay 801 to ground; (2) connects ground at its outermost left-hand armature and contact to the future operating circuit for relays 504 and 505; (3) closes at its innermost left-hand armature and contact an operating circuit for trunk test relay 901 which operates, the circuit extending from grounded battery 819, conductors 820 and 612, innermost left-hand armature and contact of relay 503, conductor 507, through the upper winding and inner upper armature and contact of trunk test relay 901, conductor 911 to ground at the outermost upper armature of relay 902; (4) closes at its outer right armature and contact an operating circuit for relay 710 which operates, the circuit extending from ground at the winding of relay 710, conductor 730, contact and outer right armature of relay 503, conductor 525, contact and outer right armature of relay 705, conductor 716, contact and innermost lower armature of relay 1003 to grounded battery; and (5) prepares at the innermost right-hand armature and contact the operating circuit for relay 506 which circuit, when completed, will extend from grounded battery at the winding of relay 506, conductor 728, contact and left armature of relay 718, conductor

523, contact and outermost left armature of relay 504, back contact and inner left armature of relay 505, conductor 522, inner right armature and contact of relay 503, conductor 638, next to the outermost right armature and contact of relay 606, conductor 637, to grounded source 617 of 2 second-4 second ringing current. Relay 901, upon operating, locks itself over its outer upper armature and at its lower armature and contact makes the next idle trunk circuit available for calls. Relay 710, upon operating, (1) transfers from the back contact at its left armature its front contact the energizing circuit for relay 613 which circuit now extends to a back contact on operated relay 902 and relay 613 releases, (2) transfers from the back contact at its outer right armature to its front contact the grid circuit of vacuum tubes 605 and 807 to the marking contact of relay 904, the transferred path at this time extending through an open contact at the middle right armature of relay 704, and (3) closes at its inner right armature and contact another holding circuit for relay 902.

With both relays 904 and 701 remaining on their marking contacts the grid circuit of vacuum tube 809 which is connected to the spacing contacts of both relays is ungrounded. In approximately one-tenth second the current in the plate circuit of vacuum tube 809 operates relay 821 in a circuit which extends from grounded positive battery 819 at one end to ground at the outermost upper armature and contact of relay 902 at the other end. Relay 821, upon operating, closes an operating circuit for relay 704 which operates to close at its outermost right-hand armature and contact a locking circuit for itself, extending to ground at the inner lower armature and contact of busy relay 905. Relay 704, upon operating, also (1) connects at its middle left-hand armature and contact, grounded battery on the winding of relay 731 to conductor 712 which extends over the contact and outermost right-hand armature of relay 606, conductor 614, outer left armature and contact of relay 505, conductor 508, to the marking, or right-hand, contact of relay 501 so that relay 731 is under the control of relay 501, (2) replaces at its innermost left-hand armature and contact the ground at the marking contact of relay 904 with another ground to hold "mark" relay 1002 operated, the circuit now being traceable from ground, innermost left-hand armature and contact of relay 704, outermost left-hand armature and contact of relay 705, conductor 813, upper armature and contact of relay 1010, conductor 1013, next to the outermost lower armature and contact of relay 803, conductor 818 through the winding of relay 1002, to grounded battery 1014, (3) connects at its middle right-hand armature and contact the marking contact of relay 904 to conductor 713, front contact and outer right-hand armature of relay 710, which now in an operated position transfers the grid circuit of vacuum tubes 605 and 807 from a holding ground to the ground at the marking contact of relay 904, (4) closes a contact at its innermost right-hand armature a future operating circuit for relay 714, the circuit when completed, will extend over conductor 715, contact and armature of relay 615 (now unoperated), conductor 616, contact and innermost right-hand armature of relay 704, conductor 508, marking, or right-hand, contact and armature of relay 501 (now unoperated) to ground at the outermost left-hand armature and contact of relay 503, and (5) completes at its outermost left-hand armature and contact an operating circuit for sleeve relay 105 which circuit is traceable from ground through the winding of relay 105, sleeve conductor 106, first contact, brush and strap on bank C, of the selector switch, conductor 616, through the winding of relay 509, conductor 510, outermost left-hand armature and contact of relay 704, contact and outer right-hand armature of relay 705, conductor 716, innermost lower armature and contact of disconnect relay 1003, to grounded battery.

Relay 509 operates in series with the sleeve relay 105. Relay 105, upon operating, cuts through subscriber's line from station 101 to the selected trunk circuit. Relay 509, upon operating, (1) closes at its inner left-hand armature and contact, a holding circuit for relay 503, the holding circuit extending from grounded battery at the innermost lower armature and contact of disconnect relay 1003, conductor 716, inner left-hand armature and contact of relay 509, conductor 511, through the winding of relay 503 to ground; (2) connects at its right-hand armature and contact, the tip conductor 512 to the strap, brush and first contact of bank E of the selector switch, to which contact is connected to the subscriber's line tip conductor 107 and (3) connects at its outer left armature and contact ring conductor 513 to the strap, brush and first contact of bank D on the selector switch, the first contact being connected to the subscriber's line ring conductor 108. Current will then flow from grounded positive battery 724 on the marking contact of relay 717, back contact and armature of relay 731, through the lower winding of send relay 702, outer right armature and back contact of relay 714, through the lower winding of relay 701, back contact and outer left armature of relay 506, conductor 512, front contact and right armature of relay 509, zero contact, strap, brush and first contact of bank E over the tip conductor 107 of the subscriber's loop, through the subscriber's teletypewriter, back over the ring conductor 108 of the loop, first contact, brush, strap and zero contact of bank D, outer left armature and contact of relay 509 and through the upper, or primary, winding of relay 501 to ground. Relay 501 will operate and, in turn, will operate relay 504. Relay 504, upon operating, (1) will in offices equipped for automatic ringing, operate a ringing relay (not shown); (2) will reverse the current in the lower, or biasing winding, of relay 501 to aid in holding the armature of relay 501 on its marking, or right-hand, contact, the current now flowing over the middle right-hand armature and front contact of relay 504 instead of over the back contact associated with the same armature; (3) will remove at its innermost right-hand armature and contact the holding ground from the grid circuit of vacuum tube 603, the subscriber's break timing unit, and placing it under the control of the marking, or left-hand, contact of relay 701; (4) will replace at the next to the innermost left-hand armature ground connection 513 with the source 617 of grounded 2 seconds-4 seconds ringing current for subsequently operating relay 718; (5) will open at its outermost left-hand armature and contact, the operating circuit for relay 506; (6) will add at its next to its outermost right-hand armature and front contact one more holding ground 513 for relay 902.

At master office immediately after the transmission of stepping pulses over the transmission line is completed

When the selector switch brushes, or wipers, at the originating office, which in this case is the concentrating unit office, have stepped to the contact corresponding to the calling subscriber's line and no more stepping pulses are transmitted therefrom, relay 1101 remains on its marking, or right-hand contact. Relay 1505 is also on its marking, or left-hand, contact due to grounded positive battery 1603 which is connected to the marking contact and armature of relay 1208 over a circuit traceable over conductor 1610, innermost upper armature and contact of relay 1304, back contact and outer upper armature of relay 1309, conductor 1312, armature and marking, or left-hand, contact of relay 1208, conductor 1213, conductor 1611, make-before-break contacts of relay 1517, conductor 1514, through the lower winding of relay 1505, back contact and lower armature of relay 1313, through the lower winding of relay 1311, outermost upper armature and back contact of relay 1310 to grounded negative battery 1314. Under these conditions wherein relay 1101 is in its marking position no restraining ground is present on the grid circuit of vacuum tube 1203. One-tenth second after relay 1208 last operated to its marking contact in response to the operation of relay 1408, as hereinbefore described, relay 1121 operates in the plate circuit of vacuum tube 1203 and thereby causes the operation of relay 1310. Relay 1310, upon operating, (1) transfers the mid-tap terminal on the winding of send relay 1311 from a direct connection with grounded negative holding battery 1314 to a connection with the same battery over the armature of relay 1303, the transfer being effected at the outermost upper armature of relay 1310; (2) removes holding ground at its next to the innermost lower armature, from the grid circuit of vacuum tube 1202; (3) transfers at the innermost upper armature, the winding of relay 1404 from its ground connection on the marking contact of relay 1101 to a direct holding ground, the circuit from the holding ground being traceable over conductor 1330, contact and upper armature of relay 1510, conductors 1520 and 1223, upper make-before-break contacts of relay 1214, conductor 1217, middle lower armature and back contact of start relay 1601, conductor 1418, through the winding of relay 1404, conductor 1224 to grounded battery 1221; (4) closes at its innermost lower armature a locking circuit for itself extending to ground at the next to the outermost armature of associated relay 1109; (5) prepares at its next to its outermost upper armature and contact a circuit for connecting the grid circuit of vacuum tubes 1402 and 1403 to the marking contacts of relay 1101, the circuit in the course of preparation being traceable from marking contact of relay 1101, conductor 1111, contact and middle upper armature of relay 1310, conductor 1315, front contact and innermost armature of relay 1316, in its unoperated condition, conductor 1317 to the grids in parallel, of vacuum tubes 1402 and 1403; (6) connects ground at its middle lower armature and contact to an operating circuit for relay 1501, the circuit being traceable over conductor 1318, middle upper armature and contact of relay 1107, conductor 1112, back contact and outermost armature of relay 1316, conductor 1319, lower armature and contact of relay 1308, conductor 1320, through the winding of relay 1501 to grounded battery. Relay 1501 operates to connect grounded battery over its inner armature and contact to a circuit for lighting an answering lamp 1701 at the operator's switchboard, the latter circuit being traceable over the armature and back contact of test relay 1507, conductor 1503, zero contact, strap, brush and the first contact on bank A—1 of the selector switch, conductor 1639, upper armature and contact of relay 1701, through the filament of the answering lamp 1701 to ground; (7) prepares at its next to its outermost lower armature and contact one connection in the trunk ring circuit which extends from ground at the contact and outermost upper armature of relay 1108, now in an operated condition, over conductor 1113, next to the outermost lower armature and contact of relay 1310, conductors 1321 and 1518, front contact and inner lower armature of relay 1517, in an unoperated condition, conductor 1502, zero contact, strap, brush and first contact of bank D', conductor 1513, contact and outer upper armature of relay 1703, in an unoperated condition, to the ring spring of answering jack 1704; and (8) connects grounded battery at the innermost lower armature and contact of disconnect relay 1602 to a circuit extending over conductor 1614, contact and lower armature of relay 1510, conductor 1511, outermost lower armature and contact of relay 1310, conductor 1322, through the winding of relay 1517, conductor 1512, zero contact, strap, brush and first contact of bank C', conductor 1615, through the winding and inner upper armature and contact of relay 1703, conductor 1705, make-before-break contacts of relay 1706, conductors 1707 and 1801, outermost upper armature and contact of relay 1821, conductor 1803, through the winding of relay 1810 to grounded battery, but relay 1517 does not operate at this time because of like batteries at both ends. The subscriber's station 101 is at this time cut through to its corresponding jack 1704 at the operator's switchboard in the master office.

The answer lamp 1701 lights and the operator answers by connecting a cord circuit 1708 to the answering jack 1704, which is associated with answering lamp 1701; grounded battery connected to the sleeve conductor in the cord circuit serves to operate relay 1702 and the ground connection connected to the lower armature of relay 1702 is thereby connected to the operating circuit for relay 1703 and relay 1703 operates in conjunction with relay 1517. Relay 1517, upon operating, (1) cuts through at its outer lower armature and contact, the tip conductor 1514 to conductor 1515, zero contact, strap, brush and first contact of bank E', conductor 1516, lower armature and front contact of relay 1703, conductor 1712, tip spring of jack 1704, tip conductor of cord circuit 1708, to grounded positive or grounded negative battery at the cord repeater in a manner similar to that disclosed in U. S. Patent 2,106,357 granted to T. A. Marshall on January 25, 1938; (2) connects at its inner lower armature and contact, ring conductor 1518 to ring conductor 1502, zero contact, strap, brush and first contact of bank E', ring conductor 1513, contact and outer upper armature of relay 1703, spring member of jack 1704, ring conductor of the cord circuit, through the winding of a supervisory relay to grounded battery as shown in U. S. Patent 2,106,357, supra, the ring conductor circuit at the trunk circuit end being at this time

open at the outermost upper armature and back contact of relay 1108; (3) closes at its inner upper armature and contact an operating circuit for relay 1523 and relay 1523 operates, the circuit extending to grounded battery at disconnect relay 1602, and (4) at its outer upper armature and contact closes a path for shunting resistance 1524 which is part of the grid charging resistance of vacuum tube 1402. Relay 1523, upon operating, closes at its upper armature and contact an operating circuit for relay 1316, the circuit being traceable from grounded battery at the innermost lower armature and contact of the disconnect relay 1602, conductor 1614, contact and lower armature of relay 1510, upper armature and contact of relay 1523, through the winding of relay 1316 to ground, and relay 1316 operates. Relay 1316, upon operating, (1) opens at its outermost lower armature and contact the operating circuit for relay 1501 which releases to extinguish the answering lamp 1701; (2) connects at its middle armature and front contact the grid circuits of vacuum tubes 1402 and 1403 to the marking, or right-hand, contact of relay 1101, the circuit now being traceable over conductor 1317, innermost armature and contact of relay 1316, conductor 1315, middle upper armature and front contact of relay 1310, conductor 1111, to the marking contact of relay 1101; (3) placing an additional holding ground on relay 1304, the circuit being traceable from grounded battery and the winding of relay 1304, conductor 1323, contact and middle armature of relay 1316, conductor 1324, back contact and outer upper armature of relay 1519 to ground.

The operator upon operating her teletypewriter key (not shown) in the cord circuit connects her teletypewriter to the line jack 1704 which corresponds to the line of the calling subscriber at the concentrating unit office and the trunk circuit line is in condition for communication.

Subscriber flashes

If the subscriber flashes before the relay 704 has operated, by slowly operating the teletypewriter power switch to "off" and then to "on," sequence circuit relay 202 which is associated with the subscriber's line will release during the "off" and release the start relay 801 of the trunk first seized.

When the switch is again turned to the "on" position, the sequence circuit will seize the next idle trunk and start to reestablish the connection while the first trunk seized returns to normal.

If the subscriber flashes after relay 704 has operated, send relays 701 and 702 operate to their respective spacing contacts during the "off" position of the switch and relay 702 transmits this condition to the master office. Relay 701, upon moving to its spacing, or right-hand, position, disconnects ground from the grid circuit of the subscriber's break vacuum tube 603. In approximately four seconds the charge on condenser 618 is at such a potential that the plate current will operate relay 615 which in turn operates relay 714 in a circuit traceable from grounded battery through the windings, in parallel, of relay 714, conductor 715, contact and armature of relay 615, conductor 616, resistance 839, conductor 823, outer left-hand armature and contact of relay 707, conductors 719 and 720, contact and outer right-hand armature of relay 505 to ground. Relay 714, upon operating, causes spacing bias current to flow in the biasing, or lower, winding of relay 501 causing it to release as there is no current in the line, or upper winding, the biasing circuit being traceable from grounded battery 819, conductors 820 and 619, resistances 521 and 520, through the lower winding of relay 501, conductor 514, contact and outer left-hand armature of relay 714, conductor 721, contact and innermost lower armature of relay 902 to ground. Relay 501, upon releasing, causes, in turn, the release of relay 504, the release position of relay 501 being that in which the armature is in engagement with its left-hand, or spacing, contact as shown. Relay 504, upon releasing, again connects ground to the grid circuit of subscriber's break vacuum tube 603 and tube 603 thereby becomes non-conductive to cause the release of relays 615 and 714. During this period a continuous space signal has been sent over the trunk circuit conductor 703 to the master office. When the power switch is again turned to its "on" position, relay 702 sends a mark signal over the trunk circuit conductor 703 to the master office. The closure of the loop circuit extending to the subscriber's station reoperates relays 501 and 504 and the circuit is again in operated condition.

Subscriber abandons call before stepping is completed

In this case the start relay 801 will release removing all ground connections which permit of sending mark signals over the trunk circuit conductor 703 to the master office. A permanent space will therefore be sent over the trunk circuit which will result in a disconnect condition at the master office. A short time interval before the disconnection is completed at the master office, a spacing condition is placed on the trunk circuit conductor 1312 extending to the concentrating unit office. At the concentrating unit office this space condition opens at the marking, or right-hand, contact of relay 904 the operating circuit for "mark" relay 1002 which circuit has already been opened by the release of start relay 801 and, in turn, relay 902. Relay 1002, upon releasing, opens at its outermost upper armature and contact the grounded circuit for the grid element of vacuum tube 605, the circuit being traceable from ground at the next to the innermost right armature and contact of relay 606, conductor 631, contact and outermost upper armature of relay 1002, conductor 1026, back contact and outer right armature of relay 710, conductors 711 and 635 to the grid element of tube 605. The release of relay 1002 causes vacuum tube 605 to operate so that vacuum tube 604 becomes non-conducting thereby releasing relays 609 and 706. After approximately three-quarters of a second spacing condition, vacuum tube 807 operates to cause the operation of relay 824, which upon operating causes the release of relay 606 and the release of relay 606 opens the holding circuit for relay 902 which also releases. Relay 902, upon releasing, completes the operating circuit for disconnect relay 1003 the circuit being traceable from grounded battery, through the winding of disconnect relay 1003, conductor 623, contact and outermost lower armature of relay 902, conductor 919, to ground at the outermost upper armature and contact of relay 1004. Disconnect relay 1003 operates and locks to ground over its innermost upper armature and front contact, conductor 1020, zero contact, strap, brush and first contact on bank A of the selector switch, conductors 620 and 621, make-before-break contacts of start relay 801, conductor 825, outermost upper armature and

front contact of disconnect relay 1003 to ground. Disconnect relay 1003, upon operating, (1) closes an operating circuit for selector switch stepping magnet 608, the operating circuit being traceable from grounded battery through the winding of magnet 608, conductor 622, outermost lower armature and front contact of relay 1003, conductor 1021, contact and armature of magnet 608, conductor 623, front contact and innermost upper armature of relay 1003, conductor 1020, zero contact, strap, brush and first contact of bank A of the selector switch, conductors 620 and 621, make-before-break contacts of start relay 801, conductor 825, outermost upper armature and front contact of relay 1003 to ground; and (2) removes the holding ground for relays 1004, 1010 and 803 which release stepping magnet 608 which operates and then alternately opens and closes its own operating circuit at its armature and contact. The selector switch under the influence of a self-interrupting action of a stepping magnet 608 rapidly steps its brushes to terminal zero where ground is removed from the brush on bank A to open the operating circuit for disconnect relay 1003 and the selector switch comes to rest in its normal position.

When the continuous spacing condition transmitted from the concentrating unit office is received at the master office, "mark" relay 1404, if in an operated condition, will release and thereby opens a circuit traceable from ground at the next to innermost upper armature and contact of relay 1108, conductor 1125, outermost upper armature and contact of relay 1404 (now opened), conductor 1416, back contact and innermost lower armature of relay 1316, conductor 1317 to grid element of vacuum tube 1403. Vacuum tube 1403 operates and the plate current flowing over conductors 1419 and 1335, resistance 1336, conductor 1337, middle lower armature and contact of relay 1108, resistance 1104 to grounded positive battery 1102, will render vacuum tube 1201 non-conducting to release relays 1106 and 1107. Vacuum tube 1402 operated when the grounded circuit was opened at the outermost upper armature and contact of released relay 1404, to cause relay 1325 to operate whereby the winding of relay 1108 is shunted. Relay 1108 releases and thereby causes the release of relay 1304. Relay 1304, upon releasing, (1) completes an operating circuit for disconnect relay 1602 the circuit being traceable from ground at the outermost upper armature of relay 1405, conductor 1326, outermost lower armature and contact of relay 1304, conductor 1616, through the winding of disconnect relay 1602 to grounded battery; and (2) opens at its innermost upper armature and contact the circuit extending from grounded positive battery 1603 through the windings, in series, of send relays 1505 and 1311 whereby the send relays operate to their respective "space" positions to place a spacing condition on send conductor 1312 toward the concentration unit office. Disconnect relay 1602 operates and (1) locks itself over its innermost upper armature and front contact, conductor 1605, zero contact, strap, brush and first contact of bank A' of the selector switch, conductors 1606 and 1607, contact and next to the outermost lower armature of relay 1601, conductor 1608, middle upper armature and front contact of disconnect relay 1602 to ground; and (2) closes an operating circuit for selector switch stepping magnet 1604 which circuit may be traced from grounded battery through the winding of the stepping magnet, outermost lower armature and front contact of relay 1602, armature and contact of magnet 1604, conductor 1617, front contact and innermost upper armature of relay 1602, conductor 1605, zero contact, strap, brush and first contact of bank A', conductors 1606 and 1607, contact and next to the outermost lower armature of relay 1601, conductor 1608, middle upper armature and front contact of relay 1602 to ground. The selector switch at the master office is rapidly stepped by means of a self-interrupting circuit for stepping the brushes back to their zero contacts where ground is removed from the brush at bank A' to open the operating circuit for disconnect relay 1602 which releases. Disconnect relay 1602, when it operated, removed at its make-before-break contacts the holding ground for relays 1405, 1408 and 1211, all of which release. Approximately 1.5 seconds after relay 1304 releases due to the capacity value of condenser 1334, vacuum tube 1401 becomes non-conductive and relays 1307 and 1308 release. Relay 1308, upon releasing, opens at its inner upper armature and contact the operating circuit for busy relay 1109 which also releases, release relay 1103. The trunk circuit line is now in the normal idle condition.

Reception at the concentrating unit office of a break signal from subscriber station

When the trunk circuit line is in the normal operating condition, a break signal transmitted from the subscriber's station connected to the concentrating unit office is received as a spacing condition and operates both send relays 701 and 702 to their respective spacing contacts. The subscriber's station is of the type which maintains a small current, around 5 milliamperes, in the line during a spacing or break signal condition. Relay 701, upon operating to its spacing contact, disconnects ground at its marking contact from the grid circuit of vacuum tube 603, the circuit being traceable from the grid element, resistance 630, conductor 644, to the marking contact of relay 701. After three-quarters of a second tube 603 operates and thereby causes relay 615 to operate. Relay 615, upon operating, closes a circuit extending from grounded battery, through the windings, in parallel, of relay 714, conductor 715, contact and armature of relay 615, conductor 656, resistance 639, conductor 823, outer left armature and contact of relay 707, conductors 719 and 720, to ground at the outer right armature and contact of relay 505. Relay 714 operates to (1) close at its outer left armature and contact a circuit for transferring ground conductor 721 from conductor 723 to conductor 514 for maintaining the biasing current in the lower winding of relay 501; (2) close at its inner right armature and contact a circuit for maintaining grounded positive battery 724 on the subscriber's loop which extends through the lower winding of relay 701 and (3) close at its outer right armature and front contact a circuit traceable from grounded source 607 of 20-cycle pulse current, resistance 633, conductor 645, innermost left armature and contact of relay 504 in operated position, conductor 526, front contact and outer right armature of relay 714, conductor 732, through the lower winding of send relay 702, outer left armature and back contact of relay 731 to grounded positive battery 724. Send relay 702 responds to the 20-cycle pulse current which is impressed on send conductor 703 for transmission to the master office. Relay 504 is in an operated position because relay 501 remains operated

due to current in the subscriber's loop even though relay 714, upon operating, reversed the current in the biasing, or lower, winding. The transmission of 20-cycle pulse current to the master office continues for the duration of the time during which the subscriber's break key (not shown) is held operated. When the break key is released send relay 701 operates to its marking contact whereby ground is again connected to the grid circuit of vacuum tube 603 which then becomes non-conductive. The cessation of plate current in tube 603 causes relay 615 and, in turn, relay 714 to release and the trunk circuit is again in condition for the resumption of communication.

Effect at master office of a break signal transmitted from subscriber's station

The spacing condition established at the concentrating unit office by a break signal transmitted from the subscriber's station, is repeated to the master office over conductor 703 for the duration of two-thirds of a second and is followed by the 20-cycle pulse current repeated by send relay 702 as hereinbefore described. Upon reception of the break signal, relay 1101 operates to its spacing or left-hand position. Relay 1101, upon operating to its spacing contact, disconnects at its marking contact the ground connection from the circuit traceable over conductor 1111, contact and middle upper armature of relay 1310, conductor 1315, front contact and innermost armature of relay 1316, conductor 1317, to the grid element of vacuum tube 1403. After one-third of a second, vacuum tube 1403 will become conductive thereby causing the grid of vacuum tube 1201 to become negative with respect to its filament which condition allows relays 1106 and 1107 to release. Relay 1107, upon releasing, closes a circuit from grounded negative battery, through the lower winding of relay 1303, conductors 1114 and 1115, contact and outermost upper armature of relay 1107, conductor 1116, through the lower winding of relay 1101 to ground and relay 1303 is conditioned to continue the spacing condition toward the cord circuit 1708 and to be non-responsive to signals received from the concentrating unit office. When the 20-cycle pulses are received from the concentrating unit office relay 1101 will follow these pulses, thereby holding vacuum tubes 1403, 1201 and 1402 non-conductive. The purpose of the 20-cycle pulse current at this time is to differentiate between a break signal and the signals for recall and disconnect, whereby the apparatus not effected by the break signal will not release as in the case of a disconnect signal.

Reception of a break signal from the switchboard at the master office

When a break signal is received from the operator's cord circuit 1708 and relays 1505 and 1311 operate to their spacing contacts; the spacing contact on relay 1311 is shown on the left-hand side of the armature and that of relay 1505 is shown on the right-hand side of its armature. When relay 1505 moves to its spacing position, ground at the marking contact is disconnected from a shunt path for condenser 1117, the shunt path being traceable over conductors 1525 and 1129 whereby condenser 1117 is permitted to start charging from grounded battery 1102 and after two-thirds of a second vacuum tube 1202 will thereby operate to cause relay 1118 to operate. Relay 1118, upon operating, closes at its armature and contact an operating circuit for relay 1313, the circuit being traceable from grounded battery through the winding of relay 1313, conductor 1338, armature and contact of relay 1118, conductors 1128 and 1318 to ground at the middle lower armature and contact of relay 1310. Relay 1313 operates and closes at its upper armature and contact two parallel paths, one extending over conductor 1327, outermost upper armature and front contact of relay 1310, armature and spacing contact of relay 1303 to grounded positive battery, and the other extending through the upper windings, in series, of relays 1303 and 1505 to ground. Relay 1505 remains in its spacing position. Relay 1311, however, responds to a 20-cycle pulse current flowing from grounded source 1407 in a circuit traceable over conductor 1409, front contact and lower armature of relay 1313, through the lower winding of relay 1311, conductor 1327, outermost upper armature and front contact of relay 1310, armature and spacing contact of relay 1303 to grounded positive battery. Send relay 1311 repeats the 20-cycle pulses over send conductor 1312 to the concentration unit office for the duration of the break signal. At the conclusion of the break signal relay 1505 will operate to its marking, or left-hand, contact, to cause vacuum tube 1202 to become non-conductive thereby releasing relays 1118 and 1313 and the trunk circuit line will again be in normal transmission condition.

Effect at the concentrating unit office of a break signal transmitted from switchboard

The spacing condition established at the master office by a break signal transmitted from the operator's switchboard is repeated to the concentrating unit office over conductor 1312 for the duration of two-thirds of a second and is followed by the 20-cycle pulse current repeated by send relay 1311 as hereinbefore described. Upon reception of the break signal, relay 904 operates to its spacing, or left-hand position. Relay 904, upon operating, to its spacing contact, disconnects at its marking contact the ground connection from the circuit traceable over conductor 903, middle right armature and contact of relay 704, conductor 713, front contact and outer right armature of relay 710, conductors 711 and 835 to the grid element of vacuum tube 605. After one-third second tube 605 will become conductive thereby causing the grid of vacuum tube 604 to become negative with respect to its filament which condition allows relays 609 and 706 to release. Relay 706, upon releasing, closes at its back contact and outer left armature a circuit extending from ground, at the innermost right armature and front contact of relay 606, conductors 629 and 515, outer left armature and back contact of relay 706, conductor 733, through the winding of relay 707 to grounded battery. Relay 707 operates and at its front contact and right-hand armature closes a circuit for holding relays 904 and 717 conditioned to continue the spacing condition toward the master office.

Disconnect by the subscriber—operation at concentration unit office

When a disconnect signal is received from the subscriber it is received as a continued open line condition. Relays 701 and 702 operate to their respective spacing contacts. Relay 701, upon operating to its spacing contact, disconnects ground at its marking contact from the grid circuit of

vacuum tube 603, the circuit being traceable from the grid element, resistance 630, conductor 644, to the marking contact of relay 701. After three-quarters of a second tube 603 operates and thereby causes relay 615 to operate. Relay 615, upon operating, closes a circuit extending from grounded battery, through the windings, in parallel, of relay 714, conductor 715, contact and armature of relay 615, conductor 616, resistance 839, conductor 823, outer left armature and contact of relay 707, conductors 719 and 720 to ground at the outer right armature and contact of relay 505. Relay 714 operates to close at its outer left armature and contact a circuit for transferring ground conductor 721 from conductor 723, to conductor 514, for maintaining the biasing current in the lower winding of relay 501. However, in this case there is no line current in the upper, or line, winding of relay 501 because the subscriber's loop is held opened when a disconnect signal is transmitted from the subscriber station. Therefore, relay 501 operates to its left-hand position and relay 504 thereby releases. Relay 504, upon releasing, does not permit ringing current from source 617 to be sent to the master office. Relay 501, upon releasing, causes relay 731 to release in a circuit traceable from grounded battery through the winding of relay 731, middle left armature and contact of relay 704, conductor 712, contact and outermost right armature of relay 606, conductor 614, outer left armature and contact of relay 505, conductor 508 to the opened marking contact of relay 501. Relay 504, upon releasing, connects ground at its innermost right armature and contact to the grid circuit of vacuum tube 603 which now becomes non-conductive to release, in turn, relays 615 and 714, and opens at its outermost right-hand armature and contact the operating circuit for relay 902.

Relay 902 releases and (1) closes at its outermost lower armature and contact an operating circuit for disconnect relay 1003, the circuit being traceable from grounded battery through the winding of relay 1003, conductor 623, contact and outermost lower armature of relay 902, conductor 919, to ground at the outermost upper armature of relay 1004 and relay 1003 operates; (2) removes at the outermost upper armature and contact the ground connection from the grid circuit for vacuum tube 807, the circuit being traceable over conductor 908, middle right armature and contact of relay 704, conductor 713, front contact and outer right armature of relay 710, conductor 711 to the grid element of tube 807, relay 904 being open at its marking contact.

Disconnect relay 1003, upon operating, closes an operating circuit for selector switch stepping magnet 608, the circuit being traceable from grounded battery, through the winding of magnet 608, conductor 622, outermost lower armature and front contact of relay 1003, conductor 1021, contact and armature of magnet 608, conductor 623, contact and outermost lower armature of relay 902, conductor 919 to ground at the contact and outermost upper armature of "mark" relay 1004. This operating circuit being of the self-interrupter type causes the brushes of the selector switch to continue a stepping operation over their respective bank until they are restored to their zero positions as hereinbefore described.

Ground being removed from the grid circuit of vacuum tube 807, the tube operates to cause relay 824 to operate. Relay 824, upon operating, closes a circuit extending from grounded battery 832, conductor 840 to ground at the right armature and contact of relay 731. This circuit shunts the holding circuit for relay 606 which now releases to restore in conjunction with stepping magnet 608 the apparatus at the concentrating unit as hereinbefore described.

At the master office the reception of the continuous spacing without ringing is interpreted as a disconnect signal.

Discrimination by the satellite office between a subscriber break signal and a subscriber disconnect signal

The operation at the satellite office in response to a subscriber break signal and a subscriber disconnect signal has been described above. It has also been described that these produce different effects at the satellite office. In the application of Fitch et al., Serial No. 173,958, described above, there is disclosed a form of subscriber's circuit in which a residual current flows in the subscriber's line or loop during the break condition but no residual current flows in the subscriber's line, or loop, except possible currents produced from foreign sources, during the disconnect condition. At the satellite office there are three polar relays effectively connected to the subscriber's line, or loop, during the marking condition. During the break condition two of these relays, namely, 701 and 702, which have windings in series with the tip, or transmitting side, 102, 107 of the loop are caused to operate to spacing condition during a break condition; however, a relay 501 which is effectively in series with the ring, or supervisory side, 103, 108 of the loop remains in the break condition in the same position as in the marking condition.

In the case of a disconnect condition placed upon the subscriber's line or loop at the subscriber's office, the relays 701 and 702 are also operated to the spacing condition but in this case the relay 501 is also operated to its spacing, or released, contact. Consequently, the discrimination between a subscriber's break condition and a subscriber's disconnect condition is effected by the relay 501. In the case of a break condition the satellite office responds thereto by transmitting first a spacing condition and then a 20-cycle current to the master office during the continuance of the break in the manner hereinbefore set forth. However, in the case of a disconnect condition the signal transmitted from the satellite office to the central office consists of a continued marking signal transmitted in the manner hereinbefore set forth.

Disconnect by the subscriber—operation at master office

When the disconnect signal is received from the subscriber, it is received as a permanent spacing condition and relays 1101 and 1303 operate to their spacing positions. Ground at the marking contact of relay 1101 is therefore removed from the circuit extending over conductor 1111, contact and middle upper armature of relay 1310, conductor 1315, front contact and innermost lower armature of relay 1316, conductor 1317, to the grid elements of vacuum tubes 1402 and 1403, which now operate. Tube 1402 which operates one second after the space signal is received, causes relay 1325 to operate and thereby close at its armature and contact an obvious circuit with grounded battery 1333, the obvious circuit serving as a shunt for the holding circuit for relay 1108 which releases. Tube 1403 which operates

after approximately one-third of a second, causes the grid element of vacuum tube 1201 to become negative with respect to its filament as hereinbefore described, under "Reception of a break signal from concentrating unit office," thereby releasing relays 1106 and 1107 in turn.

Relay 1108, upon being released, connects ground at its outermost upper armature and contact to a circuit extending over conductor 1113, next to the outermost lower armature and contact of relay 1310, conductor 1321 which is the ring conductor of the operator's cord circuit and this ground causes to light the cord circuit supervisory lamp (not shown but well-known in the art). If the operator releases the connection by taking down the cord circuit, relay 1517 which is connected in the sleeve conductor releases thereby causing the release of relay 1523 and in turn the release of relay 1316. Relay 1316, upon releasing, opens at its middle lower armature and contact, the holding circuit for relay 1304 which now releases. Relay 1304, upon releasing, closes at its outermost lower armature and front contact an operating circuit for disconnect relay 1602 which may be traced from grounded battery, through the winding of relay 1602, conductor 1616, contact and outermost lower armature of relay 1304, conductor 1326, to ground at the outermost upper armature and contact of relay 1405. Disconnect relay 1602, upon operating, restores in a manner as hereinbefore described the trunk circuit to its normal idle condition.

All trunks busy condition at the concentrating unit office

If no idle trunk is available, all the trunk test relays corresponding to relay 901 shown in the first trunk and similarly operated in the remaining trunks respectively, are in an operated condition and at the lower armature and front contact of each of these relays is closed a chain circuit from ground at the lower armature of relay 901, conductor 912, to a point in the sequence circuit shown in Fig. 2 where two parallel paths are formed one extending over conductor 222 and the other over the outer lower armature and contact of relay 202 (assuming that the subscriber at teletypewriter station 101 originated the call), conductor 223; the conductor 222 extending through the winding of relay 110 to grounded battery and the conductor 223 extending through the winding of busy-back relay 111 to grounded battery, whereby relays 110 and 111 operate. Busy-back relay 111, upon operating, (1) connects at its inner right armature and contact the secondary, or left-hand, winding of relay 104 to prepare a holding circuit for line relay 104, over conductor 112 of the all-trunks-busy circuit; (2) transfers at its outer left armature and contact the tip conductor 102 of subscriber's line for station 101 from grounded battery 126 to conductor 113 of the all-trunks-busy circuit; (3) removes at the outer right armature and back contact ground from the start lead 201 of the sequency circuit causing it to return to normal; (4) connects at its inner left armature and contact ground to conductor 114 of the all-trunks-busy circuit whereby relay 120 operates; and (5) locks up over its outer right armature and front contact to ground at the operated relay 104. Relay 119, upon operating, (1) removes at its outermost right-hand armature and back contact, a connection between the left-hand contact of polarized relay 115 and condenser 116; (2) removes at its innermost right-hand armature and contact, grounded battery 117 from the windings of relay 115; (3) connects at the outermost right-hand armature and front contact, condenser 116 to the contact of relay 118; and (4) connects at its middle right-hand armature and contact, a grounded source 119 of 60 I. P. M. pulses to the winding of relay 118.

When a subscriber such as at station 101, originates a call during the all-trunks-busy period, the subscriber's line comprising conductors 102 and 103 is caused to function to connect conductors 113, 112 and 114 to the all-trunks-busy circuit shown in the lower part of Fig. 1. Ground connected at the inner left-hand armature and contact of busy-back relay 111 causes, as hereinbefore stated, relay 120 of the all-trunks-busy circuit to operate, to thereby connect the winding of slow-release relay 121 to a grounded source 122 of 2 seconds-4 seconds ringing ground. Relay 121 operates in response to the pulses of current received from the source 122 of ringing ground and, upon operating, (1) places a direct ground on conductor 112 which provides over the inner right-hand armature and contact of relay 111, a holding circuit for subscriber's line relay 104 during the spacing condition which exists whenever the subscriber originates a call and (2) closes at its right-hand armature and contact, an operating circuit extending from grounded source 122, through the winding of slow-to-operate relay 123. Slow-to-operate relay 123, upon operating, removes at its armature and contact a short circuit of the secondary, or lower, winding of polarized relay 124, at the same time permitting current to flow through the lower, or secondary, winding of relay 124. When a subscriber's line circuit is connected to the all-trunks-busy circuit during the "no circuit" period, as hereinbefore indicated, relay 118 follows the 60 I. P. M. current and relay 123 follows the ringing ground. With relay 123 normal, the short circuit of the secondary, or lower, winding of relay 124 keeps the armature of the latter relay on its marking, or right-hand, contact, transmitting a "mark" signal over the armature and right-hand contact of relay 124, conductor 113 and thence to those subscribers' lines associated with the all-trunks-busy circuit at this time. When relay 123 operates, it permits current to flow through the lower, or secondary winding of relay 124 causing condenser 116 to discharge through the secondary winding thereby causing relay 124 to operate to its spacing, or left-hand, contact and to thereby transmit a space signal over conductor 113 to the subscriber's line. When the discharging current has decreased sufficiently, relay 124 again returns to marking. If relay 118 is operated, relay 124 does not function until relay 118 releases. On subsequent operation of relay 118, condenser 116 discharges, but the current in this case holds relay 124 to marking. Each subsequent release of relay 118 again causes a spacing signal to be transmitted to the subscriber's line. Therefore a space signal of approximately 22 mil seconds, once per second, is originated during the active interval of the ringing ground circuit while the circuit originates a steady mark signal during the silent interval.

As soon as a trunk becomes idle under this condition, ground is removed from conductor 912 which is an extension of conductor 222, and relay 1110 releases. Relay 110, upon releasing, (1) opens at its middle right-hand armature and contact the operating circuit for relay 118 which

releases and at the same time (2) connects at its innermost right-hand armature and contact, grounded battery to the windings of relay **115**. The connection of grounded battery to the windings of relay **115** causes a current to flow in both the primary and the secondary windings of this relay, the current in the primary, or lower, winding, tend to operate the relay to its right-hand contact and that in the secondary, or upper, winding tending to keep the relay in engagement with the left-hand contact provided relay **123** is still operated. When the discharging current flowing through the secondary winding of relay **115** has decreased sufficiently, relay **115** operates on its primary winding. As soon as the right-hand contact is engaged by the armature, the current is reversed in the primary winding of relay **115** tending to operate the armature to its left-hand contact. The charge on condenser **125**, however, causes a current to flow through the secondary winding in a direction tending to hold relay **115** on its right-hand contact. When this discharge current has been sufficiently dissipated, relay **115** is driven to its left-hand position under the influence of the reverse current in the primary winding. When the right-hand contact and armature of relay **115** are opened, the reverse current in the primary winding ceases and the current through the secondary and the operating current through the primary again begins to flow causing a repetition of the complete cycle. Relay **115** therefore operates and releases at a rate of about 9 cycles per second. The short circuit of the secondary winding of relay **124** occurs nine times per second instead of once per second. Space pulses of 22 mil seconds, nine times per second, create a "K" character on the subscriber's teletypewriter as a signal that a trunk is now available. These signals are, of course, produced only during the active period of the ringing ground circuit. The subscriber disconnects and tries again. If several subscribers have been waiting only one will be serviced by the available trunk and the others in turn will be again connected to the all-trunks-busy circuit which by that time will be producing "letters" signals.

Miscellaneous alarm circuit at the concentrating unit office

The first alarm circuit to be described is that for "timing of the sequence circuit on an outward call." When a subscriber originates an outward call and the sequence circuit is caused to operate relay **324** as hereinbefore described, ground is connected at the inner upper armature and contact of relay **324** in a circuit extending over conductors **326** and **327** through the winding of relay **401** to grounded battery thereby causing relay **401** to operate. Relay **401**, upon operating, (1) removes ground at its left-hand armature from resistance **404** and **405** and condenser **406** and (2) connects grounded positive battery **407** at its right-hand armature and contact to resistance **405**, relay **408** and resistances **409** and **410** which will cause vacuum tube **411** to be lighted. At the same time grounded positive battery connected through resistance **405** will cause condenser **406** to begin charging to a positive potential through resistance **412** to ground. As soon as condenser **406** has assumed a sufficient positive potential, in this case the time being approximately 10 seconds due to selection of proper values for resistance **405** and condenser **406**, a plate current will be caused to flow through the winding of relay **408** which will be sufficient to operate this relay. Relay **408**, upon operating, operates relay **413**. Relay **413**, upon operating, closes at both its upper armatures and contacts an operating circuit for a signal alarm **414** which may be an annunciator circuit or an audible alarm circuit and pilot lamp circuit, and at its lower armature and contact an operating circuit for a visual alarm such as lamp **415**, which will be designated sequence lamp to indicate the sequence circuit has not completed its function within the allowable time of 10 seconds. If the sequence circuit is released in less than 10 seconds, relay **401** will be released due to ground being removed from conductors **326** and **327**, grounded positive battery will be removed from the various elements thus extinguishing vacuum tube **411** and ground will be connected to condenser **406** which will discharge this condenser in preparation for the next timing cycle. Relay **408** under this circumstance will not be operated. If at any time after 10 seconds when relay **408** has been operated and the sequence circuit is released, the circuit will restore to normal.

The next alarm circuit to be described is that of "timing" of permanent mark conditions in trunk circuits on an outward call. The equipment for timing of the permanent mark condition is identical with that employed for timing of the sequence circuit except that the operating circuit for the start relay in the timing circuit is different. Therefore, the elements of the circuit, shown in Fig. 4B, for timing a permanent marked condition have like reference characters as the circuit shown in Fig. 4A for timing the operation of the sequence circuit except that the reference characters in the circuit for timing a permanent mark condition have prime mark indications. Where a subscriber originates an outgoing call and the trunk circuit is caused to function, ground is connected at the back contact and outermost upper armature relay **803** in the trunk circuit to a circuit extending over conductor **826**, contact and middle upper armature of relay **1004**, conductor **1022**, through the winding of relay **401'** to grounded battery thereby causing relay **401'** to operate. Further operation of Fig. 4B will take place similarly as described above for Fig. 4A except that a permanent mark lamp **415'** will be lighted instead of the sequence lamp **415**. If the permanent mark condition in the trunk is removed in less than 10 seconds, the equipment in Fig. 4B will also restore to normal as previously described for the sequence circuit timing alarm due to the removal of ground on conductor **1022**. The equipment shown in Fig. 4B will also restore to normal if the permanent marked condition is removed from the trunk circuit at any time after 10 seconds.

The next alarm circuit to be described is "timing of non-verification and non-completion conditions in trunk circuits on an outward call." When a subscriber originates an onward call and the sequence circuit is caused to function, grounded battery is connected to the lower armature and contact of relay **324** to a circuit which will cause the trunk circuit to function as hereinbefore described. In turn, ground at the outermost lower armature and back contact of relay **803** is connected to a circuit extending over conductor **827**, outer lower armature and contact of relay **903**, conductor **906**, middle lower armature and back contact of relay **420**, through the winding of relay **402** to grounded battery. Relay **402**, upon operating, will (1) remove ground from resistances **421** and **422** and condenser **423** and (2)

connect grounded positive battery 424 to resistance 422 and relay 437 and resistances 425 and 426 which will cause vacuum tube 427 to be lighted. At the same time grounded positive battery through resistance 422 will cause condenser 423 to begin charging to a positive potential through resistance 428 to ground. As soon as condenser 423 has been charged to a sufficient positive potential, in this case, however, resistance 422 and condenser 423 are of such value as to give a time of one second to charge condenser 423 to a positive charge sufficient to cause vacuum tube 427 to operate relay 437. Relay 437, upon operating, closes the operating circuit for relay 429 which, upon operating, closes at both its lower armatures and contacts operating circuits for annunciator or audible alarm and pilot lamp circuits 430 and at its upper armature and contact connects ground to the operating circuit for relay 420. Relay 420, in operating, (1) will close at its innermost lower armature and contact a locking circuit for itself extending to ground at alarm circuit release key 431, (2) closes at its middle lower armature and front contact, a circuit extending from grounded conductor 906 through the non-verification lamp 432 to grounded battery 433, and lamp 432 will become lighted to indicate that the distant end ready signal has not been received in the trunk at the concentrating unit office end; and (3) closes at its middle upper armature and contact a circuit extending from grounded conductor 814 through the non-completion lamp 434 to grounded battery 433 and lamp 434 will become lighted to indicate that the connection of the trunk circuit between the master office and the concentrating unit office terminal has not been completed. If the verification signal is received at the concentrating unit office end within one second, vacuum tube 427 will not function to cause relay 437 to operate and the circuit shown in Fig. 4 will restore to normal. The restoration to normal of this circuit would be caused by ground being removed from conductor 906 whereby relay 402 would release. Assuming that the verification signal, that is the distant end ready signal, has been received at the concentrating unit office end within one second, a ground will next be connected to conductor 814 which will cause relay 403 to operate. Relay 403 upon operating, will cause relay 402 to operate and will also disconnect resistance 435 from a parallel connection with resistance 422. Further function of the circuit shown in Fig. 4, will take place similarly as hereinbefore described except that in this case, due to resistance 435 being disconnected, the time constant of resistance 422 alone and condenser 423 will be approximately 10 seconds instead of one second. After 10 seconds then relay 429 will be operated and similarly will cause relay 420 to be operated which will be locked under control of the alarm circuit release key 431 and light the non-completion lamp 434. The lighting of the non-completion lamp 434 will indicate that the connection between the master office and concentrating unit office terminals has not been completed. If the connection has been cut through between these terminals within 10 seconds ground will be removed from conductor 814 in the trunk circuit thereby releasing relay 403 which will restore the alarm circuit to normal. Completion of the connection between the master office and the concentrating unit office terminal will also cause grounded battery to be removed from conductor 325 in the sequence circuit thus restoring relay 420 and lamp 434 to normal.

Operator at master office originates a call to a subscriber's station

Assuming that switchboard jack 1704 corresponds to subscriber's station 101 which is connected to the concentrating unit office and that a connection to the station 101 is desired, the operator inserts the calling plug of cord circuit 1708 in jack 1704 and thereby closes a circuit extending from grounded battery (not shown) in the cord circuit, sleeve conductors of the calling plug and jack 1704 to operate sleeve relay 1702. Sleeve relay 1702, upon operating, closes at its lower armature and contact a circuit extending from ground, lower armature and contact of relay 1702, conductor 1709, inner upper armature and contact of relay 1703, conductor 1705, make-before-break contacts of relay 1706, conductor 1707, conductor 1801, outermost upper armature and contact of subgroup relay 1821, conductor 1803, through the winding of relay 1810, to grounded battery to operate relay 1810. Also, relay 1702, upon operating, (1) disconnects answering lamp 1701 which is associated with jack 1704 and (2) connects ground at its lower armature and contact to the winding of relay 1703. Assuming the sequence circuit shown in Figs. 18 and 19 is in an idle condition and all trunk circuits are avaliable the first idle trunk will be selected in the following manner. Relay 1810, upon operating, connects grounded conductor 1707, through a chain circuit extending over the front contact and inner lower armature of relay 1810, then over the back contact and inner lower armature of each of the relays, in succession, as hereinbefore described in connection with the sequence circuit at the concentrating unit office, and through the winding of relay 1924 to grounded battery to operate relay 1924. Relay 1924, upon operating, (1) connects ground at its inner upper armature and contact to a circuit extending over the inner upper armature and back contact of each of the relays, in turn, of the sequence circuit as far as relay 1810 and at this point the circuit is closed over the inner upper armature and front contact of relay 1810 to grounded battery thereby providing a locking circuit for relay 1810, (2) connects at its innermost upper armature and front contacts an operating circuit for subgroup relays 1821 and 1921 which disconnects all the start conductors, such as conductor 1707 for the line terminating at jack 1704, to eliminate interference from other calling jacks, (3) connects at its outer upper armature a ground connection to conductor 1926 through the winding of relay 2001, to grounded battery 2007 to close the operating circuit for furnishing an alarm if the sequence circuit does not select an idle trunk within ten seconds, and (4) connects grounded battery in a circuit extending over its lower armature and contact, conductor 1925, upper make-before-break contact of relay 2020, conductor 2036, through the winding of start relay 1601, conductor 1616 to ground at the outer lower armature and back contact of trunk test relay 1103 providing the trunk circuit shown is idle. Should the trunk circuit shown be busy at the time the operator originates a call at jack 1704, relay 1103 in the trunk circuit shown will be in an operated condition and the operating circuit for start relay 1601 of the trunk circuit shown cannot be completed. However, conductor 2036 to which the grounded battery of relay 1924 is connected is permitted access through the winding of trunk start relay of trunk No. 2 to

the back contact and outer lower armature of trunk test relay 1103', front contact and outer lower armature of relay 1103 to ground thereby allowing the start relay of trunk No. 2 to operate. Should trunk test relay 1103' of trunk No. 2 be busy at this time, conductor 2036 to which grounded battery is connected may be extended through the winding of the start relay of trunk No. 3 through the back contact and outer lower armature of trunk test relay 1303'' (not shown), front contact and outer lower armature of relay 1103', front contact and outer lower armature of relay 1103 to ground. The release of any one busy trunk will make that trunk available for the next call. Also, relay 1924, upon operating, connects at its innermost upper front contacts a ground connection to conductor 1928 which extends over the contact and outer upper armature of relay 1810 to conductor 1822. By placing ground on conductor 1822 the calling line connected to jack 1704 is prepared for selection by the first idle trunk circuit.

All-trunks-busy circuit at master office

If all trunks circuits are busy when a call to a subscriber is originated, ground will be found on the front contact and outer lower armature of relay 1103^N which is the trunk test relay in the last trunk circuit, and connected to the all-trunks-busy conductor 1122 through the winding of relay 1710 to grounded battery and relay 1710 operates. Also grounded conductor 1122 is connected over the outer lower armature and contact of relay 1810, conductor 1823 through the winding of the busy-back relay 1706 to grounded battery, and relay 1706 operates. Relay 1706 upon operating (1) closes at its lower armature and front contact a locking circuit for itself extending over conductor 1705, contact and inner upper armature of relay 1703, conductor 1709, contact and lower armature of relay 1702 to ground; (2) closes at its inner upper armature an operating circuit for relay 1711 and (3) connects at its outer upper armature and front contact tip conductor 1712 to the armature of polarized relay 1713. Relay 1710 upon operating (1) removes the connection between the right-hand contact of relay 1714 and condenser 1715; (2) removes at its outer right-hand armature and contact grounded positive battery 1716 from the windings and left-hand contact of relay 1714 and (3) connects at its outer left armature and front contact condenser 1715 to the contacts of relay 1717. This transfer as will be seen hereinafter results in the production of "letters" signals at the rate of one per second instead of forty speed "K" signals.

Relay 1711, upon operating, connects source 1718 of two second-four second ringing ground through the winding of relay 1719 which then operates in accordance with pulses received from source 1718.

Relay 1717 follows the 60 I. P. M. pulses received from grounded source 1720 of 60 impulses per minute.

When the switchboard line circuit at which the operator originated the call is connected to the all-trunks-busy circuit during the "no-circuit period" as hereinbefore indicated, relay 1717 follows the 60 I. P. M. pulses and relay 1719 follows the ringing ground. With relay 1719 normal, a current flows from grounded positive battery 1721, resistance 1722, conductors 1723 and 1724, contact and back armature of relay 1719, resistances 1725, 1726 and 1727, through the lower winding of relay 1713, to ground. Also condenser 1715 is charged to a potential approximately equal to that of battery 1721. This current keeps the armature of relay 1713 against its marking or right-hand contact thereby transmitting a mark signal out on conductor 1728, front contact and outer upper armature of relay 1706, conductor 1712 to the operator's teletypewriter (not shown) connected in the cord circuit 1708. This marked signal may also be transmitted to other operated teletypewriters that may happen to be connected to the all-trunks-busy circuit at the time. When relay 1719 operates in response to the ringing ground from source 1718, ground is connected at the armature and front contact of relay 1719 causing condenser 1715 to charge through the primary winding whereby relay 1713 operates to its spacing, or left-hand contact to transmit a space signal over conductor 1728. When the discharging current has decreased sufficiently, the armature of relay 1713 again returns to marking. If relay 1717 is operated, relay 1713 does not function until relay 1717 releases. On subsequent operation of relay 1717, condenser 1715 discharges but the current in this case holds the armature of relay 1713 on its marking, or right-hand, contact. Each subsequent release of relay 1717 again causes a spacing signal to be transmitted over conductor 1728 to the switchboard operator. Therefore a space signal of approximately 22 mil seconds, once per second, is originated during the active interval of the interrupter relay circuit connected to source 1718 while the circuit originates a steady mark signal during the silent interval.

As soon as a trunk becomes idle, under this condition ground is removed from conductor 1122, causing the release of relay 1710. Relay 1710 upon releasing opens at its inner left armature and contact the operating circuit for relay 1717 and at the same time connects at its outer right-hand armature and contact grounded battery 1716 to the windings and left contact of relay 1714. The connection of grounded battery 1716 to the windings of relay 1714 causes a current to flow in both its primary and the secondary windings, the current in the primary winding tending to operate the relay to its left-hand contact and the current in the secondary winding tending to keep the relay armature on its right-hand contact provided relay 1710 is operated. When the discharging current flowing through the secondary winding of relay 1714 has decreased sufficiently, relay 1714 operates on its primary winding to its left-hand contact. As soon as the armature of relay 1714 closes to its left-hand contact, the current is reversed in the primary winding of relay 1714 tending to drive the armature to its right-hand contact. The charge on condenser 1729, however, causes a current to flow through the secondary in a direction tending to hold relay 1714 on its left-hand contact. When this discharge current has been sufficiently dissipated, relay 1714 is operated so that its armature moves into engagement with its right-hand contact under the influence of the reverse current in the primary winding. When the armature disengages its left-hand contact, the reverse current in the primary or lower winding ceases and the current through the secondary or upper winding and the operating current through the primary again begins to flow causing a repetition of the complete cycle. Relay 1714 therefore operates and releases at a rate of about nine cycles per second. Space pulses of 22 mil seconds, nine

times per second, create a "K" character on the operator's teletypewriter as a signal that the trunk is now available. These signals are, of course, produced only during the active period of the interrupter relay circuit connected to source 1720. The operator disconnects and tries again. If several operators have been waiting, only one will be serviced by the available trunk and the others in turn will be again connected to all-trunks-busy circuits which by this time will be producing "letters" signals.

Operation of the trunk circuit

When the trunk start relay 1601 operates, it (1) connects at its middle upper armature and contact, grounded battery to the winding of relay 1618; (2) opens at its outermost upper armature and back contact an operating circuit for trunk test relay 1103 (one of the chain relays); (3) closes at its next to the innermost upper armature and back contact conductor 1619 which extends to the miscellaneous alarm circuit; (4) closes at its next to the outermost upper armature and contact a ground connection to conductor 1620 which extends through the winding of relay 1304 to grounded battery to operate relay 1304; (5) closes at its innermost upper armature and front contact a locking circuit for itself; (6) closes at its middle lower armature and front contact a future operating circuit for alternating current relay 1205 and at the same time opens the operating circuit for "mark" relay 1404 at its associated back contact; (7) connects at the innermost lower armature and front contact grounded positive battery 1603 to a circuit extending over conductor 1621, back contact and next to the innermost upper armature of relay 1408, conductor 1410, back contact and outermost upper armature of relay 1214, conductors 1213 and 1611, make-before-break contacts of relay 1517, conductor 1514, through the lower winding of polarized relay 1505, back contact and lower armature of relay 1313, through the lower winding of polarized send relay 1311, conductor 1327, outermost upper armature at relay 1310, to grounded negative battery 1314 whereby relays 1311 and 1505 operate to their marking positions (relay 1311 operating to its right-hand position and relay 1505 to its left-hand position) to place a marking condition on tip conductor 1312 extending to the concentrating unit office; (8) connects at its outermost lower armature and front contact the zero contact on bank A' of the rotary selector switch in a circuit extending from grounded battery, middle upper armature and contact of relay 1204, conductor 1215, through the winding of relay 1210, conductors 1216 and 1622, front contact and outermost lower armature of relay 1601, conductor 1623, brush of switch bank A' in its normal position, conductor 1605 to ground at the innermost upper armature and back contact of disconnect relay 1602 to operate relay 1210; (9) closes at its next to the innermost lower armature and contact a ground connection to a circuit extending over conductor 1624, through the winding of relay 1309 to grounded battery which causes relay 1309 to operate; (10) opens at its next to the outermost lower armature and contact a circuit for operating relay 1408. Relay 1309, upon operating, (1) places at its outer lower armature and contact a ground connection in a circuit traceable from ground at next to the innermost lower armature and back contact of relay 1408, conductor 1411, outer lower armature and contact of relay 1309, conductor 1328 which extends into the miscellaneous alarm circuit; (2) completes at its inner lower armature and front contact a locking circuit for itself extending over conductor 1329 to ground at the outermost lower armature and front contact of busy relay 1109 which operated subsequently to relay 1304 as hereinafter described; and (3) supplies at its upper armatures and front contacts grounded positive battery 1603 in a circuit traceable over the innermost lower armature and contact of relay 1601, conductors 1621 and 1412, to its upper armatures and then over two parallel paths, one beginning at its inner upper armature and front contact to form two other parallel paths, respectively extending to the inner lower armature, in normal position, of relay 1523 and to the upper armature, in normal position, of relay 1618, and the other beginning at its outer upper armature and front contact, and extending through conductor 1342 to the armature and left-hand contact of relay 1208 and to the front contact and the outermost lower armature of relay 1204, conductors 1213 and 1611, to the lower winding, in series, of send relays 1505 and 1311, the grounded positive battery 1603 being used at various times to place a marking condition on the windings of the send relays 1311 and 1505 for the purpose of placing a marking condition on tip conductor 1312 which extends to the concentrating unit office.

Relay 1304, upon operating, opens at its outermost lower armature and contact the operating circuit for disconnect relay 1602; (2) closes at its innermost lower armature and front contact a circuit traceable from the marking contact on receive relay 1101, conductor 1111, front contact and innermost lower armature of relay 1304, make-before-break contacts of relay 1310, conductor 1330, contact and upper armature of relay 1510, conductors 1520 and 1223, upper make-before-break contacts of relay 1214, conductor 1217, middle lower armature and front contact of start relay 1601, conductor 1625, contact and middle lower armature of relay 1405, conductor 1413, resistance 1218, condenser 1219, through the winding of alternating current relay 1205, to ground whereby relay 1205 operates by means of an alternating current potentiometer comprising resistances 1218 and 1414 and grounded positive battery 1603; (3) transfers at its middle lower armature the grid circuit of vacuum tube 1401 from holding ground through resistance 1305 at the back contact, to grounded positive battery 1102 through resistance 1306 at the front contact (the filaments of vacuum tubes 1201, 1202, 1203, 1401, 1402 and 1403 are lighted by the heating circuit which extends to ground at the innermost lower armature and front contact of busy relay 1109 or at the marking contact of relay 1101), permitting tube 1401 to thereby operate in successive order relays 1307 and 1308; (4) connects at its innermost upper armature and front contact grounded positive battery 1603 in a circuit extending over conductor 1610, innermost upper armature and front contact of relay 1304 to the back contact at the outer upper armature of relay 1309 which contact is now open; (5) supplies at its middle upper armature and contact a ground connection through a path extending over conductor 1331, through the winding of busy relay 1109 to grounded battery to operate relay 1109 to which reference hereinbefore was made; (6) removes at its outermost upper armature and contact a ground connection from the

grid circuit of vacuum tube **1203** in a path traceable over conductors **1123** and **1124** when vacuum tube **1203** is held non-operative by ground at the outermost lower armature and contact of relay **1108**. Relay **1308**, upon operating, (1) removes at the outer upper armature and contact the ground connection from the grid circuit of vacuum tubes **1402** and **1403** which remain non-operative however under control of the ground connection at the next to the outermost upper armature and contact of relay **1108**; (2) closes at its lower armature and contact one of the closing points in the operating circuit for line relay **1501**. Busy relay **1109**, upon operating, (1) supplies at its next to its innermost lower armature and front contact a ground for the future locking circuit for trunk test relay **1103**, (2) supplies at the outermost lower armature and contact a ground connection for the locking circuit of relay **1309** and at its next to the outermost lower armature and contact a future locking circuit for relay **1310**; (3) connects at its upper armature and contact a source **1124** of six volt alternating current supply to a circuit for lighting busy lamp **1504** associated with the trunk jack **1521** at the operator's switchboard which jack corresponds to jack **1704**; and (4) as hereinbefore stated, supplies at its innermost lower armature and front contact a ground connection for the future operating circuit of relay **1103** and for the heating circuit of vacuum tubes **1201**, **1202**, **1203**, **1401**, **1402** and **1403**. Jack **1521** and answering lamp **1522** are provided to permit manual completion of calls in case of failure of the automatic equipment.

Reception of marking pulse at the concentrating unit office

The marking pulse placed on conductor **1312** is received through the lower winding of polarized receive relay **907** which operates to its marking, or right-hand, contact to complete a circuit from ground, marking contact and armature of relay **907**, through the windings, in parallel, of polarized receive relay **904**, right-hand armature and back contact of relay **707**, through the lower winding of polarized relay **717**, to grounded positive battery connected to the left-hand, or spacing, contact of relay **907**, to operate relay **904**. Relay **904**, upon operating, connects ground over its armature and right-hand, or marking, contact to a circuit extending over conductor **908**, make-before-break contacts of relay **902**, conductor **913** through the filaments, in series, of vacuum tubes **605**, **604**, **603**, **809**, **808** and **807**, resistance **828**, conductors **829**, **830** and **820** to grounded positive battery **819** whereby the filaments of the vacuum tube are heated. Also, relay **904**, upon operating, to its marking, or right-hand, contact, connects ground to another circuit, extending over conductor **908**, make-before-break contacts of **902**, conductor **911**, back contact, inner upper armature and the winding of trunk test relay **901**, conductor **507**, back contact and middle lower armature of start relay **801**, conductors **831** and **820** and to grounded positive battery **819**. Relay **901** operates to free this particular trunk circuit from seizure for outgoing calls and to prepare for an operating circuit for the start relay corresponding to relay **801**, for the next idle trunk. Relay **901**, as hereinbefore stated, is one of a chain of relays, each relay of the chain being individual to a trunk circuit but having their lower armatures in such engageable relation that when all trunks are busy all the chain relays, such as relays **901**, **901'** and **901^n**, are operated and the ground at the lower armature of the first relay, such as relay **901**, is connected through the armatures and contacts, successively, of all the operated relays in the chain to conductor **912**, which extends to the all-trunks-busy circuit as hereinbefore described. In the event that a trunk, say the second trunk, is available for an outgoing call at the concentrating unit office, relay **901** which is assumed to be in an operated position, prepares the second trunk for selection, by connecting ground at the lower armature and front contact of relay **901** to the armature and back contact of relay **901'** which back contact is connected directly through the winding of the start relay of the second trunk. Also, relay **904**, upon operating, removes a holding ground from the grid circuit of vacuum tube **604** so that condenser **624** starts charging from grounded positive battery **819**, conductor **820**, conductor **625**, resistances **626** and **610**, conductor **627** to ground through the condenser **624**. As soon as this charge on condenser **624** reaches such a potential that the grid of vacuum tube **604** permits plate current to operate relay **609**, in approximately 0.5 second, relay **706** is operated over a circuit extending from ground at the armature and contact of relay **609**, conductors **628** and **629**, through the winding of relay **706** to grounded battery. Relay **706**, upon operating, (1) closes at its inner left-hand armature and contact an operating circuit for line relay **613**, which circuit extends from the inner left-hand armature of relay **706**, left-hand armature and back contact of relay **710**, conductor **722**, through the winding of relay **613** to grounded battery; (2) opens at its outer left-hand armature and back contact the operating circuit for relay **707**; (3) also at its outer left-hand armature, but front contact, connects ground to an operating circuit for transfer relay **606** which is traceable from grounded battery **832**, conductor **833**, through the winding of relay **606**, conductors **629** and **515**, to ground at the front contact and outer left-hand armature of relay **706** and relay **606** operates; and (4) transfers at its right-hand armature the spacing contact of relay **904** from the grid circuit of vacuum tube **604** to the grid circuit of vacuum tube **809**. Relay **613**, upon operating, (1) closes at its left-hand armature and contact an operating circuit for answering lamp **516** and at its right-hand armature and contact an operating circuit for a night alarm device **517**. Answering lamp **516** is associated with jacks **157** and **518** which serve to permit manual completion of calls between the trunk and subscribers' loops in case of failure of the automatic equipment. Transfer relay **606**, upon operating, (1) partially completes at its outermost right-hand armature and contact a future operating circuit for relay **731**; (2) partially completes at its next-to-its-outermost right-hand armature and contact a 2 second-4 second future operating circuit for relay **506**; (3) removes at its middle right-hand armature and contact one of the holding grounds from the grid of vacuum tube **808**; the circuit being traceable from the grid element of tube **808**, resistance **810**, conductor **823**, outer left-hand armature and contact of relay **707**, conductors **719**, **720** and **639** to the contact associated with the middle right-hand armature of relay **606**; (4) closes at its innermost right-hand armature and contact a locking circuit for itself; (5) shunts at its outermost left-hand arma-

ture and contact the resistive element 610 and thereby reduces the resistance in the grid charging circuit of vacuum tube 604 by one megohm; (6) closes at its next to its innermost left-hand armature and front contact the operating circuit for relay 902 and relay 902 operates, the circuit being traceable over conductors 640 and 914, through the winding of relay 902 to grounded battery; (7) removes at its innermost left-hand armature and front contact resistive element 630 from the grid circuit of vacuum tube 603 in order to reduce the operating time of the tube; and (8) removes at its next to its outermost left-hand armature and contact and at its middle left armature and contact the holding ground for vacuum tubes 809 and 605, respectively.

Relay 902, upon operating, (1) opens at its outermost lower armature and contact the operating path for disconnect relay 1003; (2) connects at its middle upper armature and front contact the marking, or right-hand, contact of relay 904 in a circuit traceable over conductors 908 and 709, make-before-break contacts of relay 704, outermost left-hand armature and contact of relay 705, conductors 813 and 812, lower make-before-break contacts of relay 804, conductor 841, middle upper armature and back contact of start relay 801, conductor 818, through the winding of "mark" relay 1002, to grounded positive battery 1014 to operate relay 1002; (3) substitutes for the ground now connected to the armature and marking contact of relay 904 with ground at the outermost upper armature and front contact of relay 902 for maintaining the heating circuit for vacuum tubes 605, 604, 603, 809, 808 and 807 operated; (4) closes at its innermost lower armature and contact a circuit from ground, over conductor 721, inner left-hand armature and back contact of relay 714, conductor 723, middle right-hand armature and back contact of relay 504, through the lower winding of relay 501, resistive elements 520 and 521, conductors 619 and 820 to grounded positive battery 819, which circuit conditions the biasing, or lower winding, of relay 501 to hold the relay on its spacing, or left-hand contact; (5) closes at its middle lower armature and front contact an operating circuit for busy relay 905; (6) removes at its innermost upper armature and front contact a holding ground from the grid circuit of vacuum tube 809; and (6) connects at its innermost upper armature and front contact ground to conductor 909 in a path extending over the back contact and outer upper armature of relay 903, conductor 1012, then over two parallel paths, one extending to the armature and contact of polarized relay 1001 and the other over conductor 1011 to the two outermost upper armatures of relay 1006.

"Mark" relay 1002, upon operating, closes at its innermost upper armature and contact a circuit extending from grounded battery, through the winding of relay 1004, front contact of innermost upper armature of relay 1002, conductors 1023, 1024 and 1025, make-before-break contacts of disconnect relay 1003, to ground to operate relay 1004; (2) closes at its outermost upper armature and front contact a circuit extending from ground at the next to the innermost right-hand armature and front contact of relay 606, conductor 631, front contact and outermost upper armature of relay 1002, conductor 1026, back contact and outer right-hand armature of relay 710, conductor 711 then over two parallel paths, one extending to the grid of vacuum tube 807 and the other over conductor 835 to the grid of vacuum tube 605 to maintain vacuum tubes 807 and 605 non-operative; (3) opens at its lower armature and contact the operating circuit for relay 1006. Relay 1004, upon operating, (1) closes at its middle upper armature and front contact an operating circuit for relay 401' in the miscellaneous alarm circuit, the circuit being traceable from ground, outermost upper armature and back contact of relay 803, conductor 826, front contact and middle upper armature of relay 1004, conductor 1022, through the winding of relay 401' to grounded battery thereby preparing the arrangement for timing the duration of the mark signal received over conductor 1312; (2) closes at its innermost upper armature and front contact a holding circuit for itself extending to ground at the make-before-break contacts of disconnect relay 1003; (3) closes at its innermost lower armature and front contact a future operating circuit for the selector switch stepping magnet 606, the circuit being traceable from grounded battery, through the winding of magnet 608, conductor 622, outermost lower armature and back contact of relay 1003, innermost lower armature and front contact of relay 1004, to the back contact and middle upper armature of relay 1002 at which point the circuit is now open; (4) closes at its middle lower armature and contact a circuit for connecting source 607 of 20-cycle ringing current through the lower winding of polarized send relay 702 which responds to the 20-cycle pulses, the circuit being traceable from grounded source 607, conductor 632, resistive element 633, conductor 634, innermost upper armature and back contact of relay 803, conductor 835, middle lower armature and front contact of relay 1004, conductors 1027 and 635, make-before-break contacts of relay 509, conductor 512, outer left armature and back contact of relay 506, through the lower winding of polarized relay 701, back contact and outer right armature of relay 714, through the lower winding of polarized send relay 702, outer left armature and back contact of relay 731, to grounded positive battery 724; (5) opens at its outermost lower armature and back contact the shunt path for the operating circuit for alternating current relay 802; and (6) prepares at its outermost upper armature and contact a future operating circuit for disconnect relay 1003.

Reception of the 20-cycle pulses as a verification signal at the master office

The 20-cycle pulses reproduced by send relay 702 are transmitted over conductor 703 to the master office. At the master office the reception of the 20-cycle verification signal causes relay 1101 to respond by operating its armature between its marking and spacing contacts and thereby alternately closes to ground the operating circuit for alternating relay 1205, the path thus alternately closed to ground extending over the marking contact of relay 1101, conductor 1111, contact and innermost lower armature of relay 1304, make-before-break contacts of relay 1310, conductor 1330, contact and upper armature of relay 1510, conductors 1520 and 1223, upper make-before-break contacts of relay 1214, conductor 1217, middle lower armature and front contact of start relay 1601, conductor 1625, contact and middle lower armature of relay 1405, conductor 1413, resistance 1218, condenser 1219, through the winding of relay 1205 to ground. The operating circuit for relay 1205 which is alternately

shunted as just described is traceable from grounded battery 1603, resistance 1414, conductor 1413, resistance 1218, condenser 1219, through the winding of relay 1205 to ground. Relay 1205 responds to the 20-cycle pulses. Relay 1205, upon operating, closes at its armature an operating circuit for relay 1214 which operates in a circuit traceable through the winding and lower make-before-break contacts of relay 1214, to ground at the contact and the next to the outermost upper armature of relay 1408.

Relay 1214, upon operating, (1) opens at its middle upper armature and contact the operating circuit for relay 1204, (2) closes at its middle lower armature and contact the operating circuit for relay 1408 which operates, (3) replaces at its innermost upper armature and contact the original operating circuit for alternating current relay 1205 with a more direct path which is independent of the contacts of start relay 1601 and relay 1405, (4) replaces its operating ground with ground at its innermost lower armature and contact, (5) supplies at its outermost lower armature and contact an operating ground for relay 1107 which operates, and (6) opens at its outermost upper armature and contact the circuit extending through the lower winding of send relay 1505 which placed the original marking condition on send conductor 1312 extending to the concentrating unit office, thus changing this marking condition to a spacing condition.

Relay 1107, upon operating, (1) opens at its outermost upper armature the circuit extending through the lower winding of relay 1101 and places relay 1103 in the receiving conductor 703, (2) closes at its lower armature and contact the operating circuit for transfer relay 1108, which operates, (3) closes at its middle upper armature and contact one point in the operating circuit for relay 1501, (4) transfers at its innermost upper armature and contact the spacing, or left-hand, contact of relay 1101 from the grid circuit of vacuum tube 1201 to the grid circuit of vacuum tube 1203. Relay 1108, upon operating, (1) locks itself to ground at its innermost upper armature and contact, (2) removes at its outermost upper armature and contact the ground connection which will later be connected to the ring conductor 1730 for operating the operator's cord lamp (not shown) at the switchboard, (3) connects at the next to its innermost upper armature and contact a ground connection which will later hold vacuum tubes 1402 and 1403 inactive during the pulsing period, that is, when the stepping pulses are being transmitted and received, (4) closes at its middle lower armature and contact a path for shunting resistive element 1105 whereby the charging resistance in the grid circuit of vacuum tube 1201 is reduced from 1.1 megohm to 0.1 megohm and the operating time of the tube is reduced from 0.5 second to 0.04 second, (5) connects at its innermost lower armature and contact a holding ground for relay 1304, (6) removes at its outermost lower armature and contact a holding ground from the grid circuit of vacuum tube 1201 which now operates, and (7) removes at the next to its outermost upper armature and contact the ground connection from the grid circuit of vacuum tubes 1402 and 1403 which do not operate at this time. Tube 1201, upon operating, permits relay 1106 to operate thereby holding relay 1107 in an operated condition.

Relay 1408, upon operating (1) locks itself to ground at the make-before-break contacts of disconnect relay 1602, (2) opens at its outermost upper armature and contact the circuit over which the 20-cycle pulses from source 1407 are transmitted over send conductor 1312 to the concentrating unit office when the call originates at the concentrating unit office, (3) closes at its innermost upper armature and contact the first contacts in an operating circuit for "mark" relay 1404, (4) closes at the next to its outermost lower armature and contact the operating circuit for relay 1405 which operates, (5) removes at the next to its outermost upper armature and contact the ground connection from the original operating circuit for relay 1214, (6) connects at its outermost lower armature and contact a ground for the future operating circuit of relay 1204, (7) removes at its middle upper armature the ground connection from condenser 1209 to permit the combination of relay 1208 and condenser 1209 and associated resistances to start timing in preparation for operating relay 1208 to its marking, or left-hand, contact, (8) transfers at the next to its innermost lower armature and contact the ground connection from conductor 1328 which extends to the miscellaneous alarm circuit, to conductor 1619 which extends to the same circuit, (9) opens at the next to its innermost upper armature and contact the circuit which caused the original marking condition to be placed on conductor 1312 extending to the concentrating unit office.

Relay 1405, upon operating, (1) locks itself to ground at the make-before-break contacts of disconnect relay 1602, (2) opens at its middle lower armature and contact the original operating circuit for alternating current relay 1205, (3) closes at its innermost lower armature and contact the 20-cycle current circuit not used when the call originates at the master office, (4) closes at its outermost lower armature and contact an operating circuit for selector switch magnet 1604 which operates, (5) closes at its outermost upper armature and contact one point in the future operating circuit for disconnect relay 1602, and (6) closes at its middle upper armature and contact a path extending to the miscellaneous alarm circuit.

As noted hereinbefore, relay 1408, upon operating placed a spacing condition on the line toward the concentrating unit office and permitted relay 1208 to start "timing out." After approximately 0.05 second the current in the lower winding of relay 1208 which is charging condenser 1209 decreases to such an extent that the current in the upper winding operates relay 1208 to its marking, or left-hand, contact as hereinbefore stated, thereby causing send relays 1311 and 1505 to again place a marking condition on conductor 1312. The spacing condition followed by a marking condition on conductor 1313 constitute the stepping pulses for operating the selector switch at the concentrating unit office as will now be described.

The reception of the first stepping pulses at the concentrating unit office

The reception of the timed spacing signal followed by a marking signal at the concentrating unit office causes the selector switch at that office to advance to the first contacts of each of the selector switch banks at that office and to replace the 20-cycle pulses that are being transmitted to the master office with a spacing signal which is changed to a mark in approximately 0.05 second.

The reception of the timed spacing signal releases "mark" relay 1002. Relay 1002, upon releasing, (1) causes selector switch stepping magnet 608 to energize in a circuit traceable from grounded battery, through the winding of magnet 608, conductor 622, outermost lower armature and back contact of disconnect relay 1003, conductor 1030, innermost lower armature and contact of relay 1004, back contact and middle upper armature of relay 1002, conductors 1023, 1024 and 1025 to ground at make-before-break contacts of disconnect relay 1003; (2) removes at its outermost upper armature, grounded conductor 631 from the grid circuit of vacuum tube 605 and 807. After approximately 0.05 second, the spacing signal from the master office again changes to a mark signal and "mark" relay 1002 again operates, thereby deenergizing the selector magnet 608 which permits the selector switch brushes to step to the first contact on their respective banks A, B, C, D and E. When brush of bank A steps to its first contact, a circuit is closed for operating relays 611 and 803, the circuit having two parallel paths both extending from ground at the innermost upper armature and contact of disconnect relay 1003, conductor 1020, zero contact, strap, brush and first contact of bank A, conductor 620, to a point where the paths divide, one being traceable through the winding of relay 611, conductor 1031 to grounded battery at the innermost upper armature and contact of relay 1006 and the other conductor 621, make-before-break contacts of start relay 801, conductor 825, outermost upper armature and back contact of disconnect relay 1003, conductor 1034, make-before-break contacts of and through the winding of relay 803, to grounded battery. Relays 611 and 803 operate and lock to separate ground connections at the contacts of disconnect relay 1003. Relay 803, upon operating, (1) disconnects ground at the next to the innermost upper armature and contact from the right-hand end of the lower winding of relay 1001, to permit condenser 1009 to start charging, the circuit being traceable over conductor 815; (2) closes at its innermost lower armature and front contact, a locking circuit for itself which extends over conductor 1025 to ground at the make-before-break contact of disconnect relay 1003; (3) opens at its outermost upper armature and back contact the operating circuit of relay 804; (4) closes at its outermost upper armature and front contact a second operating circuit for relay 1006 which is not effected, however, at this time; (5) prepares at its next to the outermost lower armature and contact an alternate operating circuit for "mark" relay 1002 also not effective at this time; and (6) opens at its innermost upper armature and contact the circuit supplying 20-cycle pulses to relay 702 so that the 20-cycle pulsing condition on the line is changed to a spacing condition. The pulsing circuit just opened is traceable through the lower windings of relays 702 and 701, conductors 512, 635 and 1027, contact and middle lower armature of relay 1004, conductor 845, contact and innermost upper armature of relay 803, conductor 634, resistance 633, conductor 632 to grounded source 607 of 20-cycle pulsing current. After approximately 0.05 second following the operation of relay 803, relay 1001 under the influence of current in its upper winding operates to its marking, or left-hand, contact. Relay 1001, upon operating, operates relays 701 and 702 to place a marking condition on the line.

The reception of the first stepping pulses at the master office

As just stated the reception of the spacing and marking signals at the concentrating unit office causes the selector switch at that office to advance to the first contact and to replace the 20-cycle pulses to the master office with a spacing signal which in turn is changed to a mark in approximately 0.05 second. At the master office the change from 20 cycle to a space condition causes the alternating current relay 1205 to release which in turn releases relay 1214. Relay 1214, upon releasing, (1) completes at its middle upper armature and contact an operating circuit for relay 1204; (2) completely opens all operating paths for relay 1205; (3) opens at its middle lower armature and contact the original operating circuit for relay 1408; and (4) opens at its outermost lower armature the original operating circuit for relay 1107. At the time relay 1107 was first operated, the grid circuit of vacuum tube 1201 was freed from restraining ground and the operation of relay 1108 which followed immediately further reduced the time required for operation of vacuum tube 1201 by removing a part of the grid charging resistance, thus before relay 1214 releases the plate current in vacuum tube 1204 has operated relay 1107 so that relay 1107 does not release with the release of relay 1214. Relay 1204 upon operating, (1) opens the operating circuit of relays 1209 and 1210, relay 1206, however, remaining operated to battery on its own contact; (2) closes at its outermost upper armature and contact an operating circuit for relay 1211 which operates and locks under the control of disconnect relay 1002; (3) closes at its outermost lower armature and contact, a circuit including grounded positive battery 1603 for holding the trunk circuit line toward the concentrating unit office in a marking condition as established by relay 1208; (4) connects at its middle lower armature and contact, a ground to the left-hand end of the lower winding of relay 1208 which now operates to its right-hand position; and (5) closes at its innermost lower armature and contact a locking circuit for itself extending to grounded battery 1220. When the spacing signal received from the concentrating unit office changed to mark, ground from the marking contact of relay 1101 causes "mark" relay 1404 to operate. "Mark" relay 1404, upon operating, (1) deenergizes the selector switch stepping magnet 1604, thus permitting the selector switch brushes to step to the first contact on all banks; (2) opens at its lower armature and contact the operating circuit for relay 1204, which, however, remains locked in operated position under control of relay 1206 and (3) connects ground at its outermost upper armature and contact to the grid circuit of vacuum tubes 1403 and 1402. The stepping of brush on bank A' to its first contact, causes relay 1206 to operate and relay 1210 to release. With the selector switch brush on the first contact of bank B' a circuit is closed from ground at the inner upper armature and front contacts of relay 1924, conductor 1928, contact and outer upper armature of relay 1610, conductor 1922, first contact, wiper, strap and zero contact of switch bank B', through the winding of relay 1610, middle upper armature and contact of start relay 1601, to grounded battery and relay 1610 operates to connect grounded positive battery 1603 to the operating circuit for relay 1311 whereby relay 1311 is held in its mark-

ing position to prevent additional stepping pulses to be sent to the concentrating unit office. Relay 1618, upon operating, closes an operating circuit for relay 1523. Relay 1523, upon operating, (1) also connects grounded positive battery 1603 to the operating circuit for send relay 1311 and (2) closes at its upper armature and contact an operating circuit for relay 1316 and at its outer lower armature and contact an operating circuit for trunk test relay 1103 which operates. Relay 1316, upon operating, (1) opens at its outermost lower armature and contact the operating circuit for relay 1501; (2) transfers at its innermost lower armature the holding circuit for vacuum tubes 1402 and 1403 from the outermost upper armature and contact of "mark" relay 1404 to the middle upper armature and contact of relay 1310 which will later connect these grid circuits to the marking contacts of relay 1101; and (3) connects at its middle lower armature and contact another holding circuit for relay 1304.

Trunk test relay 1103, upon operating, locks to ground at the next to the innermost armature and contact of busy relay 1109 and at its outer lower armature and front contact transfers ground for availability to the trunk start relay of the next idle trunk in the group whereby the trunk start relay of such idle trunk is accessible for seizure by the sequence circuit. Thus relays 1101 and 1505 remain on their marking contacts and the grid circuit of vacuum tube 1203 which is connected to the spacing contacts of relays 1101 and 1505 is ungrounded. In approximately one-tenth second, the plate current in the plate circuit of tube 1203 operates relay 1121 which in turn operates relay 1310 and relay 1310 locks to ground at the next to the outermost lower armature and contact of busy relay 1109. Relay 1310, upon operating, (1) transfers the mid-tap connection of the windings of relay 1311 from grounded negative battery 1314 to the armature of relay 1303; (2) removes at its next to the innermost lower armature and contact a holding ground for the grid circuit of vacuum tube 1202; (3) disconnects at its innermost upper armature and contact the winding of "mark" relay 1404 from the marking contact of relay 1101 and thereby provides a substitute ground for holding relay 1404 operated; (4) connects at its middle upper armature and contact the grid circuit of vacuum tubes 1402 and 1403 to the marking contact of relay 1101; (5) supplies ground at its middle lower armature and contact for the future operation of both relays 1313 and 1501; (6) closes at its next to the outermost lower armature and contact a circuit which at a later time lights the operator's cord circuit lamp (not shown herein) but designated in U. S. Patent 2,106,357, supra, as reference character 52, the circuit being traceable over the ring conductor of switchboard jack 1704; and (7) connects grounded battery at its outermost lower armature and contact to a circuit traceable from the battery at the innermost lower armature and contact of disconnect relay 1602, conductor 1614, contact and lower armature of relay 1510, conductor 1511, contact and outermost lower armature of relay 1310, conductor 1322 through the winding of relay 1517, conductor 1512, zero contact, strap, brush and first contact of selector switch banks C', conductor 1615, through the winding of relay 1703 to ground at the lower armature and contact of relay 1702. Relays 1517 and 1703 operate in series (1) to connect at the outer upper armature and contact and the lower armature and contact of relay 1703 the tip conductor 1712 and ring conductor 1730 of jack 1704 through the tip and ring conductors, respectively, of the trunk circuit; and (2) at the inner upper armature and contact of relay 1517, a holding circuit is closed for relay 1523 which short-circuits at the outer upper armature and contact of relay 1517, resistive element 1524 of 1 megohm resistance and the grid charging circuit of vacuum tubes 1402 and 1403 to reduce the disconnect signal recognition time from 3.5 seconds to 0.8 second.

Completion at the concentrating unit office of the connection to the subscriber's station 101

When the selector switch brushes at the master office have stepped to the first contact which corresponds to the called subscriber's station 101, no more stepping pulses are sent out over the line and relay 907 remains on its marking contact. Relay 701 is also on its marking contact due to the ground at the innermost upper armature and front contact of relay 902 being included in a circuit extending over conductor 909, outer upper armature and back contact of relay 903, conductor 1012, armature and left-hand contact of relay 1001, conductors 1027 and 635, make-before-break contacts of relay 509, conductor 512, outer left armature and back contact of relay 1206, through the lower winding of relay 701, back contact and outer right-hand armature of relay 714, conductor 732, through the lower winding of relay 702, outer left armature and back contact of relay 731, to grounded positive battery 724. After one-tenth second vacuum tube 809 operates and the plate current therein causes relay 821 to operate which upon operating causes relay 704 to operate. Relay 704 upon operating (1) closes at its middle left-hand armature and contact a future operating circuit for relay 731; (2) transfers at its innermost left-hand armature and contact the winding of "mark" relay 1002 from the marking contact of relay 904 to direct ground at the battery connected at the winding of relay 704, the circuit now being traceable from ground, innermost left-hand armature and front contact of relay 704, contact and outermost left-hand armature of relay 705, conductor 813, upper armature and contact of relay 1010, conductor 1013, contact and next to the outermost lower armature of relay 803, conductor 818, through the winding of relay 1002 to grounded positive battery 1014; (3) locks at its outermost right-hand armature and contact to ground in a circuit extending to the inner lower armature and contact of busy relay 905; (4) provides for a path which will connect the grid circuits of vacuum tubes 605 and 807 to the marking contact of relay 904; (5) connects ground to the armature of relay 615 for the future operation of relay 714, circuit extending over conductor 616, contact and innermost right-hand armature of relay 704, conductor 508, marking or right-hand contact and armature of relay 501 to the outermost left-hand armature and contact of relay 503 to ground which relay is now in a released position; and (6) supplies grounded battery to operate relay 509 in series with the sleeve relay 105 in the subscriber's line equipment, the circuit being traceable from ground through the winding of relay 105, conductor 106, first contact, brush strap and zero contact of selector switch bank C, conductor 616 through the winding of relay 509, conductor 510, outermost left-hand armature and contact of relay 704, back

contact and outer right armature of relay 705, conductor 716 to grounded battery at the innermost lower armature and contact of disconnect relay 1003. Relay 509 operates to connect subscriber's station 101 to the trunk selected by the operator at the switchboard in the master office. Relay 509, upon operating, (1) transfers the tip conductor 512 from grounded circuit extending over conductors 635 and 1027, left-hand contact and armature of relay 1001, conductor 1012, outer upper armature and back contact of relay 903 to ground at the innermost upper armature and front contact of relay 902, to the circuit including the tip conductor connected to the zero contact of selector switch bank E at which point the circuit extends over tip conductor 107 through the loop of subscriber's station 101, ring conductor 108, first contact, brush, strap and zero contact of selector switch bank D, outer left-hand armature and contact of relay 509 through the upper winding of relay 501 to ground, tip conductor 512 at its other end extending through the lower windings, in series, of relays 701 and 702 to grounded battery 724 to make the subscriber's loop complete; and (2) closes at its inner left-hand armature and contact an operating circuit for relay 503, which circuit extends over conductor 511 to the left-hand armature and contact of relay 509, conductor 716 to grounded battery at the innermost lower armature and contact of disconnect relay 1003. Relay 503, upon operating, (1) completes in offices equipped for automatic ringing, a circuit for operating relay 506 from 2 second-4 second pulses to ring the subscriber at station 101, the circuit being traceable from grounded source 617 of ringing current, next to the outermost right-hand armature and contact of relay 606, conductor 639, inner left-hand armature and contact of relay 503, conductor 522, inner left-hand armature and back contact of relay 505, outermost left-hand armature and contact of relay 504, conductor 523, left-hand armature and contact of relay 718, conductor 728, through the winding of relay 506 to grounded battery; (2) closes at its outer right armature and contact a circuit for operating relay 710, the circuit being traceable from ground through the winding of relay 710, conductor 730, contact and outer right armature of relay 503, conductor 525, contact and outer right-hand armature of relay 705, conductor 716, to grounded battery at the innermost lower armature and contact of disconnect relay 1003; (3) supplies at its outermost left-hand armature and contact ground for the future operating circuit of relays 505 and 504; and (4) closes a second operating circuit for trunk test relay 901, the circuit being traceable from ground at the outer lower armature and contact of busy relay 905, outer upper armature and contact of relay 901 through the upper winding of relay 901, conductor 507, contact and innermost left-hand armature of relay 503, conductors 612 and 820 to grounded positive battery 819, the operation of relay 901 not having at this time any useful function. In offices arranged for automatic ringing, the operation of relay 503 completes an operating circuit for relay 506 as hereinbefore described and relay 506 operates on the two-second closed pulse and releases for the four-second open pulse. In offices arranged for manual ringing, the ringing pulses received from the distant master office cause relay 717 to operate at the 20-cycle frequency, the operation of which closes an obvious operating circuit for alternating current relay 527. Relay 527 upon operating, operates relay 505 which (1) opens at its outer left-hand armature and contact, the operating circuit for relay 731; (2) completes at its inner left-hand armature and front contact an operating circuit for relay 506 which is traceable from grounded battery at the winding of the relay 506, conductor 723, contact and left-hand armature of relay 718, conductor 523, contact and outermost left-hand armature of relay 507, inner left-hand armature and front contact of relay 505, conductor 629 to ground at the innermost right-hand armature of contact of relay 606; (3) provides at its inner right-hand armature and contact, a locking ground for relay 902; and (4) removes at its outer right-hand armature and contact a holding ground from the grid circuit of vacuum tube 806. In both manual and automatic equipment, the operation of relay 506 (1) operates at its inner left-hand armature and contact an operating circuit for relay 528; (2) transfers tip conductor 512 to its associated front contact for closing a circuit extending over conductor 529 through lamp 646 to source 607 of grounded 20-cycle ringing current which is impressed on the subscriber's loop for ringing purposes; and (3) short-circuits at its inner right-hand armature and contact the line, or upper, winding of relay 501.

When the operator releases her ringing key (not shown) but well known in the art, relays 527 and 505 release in manual ringing or at the end of the two-second pulse in automatic ringing. Relay 505 upon releasing causes relay 506 to release thereby removing source 607 of grounded ringing current from the subscriber's loop and releasing relay 528. The operation of relay 528 also short-circuited the line, or upper, winding of relay 501 and as relay 528 is of the slow-to-release type, this short is continued after ringing has ceased for a period long enough for line surges to disappear.

It was hereinbefore stated that relay 710 operated and upon operating (1) opens at its left-hand armature and back contact the operating circuit for relay 613 which releases to extinguish answering lamp 516; (2) transfers the control of the grid circuit of vacuum tubes 605 and 807 from the outermost upper armature and contact of "mark" relay 1002 to the marking contact of relay 904 through the middle right-hand armature and contact of relay 704; and (3) to contribute at its inner right-hand armature and contact an additional holding ground for relay 902. The fact that the trunk is now connected to an opened idle subscriber's line causes relay 702 to operate to its spacing or left-hand contact, thus placing a spacing condition on the trunk. At the master office this causes the operator's cord supervisory lamp to light as an indication that she should ring on the circuit, whether the equipment is arranged for manual ringing or that the subscriber is being rung with automatic equipment.

In the silent interval immediately following the subscriber's answer, relay 501 operates to operate in turn relays 504 and 731. Relay 504, upon operating, (1) reverses the current in the biasing, or lower, winding of relay 501 to aid in holding it on the marking or right-hand contacts; (2) removes holding ground from the grid circuit of vacuum tube 603; (3) transfers a future operating circuit for relay 718 from ground at the back contact and next to the innermost left-hand armature to its front contact which is connected to grounded source 617 of 2 second-4 sec-

ond interrupted current; (4) opens at its outermost left-hand armature and contact the operating circuit for relay **506** and (5) connects at its next to the outermost left-hand armature and front contact a holding ground to the winding of relay **902**. Relay **731**, upon operating, transfers the armature of relay **717** from the winding of relay **527** to the tip of the subscriber's loop and the circuit is now in condition for transmission of messages.

Reaction at the master office when connection is cut through to the subscriber's loop

As just herein described the trunk terminating equipment at the concentrating unit office is connected through to the subscriber's loop. As this subscriber's loop is in the idle or open condition, a spacing condition is placed on the trunk circuit line toward the master office as hereinbefore stated. Relay **1101** operates to its spacing contact, removing ground from the grid circuit of vacuum tubes **1102** and **1103**. After approximately 0.25 second vacuum tube **1403** will paralyze the grid circuit of tube **1201** thereby allowing relays **1106** and **1107** to release. Relay **1107** upon releasing causes relay **1303** to lock up to its spacing or right-hand contacts and again places the grid circuit of vacuum tube **1201** under the control of the spacing contact of relay **1101**. After approximately 0.8 second, relay **1325** operates thereby shunting down relay **1108** which places a ground at the outermost upper armature and back contact of relay **1108** on a circuit traceable over conductor **1113**, next to the outermost lower armature and contact of relay **1310**, conductors **1321** and **1518**, contacts and inner lower armature of relay **1517**, conductor **1502**, zero contact, strap, brush and first contact of selector switch bank D', conductor **1513**, contact and outer upper armature of relay **1703**, ring conductor **1730** to light the supervisory lamp in the operator's cord circuit as an indication to the operator that she may ring on the circuit or if automatic ringing is provided that the subscriber is being rung. The operator's supervisory lamp is not shown in the application, but reference may be had to United States Patent 2,106,357, supra. As soon as the subscriber answers a marking condition is placed on the line toward the master office, relay **1101** operates to its marking or right-hand contact, vacuum tube **1201** operates relay **1106** and thus **1107**, relay **1108** operates, and the operator's supervisory lamp in the cord circuit is extinguished and the circuit is in normal transmission condition.

Break signal from master office

This signal is also a timed open space followed by 20-cycle pulses. Relays **907**, **904**, and **717** operate to their spacing contacts and the spacing signal is thereby repeated to the subscriber's loop. The operation of relay **904** in removing ground from the grid circuit of vacuum tube **605** permits that tube to paralyze vacuum tube **604** in approximately one-quarter second and thereby release relays **609** and **706**. The release of relay **706** completes an operating path for relay **707** which removes ground from the grid circuit of break limiting vacuum tube **808**, and places the line, or lower, winding of relay **717** under the control of relay **718**. After three-quarter second of spacing condition, 20-cycle pulses are received from the master office in time to prevent the operation of the disconnect tube **807** and vacuum tube **604**. A continuous space is thus sent to the subscriber during this period. However, it is not possible to determine the condition at the subscriber's station during the period when the loop is in spacing condition, therefore, after approximately five seconds, vacuum tube **808** operates to cause relay **822** to operate. Relay **822** upon operating connects grounded source **617** of 2 second-4 second interrupted current to conductor **647**, front contact and next to the innermost left-hand armature of relay **504**, conductor **530**, armature and contact of relay **822**, conductor **842** through the winding of relay **718** to grounded battery. Relay **718** therefore operates during the two-second interval to close the operating circuit for relay **717** which operates to its marking contact whereby the subscriber's loop is held closed, and releases during the four-second interval to continue the break space. This permits the subscriber to register a break or disconnect signal during the marking, or closed, condition. At the conclusion of the break signal the 20-cycle pulses are replaced by continuous marking conditions which, after approximately 0.05 second permits vacuum tube **604** to again operate relays **609** and **706** and thus release relay **707** and restore the circuit to normal.

Operator sends a disconnect

A disconnect signal from the master office places a steady spacing condition on relays **707**, **904** and **717**. After one-half second the operator's break vacuum tube **605** paralyzes vacuum tube **604** to release relays **609** and **706**, and operates relay **707**. After three-quarters of a second, the operator's disconnect tube **807** operates to cause the operation of relay **824**. Relay **824** upon operating causes relay **606** to release which releases relays **707** and **902**, assuming that the subscriber has in the meantime also disconnected to release relays **504** and **501** as hereinbefore described. The release of relay **902** completes the operating path for disconnect relay **1003** and the circuit is restored to normal as hereinbefore described.

Operator abandons call before final step is reached

In this case start relay **1601** will release, removing all battery which could send a marking condition to the concentrating unit office. A permanent space signal will, therefore, be sent out which will result in a disconnect condition at the concentrating unit office. A short time interval before the distant concentrating unit office completes its disconnect, a spacing condition is placed on the line toward the master office. This causes vacuum tube **1403** to operate thereby rendering vacuum tube **1201** non-conducting and causing in turn the release of relays **1106** and **1107**. After approximately three-quarter second of the spacing condition, disconnect tube **1402** operates relay **1325** and shunts down relay **1108**. The release of relay **1108** causes the release of relay **1304** which completes the operating circuit for disconnect relay **1602** which locks to ground on the brush of the selector switch bank A'. The operation of disconnect relay **1602** also completes an operating path for the selector stepping magnet **1604** through the selector off-normal contact to ground on the brush of selector switch bank A' and removes the holding ground for relays **1405**, **1211** and **1408**. The selector switch rapidly steps, self-operated, back to its zero contact where ground is removed from the brush to re-

lease disconnect relay 1602 and to stop the stepping action.

Miscellaneous alarm circuit at master office

The miscellaneous alarm circuits at the master office are the same as those described herein for the concentrating unit office and therefore it is deemed unnecessary to repeat the description of their application at the master office.

What is claimed is:

1. A switching system comprising a switching point, a remote point, lines terminating at said switching point, a trunk including telegraphic impulse relaying means extending from said switching point to said remote point, a plurality of conductive connecting terminals of said trunk at said remote point each individual to one of said lines, a conductive device adapted to contact with one of said terminals, means operated by connection of said conductive device to one of said terminals to cause the operative connection of said trunk to the line individual to said terminal, and other means responsive to a call over any one of said lines for operating the first-mentioned means to cause the operative connection of said trunk to a corresponding one of said terminals.

2. A telegraph switching system according to claim 1 wherein each of said trunks comprises means at each end for sending from one end to the opposite end identical signal pulses until said trunk at one end is in engagement with one of said lines in a calling condition and at the other end is in engagement with the corresponding one of said terminals.

3. A switching system comprising lines terminating at a switching point, a trunk including telegraphic impulse relaying means extending from said switching point to a remote point, a plurality of conductive terminals individual to said lines, devices individual to said terminals each capable of assuming a calling condition, means whereby said trunk seeks and connects itself to one of said lines, and means operable thereby to cause one of said devices individual to said one line to assume a calling condition.

4. A telegraph switching system comprising a switching center, a central office, a plurality of trunks interconnecting said center and said office, a plurality of teletypewriter sets at the opposite termini of a plurality of lines terminating at said center, a plurality of transmission conductors and connecting terminals therefor at said office, each of said conductors being individual to one of the first-mentioned lines, a sequence circuit at said center and another at said office responsive to a closure of a line circuit or transmission conductor, respectively, at one end of said system for automatically selecting an idle trunk, and switches for associating its corresponding transmission conductor or line, respectively, at the opposite ends of the trunk for telegraphic code communication.

5. A telegraph switching system comprising a switching center, a central office, a plurality of trunks of not over two conductors including telegraphic impulse repeating means interconnecting said center and said office, a plurality of subscribers' stations and a plurality of lines respectively connecting said stations to said switching center, a plurality of relays respectively associated with said stations and connected in a continuous chain circuit, switching means at each of said subscribers' stations for causing the operation of one relay of said plurality, a control relay responsive to the operation of any one relay of said plurality, preventive means responsive to the operation of said control relay for preventing more than one relay of said plurality from being in an operated position at the same time, starting means in each of said trunks responsive to the operation of said control relay, and rotary switching means individual to each of said trunks and under the control of its associated starting means for connecting the trunk circuit, when idle, to the calling subscriber's station line, and means under the control of said rotary switching means for restoring to normal the one operated relay of said plurality, said control relay and said preventive means when the calling subscriber station line is connected to the first idle trunk.

6. A telegraph switching system comprising a switching center, a central office, a plurality of trunks interconnecting said central office and said switching center, an operator's switchboard at said central office, a plurality of connecting terminals at said switchboard, rotary switching means individual to said trunks and each having a plurality of contacting elements, a plurality of lines respectively connecting said connecting terminals to said contacting elements on each of said rotary switching means, a plurality of relays respectively associated with said connecting terminals and connected in a continuous chain circuit, circuit operating means at said switchboard and arranged for engagement with any one of said connecting terminals for closing an operating circuit for the relay of said plurality, associated with the engaged connecting terminal, a control relay responsive to the operation of any one relay of said plurality, preventive means responsive to the operation of said control relay for preventing more than one relay of said plurality from being in an operated position at the same time, starting means in each of said trunks responsive to the operation of said control relay to cause the operation of one of said rotary switching means to connect its trunk, when idle, to the connecting terminal engaged by one of said circuit operating means, and other means under the control of said one rotary switching means for restoring to normal the one operated relay of said plurality, said control relay and said preventive means when the connecting terminal is connected through to the first idle trunk.

7. A telegraph switching system comprising a switching center, a central office, a plurality of trunks interconnecting said center and said central office, rotary switching means at the opposite ends of each of said trunks, a plurality of subscriber station lines adapted at said center and said central office for connection to any one of said trunks through said rotary switching means associated with said one trunk, verifying means at said center and said central office for transmitting to the opposite end of any one of said trunk circuits an alternating current of a regular frequency, said verifying means at the distant end of a selected trunk circuit being effective upon receipt of a signal from the local end of the selected trunk where a call originates, to transmit the alternating current, stepping means at said local end effective to cause stepping pulses to be transmitted to the distant end of said selected trunk in response to the alternating current, other stepping means at the distant end of said selected trunk effective, in response to stepping pulses received from the local

end, to cause stepping pulses to be transmitted to the local end of said selected trunk, said stepping means being arranged to alternately transmit stepping pulses to the opposite ends of said selected trunk until the subscriber station line over which the call originated at the local end is connected through said selected trunk to the corresponding subscriber's station line at the distant end of said selected trunk.

8. In a telegraph system, a two-conductor trunk line between two points, two selecting switches, one associated with each end of said trunk line, electromagnetic means for automatically moving said switches corresponding amounts to establish a telegraph connection over said trunk, means for seizing the trunk at either terminal thereof, means automatically operative incident to said seizure to initiate the movement of said switches, and means for releasing said switches.

9. In a telegraph system, a trunk line, two selecting switches, one at each end of said trunk line, means for automatically moving said two switches alternately step by step to extend the two ends of said trunk line to form a telegraphic impulse transmitting circuit, and means for releasing said switches.

10. In a telegraph system, a central office and a suboffice, a trunk line, a selecting switch for said trunk line at each of said offices, means for automatically moving said two switches to corresponding terminals to extend the two ends of said trunk upon the initiation of a connection at one of said offices, trunk seizing means initiated by a calling condition at either end of said trunk, means operable incidental to operation of said seizing means to automatically initiate movement of said switches, and means for returning the switches to their normal positions at the end of a telegraphic transmission.

11. In a telegraph system, a switchboard having a plurality of subscribers' line terminals, a plurality of subscribers' lines dissociated from said switchboard line terminals and pertaining respectively to each of said switchboard terminals, a two-wire trunk common to all said subscribers' lines, a switch for each end of said trunk, means for causing said switches automatically to connect one of said subscribers' lines to its corresponding switchboard terminal when a call is initiated on said line, means for releasing said switches, and means for transmitting telegraphic code current impulses over said line and trunk when connected without interference with said means for releasing said switches.

12. In a telegraph system, a switchboard having a plurality of subscribers' line terminals, a plurality of subscribers' lines dissociated from said switchboard line terminals and pertaining respectively to each of said switchboard terminals, a two-wire trunk common to all said subscribers' lines, a switch for each end of said trunk, means for causing said switches automatically to connect one of said subscribers' lines to its corresponding switchboard terminal when a call is initiated on said line, and vice versa when the call is initiated at said corresponding switchboard terminal, means for releasing said switches, and means for transmitting telegraphic code current impulses over said line and said trunk when connected without interference with said means for releasing said switches.

13. A communication trunk having two ends, a stepping switch having its rotor associated with said trunk at a first end, a stepping switch having its rotor associated with said trunk at a second end, said trunk comprising a transmission path between said ends, an electroresponsive mechanically acting stepping means for each of said switches, means for energizing said stepping means for one switch to advance it a given number of steps, and means operable incident to such advance to step the other an identical number of steps, characterized in that means is provided for seizing the trunk and initiating the stepping at either end thereof.

14. A communication trunk having two ends, a step-by-step advanceable switch means associated with each end, transmission means including said trunk whereby advance of either switch means transmits over the trunk control pulses to advance the other by an equal number of steps, and means for initiating the advance of said switches from either end of said trunk.

15. A communication trunk capable of transmitting marking and spacing conditions, pulse sending means at each end of said trunk for transmitting said conditions, a stepping switch at each end, successive terminals over which the respective switches step, and interlock means including said pulse sending means whereby said switches control each other to step over equal numbers of terminals.

16. In combination, a trunk having two ends, means for seizing the trunk at one end, means operative incidental to seizure to send a seizure signal to the far end, means operative incidental to reception of the seizure signal to return a verification signal indicating operative continuity of said trunk, means operative incidental to receipt of the verification signal to send stepping pulses over the trunk, and means operative incidental to receipt of the stepping pulses to return other stepping pulses over said trunk.

17. In a communication system, a trunk line, two selecting switches one for each end of the trunk line, stationary contacts at the switches, and electromagnetic means for automatically moving said switches step by step each under control of the stepping of the other to unite corresponding contacts.

18. A communication trunk having two ends, means operable by any one of a plurality of telegraph lines for seizing the trunk at one end, means operable coincidently with the operation of the seizing means to place a busy condition upon the trunk at the far end, a switch associated with the trunk at the far end, means operable automatically under control of the operation of said seizing means to advance said switch to selected terminals identified with said one of said telegraph lines which seized the trunk, means for establishing a disconnect condition at said terminals, means for causing said disconnect condition to be established by a disconnect condition upon said one telegraph line, and other means for preventing the establishing of said disconnect condition by a "break" condition upon said telegraph line.

19. In a telegraph system, a telegraphic transmission trunk line, two selecting switches, one for each end of said trunk line, stationary contacts at said switches, and electromagnetic means for automatically moving said switches corresponding amounts to unite with corresponding contacts, means for seizing said trunk, impulse transmission and reception means operated by said seizing means for verifying the operative continuity of said trunk, and means conditioned

upon verification of the operative continuity permitting the movement of said switches.

20. In a telegraph system, a two-way telegraphic transmission trunk extending between two switching points, two selecting switches, one associated with each end of said trunk, a plurality of lines terminating at the first switching point, electromagnetic means controllable under the influence of call condition on one of said lines for automatically moving the switch at the called end of said trunk to establish a telegraphic connection between said line and said trunk, means operable incident to said trunk to move the selecting switch on the calling end of said trunk a corresponding amount to establish a connection to terminals identified by said line, means to impress upon said line marking and spacing conditions and spacing conditions of considerable duration comprising "break" conditions, means to hold said switch in communicative relation during said transmission, means to impress upon said line at the end thereof remote from said first switching point a disconnect condition, and means operable incident thereto to establish a disconnect condition at said second switching point.

WAYNE V. K. LARGE.