May 15, 1934. F. J. SINGER 1,958,930

AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

Filed Dec. 20, 1932 6 Sheets-Sheet 1

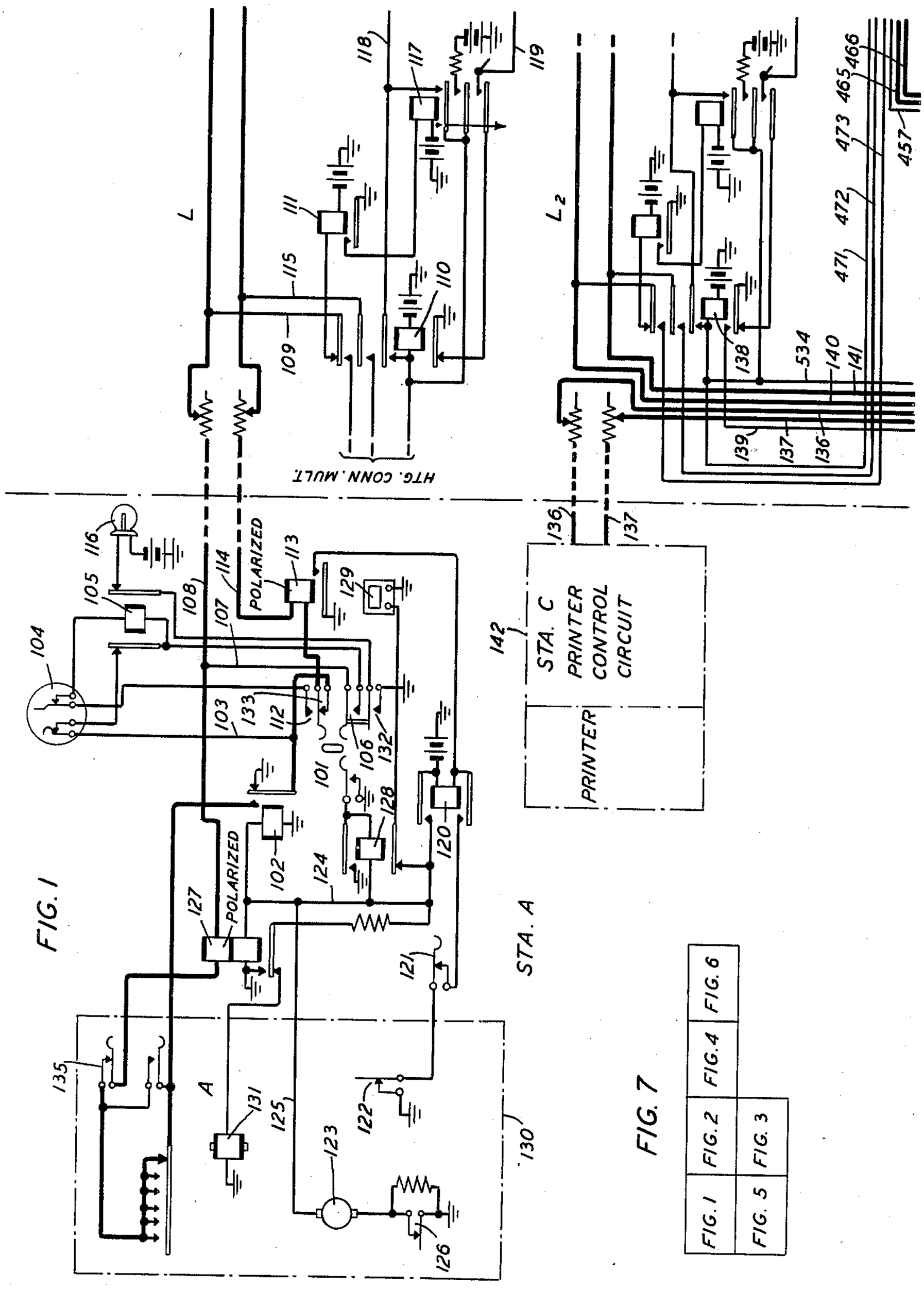

FIG. 1

FIG. 7

	FIG. 6	
	FIG. 4	
FIG. 2		FIG. 3
FIG. 1		FIG. 5

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AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

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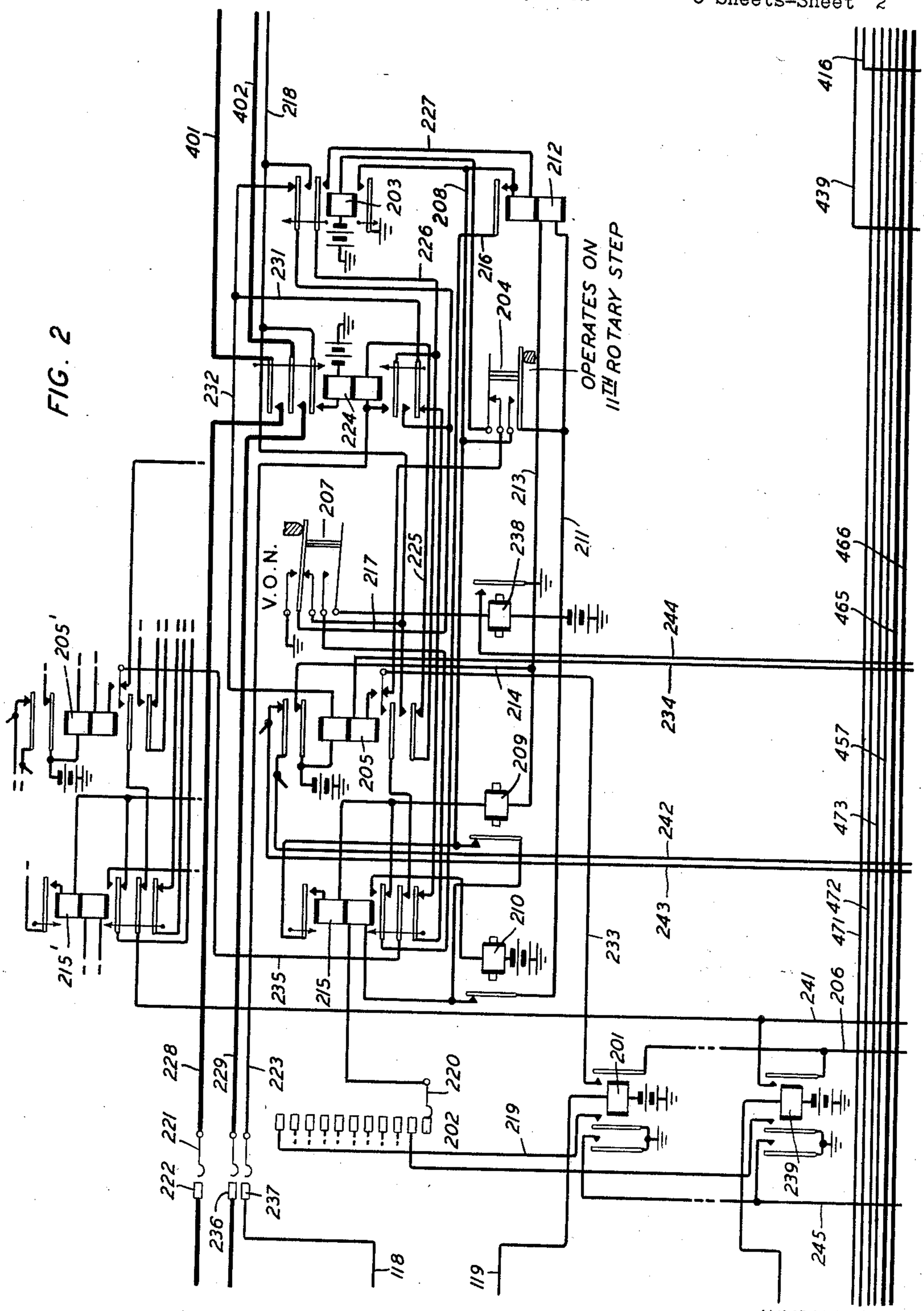
FIG. 2



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AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

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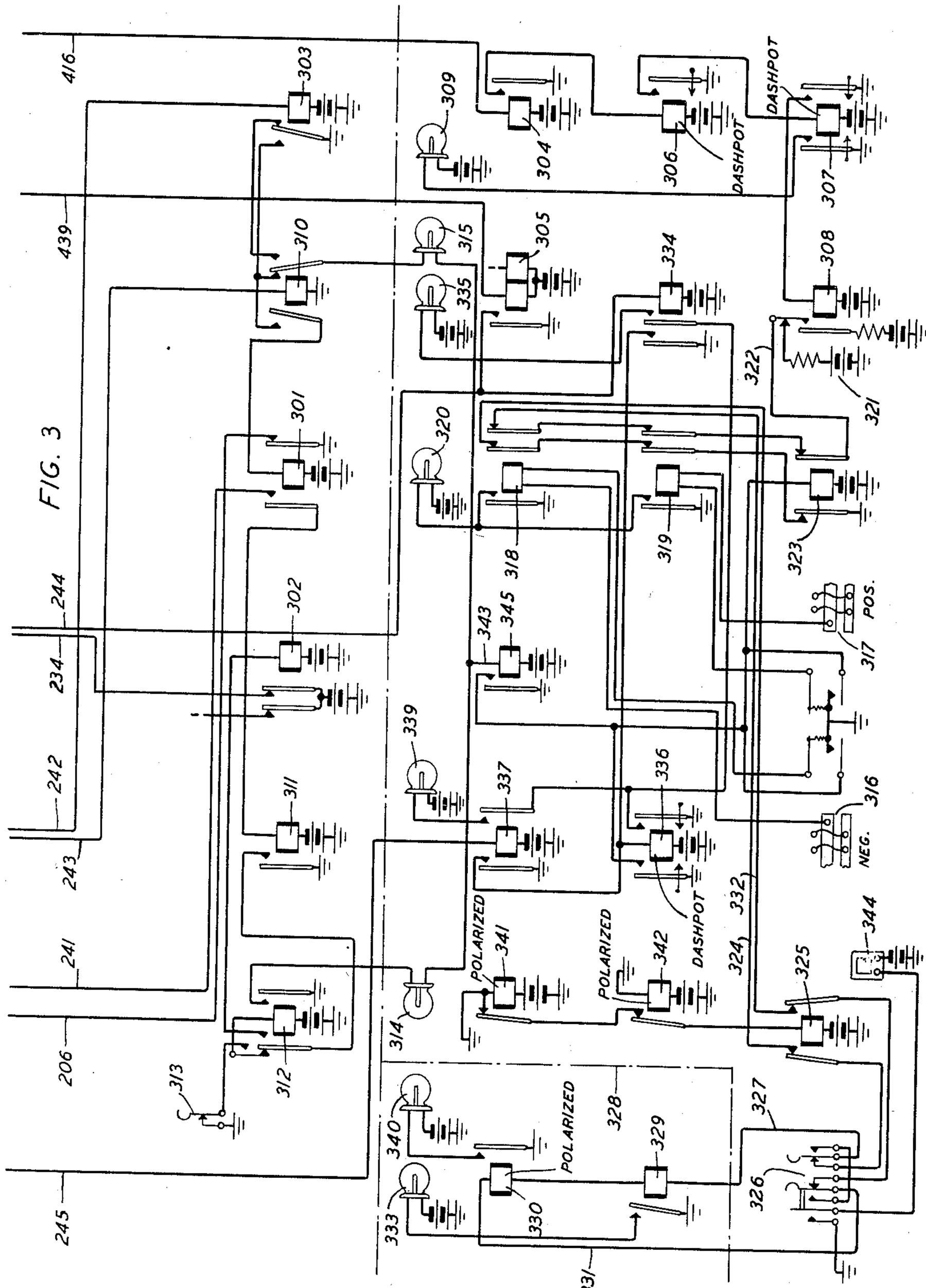

FIG. 3

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AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

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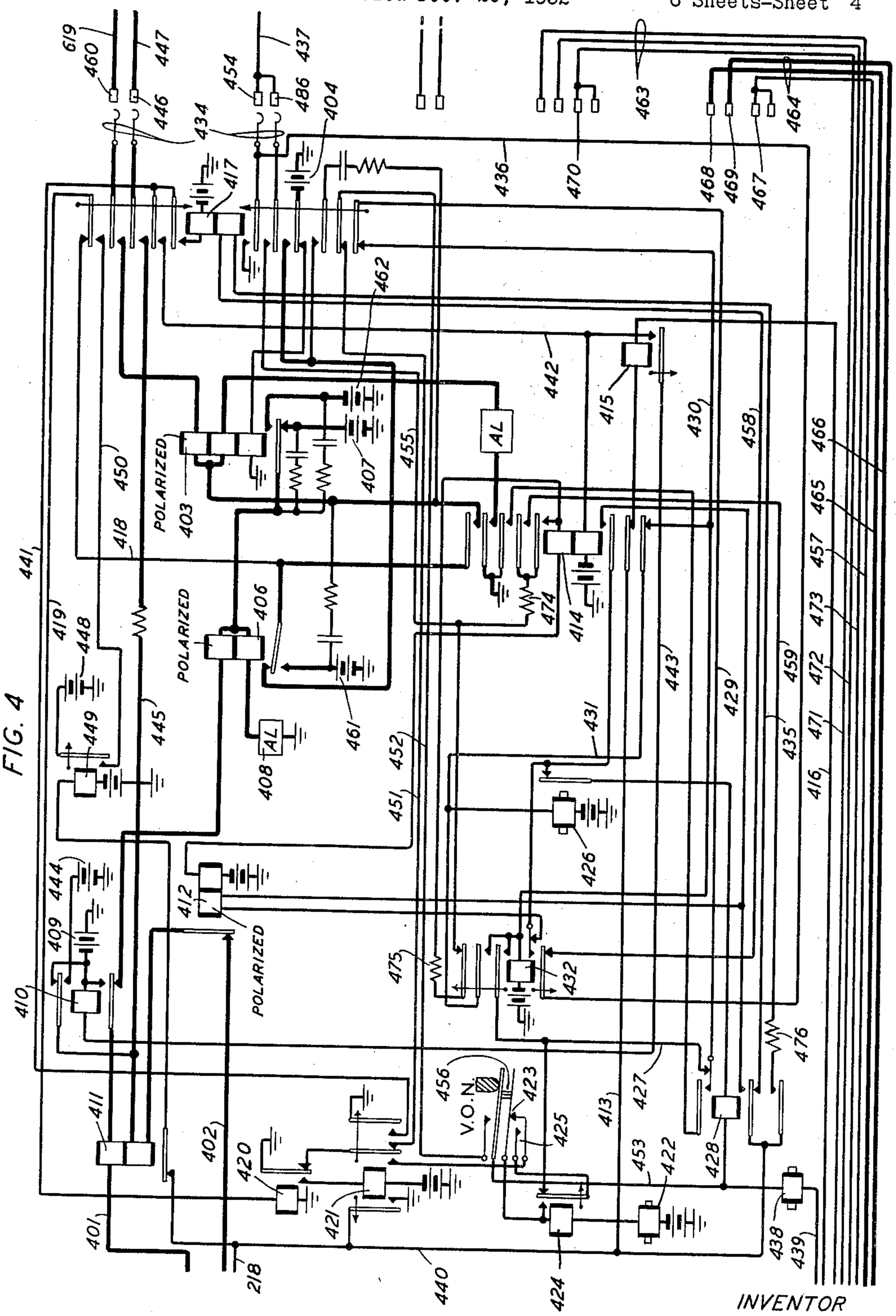

FIG. 4

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AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

Filed Dec. 20, 1932 6 Sheets-Sheet 5

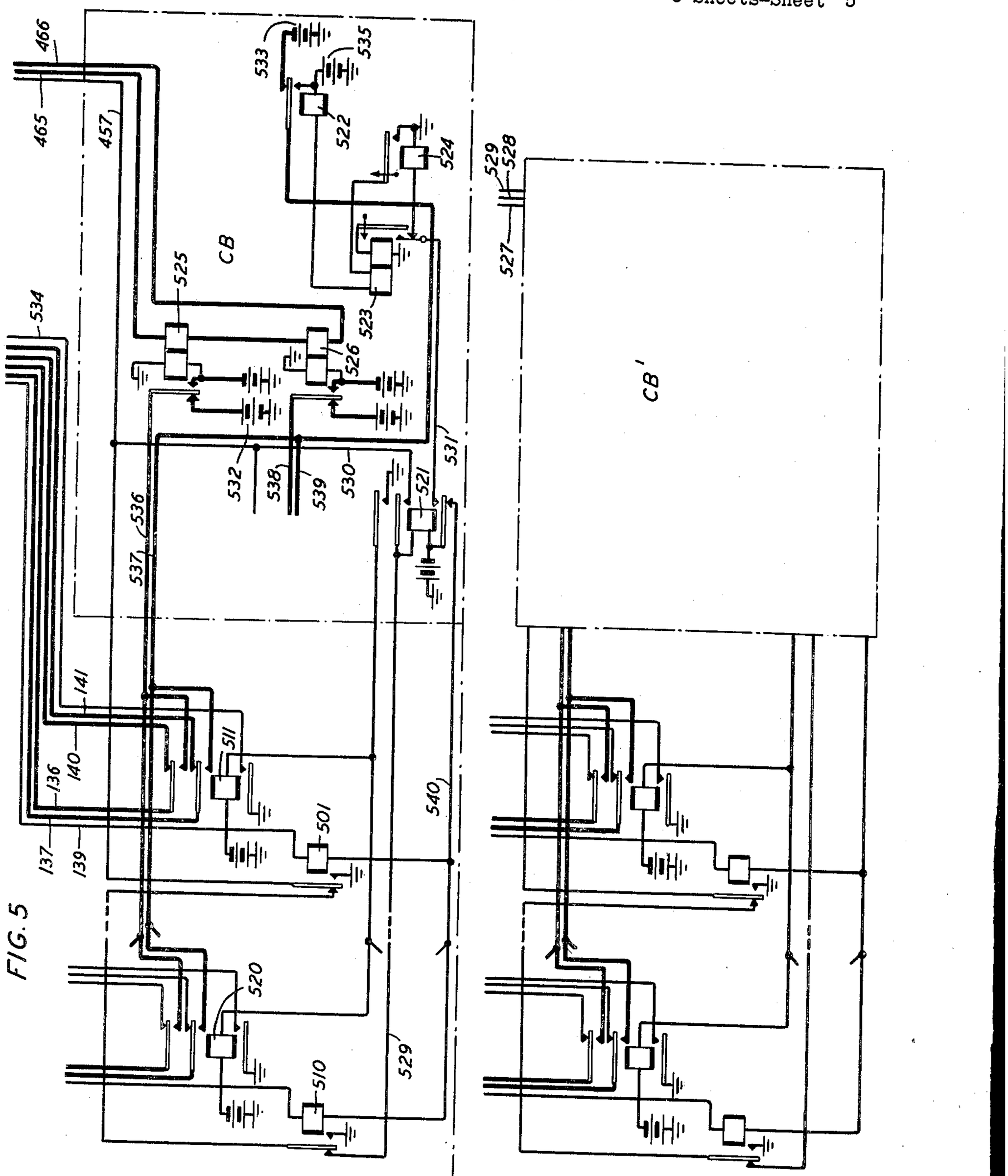

FIG. 5

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AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

Filed Dec. 20, 1932 6 Sheets-Sheet 6

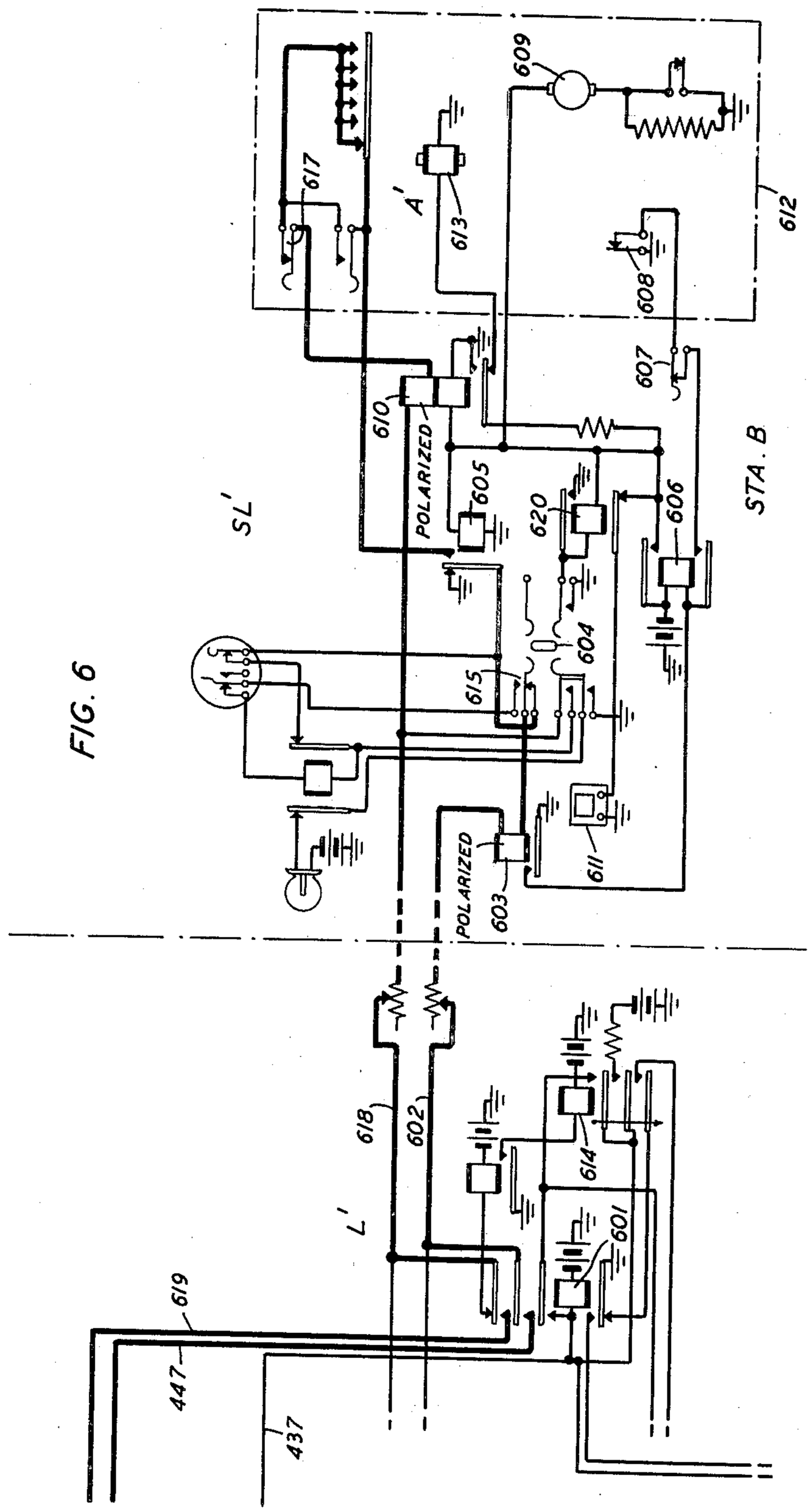

FIG. 6

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Patented May 15, 1934 1,958,930

UNITED STATES PATENT OFFICE

1,958,930

AUTOMATIC SWITCHING TELEGRAPH PRIVATE BRANCH EXCHANGE SYSTEM

Fred J. Singer, Rockville Center, N. Y., assignor to American Telephone and Telegraph Company, a corporation of New York

Application December 20, 1932, Serial No. 648,117

15 Claims. (Cl. 178—2)

This invention relates to printing telegraph systems and more particularly to telegraph systems wherein automatic switches are employed for the establishment of channels of telegraphic communication.

The invention has for its main object to provide a telegraph private branch exchange system which utilizes automatically and directively operable switches at a central office for establishing telegraphic connections between subscribers' stations whereby flexibility, economy and efficiency are greatly increased.

One of the features of this invention is a normally opened transmission line connecting each subscriber's station with a central office.

Another feature is the employment of a single line repeater arranged for automatic connection between the subscribers' stations.

Another feature is the group arrangement of conference circuits whereby said subscribers' stations may be arranged in groups and as such, be selected for connection to other subscribers' stations. It provides for any station in a group being arranged to select any other group for broadcasting purposes.

In the preferred form illustrated herein, the invention contemplates the provision of a one hundred line machine switching telegraph private branch exchange system employing automatically operated line finder and hunting connector switches of the step-by-step type. However, it is understood that the number of lines may be increased, as in machine switching telephone systems, which are well known in the art, by adding one or more selector switches of the step-by-step type with the necessary rotary single movement switches for handling call numbers of two or more digits.

Other objects and features will be found in the following detailed description and accompanying drawings.

Referring to the drawings:

Figure 1 shows two subscribers' stations with their respectively associated equipment at the central office. In the upper portion is shown in schematic layout the necessary equipment for receiving and sending printed messages at a subscriber's station, say station A, including a transmitting and receiving printer with associated driving motor and control circuit therefor. In the lower portion is shown an oblong representing the equipment at a second subscriber's station, say station C, the equipment at station C being intended to be identical with that of station A. Stations A and C are shown connected for establishing a call to any other subscriber's station.

Fig. 2 shows the operating circuit in schematic form for a line finder switch at the central office. The line finder switch hunts the calling line and then connects it to the hunting connector switch. Sufficient line finder switches are provided to satisfactorily handle the greatest number of calls that may be received at the central office at any one time.

Fig. 3 shows in the upper portion the circuit for operating a group of line finder switches, each to its tenth level when the start conductor becomes permanently grounded and then causing all the switches to restore to normal, and in the lower portion the alarm circuit associated with the system.

Fig. 4 shows the operating circuit in schematic form for the hunting connector switch which, when connected to the line finder switch, operates in response to dialing impulses received from the calling station to engage the called subscriber's line.

Fig. 5 shows the equipment provided for selecting groups of subscribers' stations for broadcasting purposes. The upper portion is equipped for selecting one group and in the lower portion equipment for selecting the second group.

Fig. 6 shows in schematic layout, the necessary equipment for receiving and sending printed messages at another subscriber's station, say station B, including a transmitting and receiving printer with associated driving motor and control circuit therefor. Also shown in this figure is the equipment associated with station B, at the central office. Station B is shown connected to the multiple bank of the hunting connector switch which is the connection for receiving a call.

Fig. 7 is a relative arrangement of Figs. 1 to 6.

In the drawings there are illustrated in comparative detail, two printing telegraph stations A and B. Station A is connected with the central office by means of tip conductor 108 and ring conductor 114, and station B is connected with the central office by means of tip conductor 618 and ring conductor 602. At the central office the line conductors 108 and 114 of station A which is shown herein as the calling station, are connected to a terminal set in the line finder switch bank. Other stations in the system are respectively connected by means of conductor pairs to the other terminal sets in the same line finder switch. The line finder switch is of the rotary step-by-step type which is disclosed in U. S. Patent 815,176, granted to A. E. Keith et al. on March

13, 1906. The subscribers' station lines may be arranged in one or more groups of one hundred lines each and each group may be arranged in ten subgroups of ten lines each. A group of one hundred lines may terminate on one or more groups of line finder switches. The line terminal sets of a line finder switch bank are arranged in ten levels of ten sets each and by arranging ten line finder switches in a group and by connecting a group of one hundred lines in a slip multiple to a group of ten line finder switches, each subgroup of lines will be available by the brushes at all line finder switches in a group, but at different levels. Thus each subgroup of lines will appear in the first level of a line finder switch. A detailed description of a slip multiple arrangement may be had by referring to U. S. Patent 1,161,655, granted to C. L. Goodrum on November 22, 1915. It is understood that the line finder switches may be provided with two banks of terminal sets and two sets of brushes for accommodating groups in 200 lines in accordance with the common practice employed in machine switching telephone exchange systems as disclosed in detail in U. S. Patent 1,742,930, granted to R. C. Paine on January 7, 1930.

For each subgroup of subscribers' lines there is provided a subgroup relay, such as relays 201 and 239 which operates when any one of the lines in the subgroup initiates a call. The operation of the subgroup relay connects ground to a segment on a commutator, such as commutator 202 which is mounted on the line finder switch. The commutator is provided with ten effective segments to correspond to the ten levels, or subgroups, of terminal sets on the switch, there being ten lines in each subgroup.

A call to a desired station is initiated by operating at the calling station a non-locking calling key, such as key 101 at station A, whereby the line finder switch is automatically operated, first in an upward movement to a particular level and then in a rotary movement to a set of terminals to which the calling line is connected. The upward movement of the line finder brush set is regulated by a brush passing over the segment of the commutator and when the brush reaches a commutator segment to which the calling line has applied ground by means of its associated subgroup relay, the upward movement of the line finder brush set is checked at the level in which the calling line terminal set is located. In this way the level at which the calling line terminates is selected and the line finder brush set then automatically starts its rotary movement over the terminal set in the selected level until it finds grounded battery which is connected to the calling line, at the time the call was initiated. Grounded battery on the calling line prevents further rotary movement of the brush set and completes an operating circuit for a cut-through relay, such as relay 224. The cut-through relay in operating extends the calling line through to the hunting connector switch which is also of the step-by-step type disclosed in U. S. Patent 815,176, supra. By means of the slip multiple arrangement of subscribers' lines at the line finder switches, the calling line is arranged to appear in the first level of one of the line finder switches of a group and this switch on which the calling line is located in the first level will have preference in hunting the line. If the particular line finder switch is busy at the time a call is initiated, the next line finder switch wherein the calling line appears in the second level, will respond. If the second line finder is busy, then the next line finder switch, wherein the calling line appears in the third level, will respond. This preference passes successively from one switch to the next until a line finder is found idle. The manner in which this preference is effected is disclosed in U. S. Patent 1,161,655, supra.

The connection of the calling line to the hunting connector switch causes a signal to be transmitted from the central office to inform the calling subscriber that the hunting connector switch is prepared to receive the dialing impulses which represent the code number of the desired station. The subscriber at the calling station then transmits by means of a dial, such as dial 104 of station A, the impulses of the code number of the desired station and the brush set of the hunting connector switch is thereby stepped up by the first set of dialing impulses to the level wherein the desired line is connected and around by the second set of dialing impulses to the terminal to which the desired line is connected. The seizure of the desired line terminal by the hunting connector switch brush set completes the circuit for operating a cut-through relay such as relay 417, whereby the calling line is connected through to the desired station. It also completes a circuit wherein the normal transmitting polarity on the communication circuit is reversed momentarily for starting the motors at the calling and the called, or desired, station. At the same time, a signal is transmitted to the subscriber at the calling station whereupon the subscriber releases the calling key so that the sending and receiving printer at the calling station may be connected to the established connection.

The hunting connector switch bank comprises banks of terminal sets, one set being provided for and connected to each subscriber's line, each subscriber's line is also connected in multiple to its respective terminal sets on the line finder switch so that should a subscriber desire to establish a connection to a subscriber's station already engaged in the established connection, the subscriber would receive a busy signal.

In a small private branch exchange system as described herein, a hunting connector switch is provided for each line finder switch. The terminal sets on the bank of one hunting connector switch are respectively connected in multiple to the terminal sets on the other hunting connector switches. However, in switching systems of the larger type, it is not necessary to provide a hunting connector switch for each line finder, because by means of the distributing switches interconnecting the line finders and the hunting connector switches, the number of hunting connector switches required may be considerably less than that of the line finders. This is in accordance with the common practice employed in machine switching step-by-step telephone systems.

In still larger type systems wherein three or more digits are required to complete the dialing of a called station number, additional selector switches may be provided for connecting between the line finder and the hunting connector switches. The use of selector switches is well known in automatic switching telephone exchange systems and are identified therein as first, second, etc., selector switches. A system of this character is disclosed in U. S. Patent 1,251,768 granted to C. L. Goodrum on January 1, 1918.

As soon as a subscriber at a calling station re-

leases a calling key, the system is in condition for the transmission of the message. The calling subscriber may call in the called subscriber by sending "Bell" signals from his keyboard. These signals would ring the bells in the two printers involved.

Another method of ringing call bells at subscribers' stations may be used by providing at each station a source of alternating ringing current, such as disclosed in a copending application of G. A. Locke and F. S. Kinkead, Serial No. 459,684, filed June 7, 1930. The message is repeated at the central office through a differential duplex single line through repeater comprising two polar relays, such as relay 406 and 403, to the sending and receiving printer at the desired station.

The power supply for the operating and the communication circuits at the central office is provided by a positive and a negative generator which are respectively connected to the lower bars of the bus-bar sections 316 and 317. However, for the purpose of illustration, the power supply is represented in the drawings as being grounded batteries.

Operation of the system

In establishing a call from station A shown in Fig. 1 to station B shown in Fig. 6, the operation is as follows:

Non-locking call key 101 is operated to the right and an operating circuit for relay 111 is thereby closed extending from ground at the back contact and armature of relay 102, conductor 103, left spring and contact of dial 104 in normal position, back contact and left armature of relay 105, contact 106 of key 101, conductor 107, tip conductor 108, conductor 109, outer upper armature and back contact of cutoff relay 110, through the winding of start relay 111, to grounded battery. Ground is connected at contact 132 of key 101 to operate lamp 116 which is provided for the purpose of supervising the progress of the call.

Start relay 111 operates and closes an obvious operating circuit for relay 117. Relay 117 in operating closes a circuit extending from ground, lower armature and contact of relay 110, outer lower armature and contact of relay 117, conductor 119, through the winding of the line finder subgroup relay 201, to grounded battery. Relay 201 is common to a subgroup of ten subscribers' lines terminating in the tenth level terminal sets on the line finder switch. The line circuit of station A is assumed herein to be in the subgroup which terminates in the tenth level. Relay 201 operates and thereby connects ground at its inner left armature and contact to segment No. 10 on the commutator 202. A subgroup relay, such as relay 201, is provided for each group of ten subscribers' lines terminating at each of the ten levels of a line finder switch. Relay 201, in operating, closes an operating circuit for a start relay 203 extending from ground at the right armature and contact of relay 301, start conductor 206, right armature and contact of relay 201, conductor 233, make-before-break contact of relay 205, upper contact of the tenth rotary step contact spring 204, through the winding of relay 203, to grounded battery. Relay 203 operates and closes at its lower armature and contact, a circuit extending from ground, conductor 208, contact and armature of vertical magnet 209, contact and armature of rotary magnet 210, conductor 211, through the lower winding of relay 212, conductors 213 and 214, contact and inner upper armature of relay 205, to grounded battery.

Relay 212 operates and thereby closes a circuit extending from ground, lower armature and contact of relay 203, contact and armature of relay 212, conductor 216, innermost lower armature and back contact of relay 215, through the winding of vertical magnet 209, conductor 214, contact and inner upper armature of relay 205, to grounded battery. Vertical magnet 209 operates to cause the line finder brush shaft (not shown) to step up one step. On the first vertical step the vertical off-normal springs 207 operate to connect ground at their uppermost contact to conductor 217, outer upper armature and front contact of relay 203, sleeve conductor 218, over two parallel paths, one extending over conductors 440 and 413, middle lower armature and contact of relay 414, through the winding of relay 415, conductor 416, through the windings of relay 304, to grounded battery, and the other extending over the contact and armature of relay 411, through the winding of relay 449 to grounded battery. This circuit is maintained closed until the dialing of the code number of station B has been completed. Relays 415, 304 and 449 operate for purposes to be hereinafter described.

The operation of vertical magnet 209 opens the operating circuit for relay 212 and the relay releases thereby opening at its armature and contact the operating circuit for the vertical magnet. The vertical magnet releases and relay 212 immediately reoperates to again close the operating circuit for the magnet. This operation is continued until the line finder shaft steps up to the level where the commutator brush 220 finds ground. In the illustration herein given ground is found on the tenth terminal of commutator 202 and a circuit is completed from ground at the inner left armature and contact of relay 201, conductor 219, tenth terminal of commutator 202, brush 220, through the lower winding of relay 215, contact and armature of rotary magnet 210, conductor 211, through the lower winding of relay 212, conductors 213 and 214, contact and inner upper armature of relay 205, to grounded battery.

Relay 215 is made slow-operating to give a short time between the last vertical step and the first rotary step to prevent snagging the brushes due to vibrations set up in them during vertical stepping.

Relay 215 operates in series with relay 212 and locks itself in a circuit traceable from grounded battery inner upper armature and contact of relay 205, conductor 214, through the winding of vertical magnet 209, through the upper winding, contact and upper armature of relay 215, conductor 208, contact and lower armature of relay 203 to ground. Relay 212 is thus held operated independently of its original operating circuit and in its operated position serves at this time to prevent further vertical stepping. The operation of relay 215 occurs at the end of a predetermined interval and transfers at its innermost lower armature the stepping circuit from the vertical magnet 209 to the rotary magnet 210 and the respective operating circuits for relay 212 and magnet 210 are alternately opened and closed in a manner similar to that described above for vertical magnet 209 and relay 212, to step the line finder brush shaft in a rotary path over the terminal 6 in the tenth level until the brush set 221 engages the set of terminals to which the

line circuit of subscriber station A is connected.

As soon as brush set 221 engages the desired terminals a test circuit having grounded battery connected to conductor 118, as hereinbefore stated, is closed, the circuit being traceable from grounded battery, through the winding of cutoff relay 110, inner lower armature and contact of relay 117, conductor 118, terminal 237, sleeve brush of set 221, conductor 223, through the lower winding of relay 224, conductor 225, back contact and outer lower armature of relay 205, conductor 226, inner upper armature and contact of relay 203, conductor 227, through the upper winding of relay 212, contact and lower armature of relay 203 to ground. Cutoff relay 110 operates, cut-through relay 224 is operated sufficiently to close a contact at its inner upper armature, and relay 212 is again held operated but at this time to prevent further rotary stepping. Relay 224 is of the slow-to-operate type and when energized by current in its lower winding operates to close a locking circuit for itself extending from grounded battery, through its upper winding, its contact and innermost upper armature, front contact and outer upper armature of relay 203, conductor 217, to ground at the uppermost contact of vertical off-normal spring 207. Relay 224 in response to the energization of both its windings, fully operates and locks at its contact and inner lower armature, the sleeve conductor 223 to a circuit extending over conductor 226, inner upper armature and contact of relay 203, conductor 227, through the upper winding of relay 212, contact and lower armature of relay 203 to ground. Relay 224 in its fully operated position closes tip conductor 228 and ring conductor 229 of the line finder to tip conductor 401 and ring conductor 402, respectively, of the hunting connector switch shown in Fig. 4. Also relay 224 in its fully operated position closes a circuit extending from ground at the uppermost contact of vertical off-normal springs 207, conductor 217, front contact and outer lower normal armature of relay 224, conductors 231 and 232, through the upper winding of relay 205 to grounded battery.

Relay 205 operates and thereby connects sleeve conductor 223 over the contact and inner lower armature of relay 224, outer lower armature and front contact of relay 205, to sleeve conductor 218 extending to the hunting connector. The line circuit of station A is now connected through to the hunting connector.

Relay 205, in operating, performs four functions such as (1) it opens at its outer lower armature and back contact the test circuit hereinbefore described; (2) it opens at its outer upper armature and contact the multiple chain circuit hereinafter described; (3) it transfers at its inner lower armature and contact the conductor 233 from the winding of start relay 203 to two parallel paths, one extending through the contact and the lower winding of relay 205, conductor 234, contact and inner armature of relay 302 to grounded battery, which locks relay 205 in an operated position, and the other, which at this time is open due to relay 215 being in an operated position, extending over the contact and inner lower armature of relay 205, contact and middle lower armature of relay 215, contact in normal position on a relay, say relay 205; corresponding to relay 205 and provided for the next line finder switch in the group, through the winding of a start relay, not shown but corresponding to relay 203, for the next line finder switch to grounded battery; and (4) it removes at its inner upper armature and contacts grounded battery from the operating circuit for relays 212 and 215 and vertical magnet 209. Relays 212 and 215 and vertical magnet 209 release, the release of relay 215 completing the closure of the path to the next line finder, the release of relay 212 preventing its operation on the release of the line finder with which it is associated, and the release of the vertical magnet 209 preventing false operation if relay 215 releases before relay 212 due to difference in releasing time of these two relays.

Hunting connector

In the idle condition of the connector, relay 403 is energized by current normally flowing through its lowermost winding and its armature is thereby held against its back contact. Relay 406 is energized by current normally flowing through its lower winding and its armature is thereby held against its front contact.

When the associated line finder finds the line extending to subscriber's station A and the cut-through relay 224 operates as hereinbefore described, the tip conductor 401 is connected to a path extending through the upper winding of relay 411, lower armature and back contact of relay 410, through the upper winding of relay 406, armature and back contact of relay 403 to the grounded positive battery 407, and the ring conductor 402 is connected to a path extending over the contact and armature of relay 412, through the lower winding of relay 411, upper armature and back contact of relay 410 to the grounded negative battery 409. The closure of this circuit, as will be hereinafter described, will cause relay 406 to move its armature into engagement with its back contact. The current in this circuit flows through the two windings of relay 411 in opposite directions and therefore the relay does not operate.

The sleeve conductor 218 of the line finder is, as hereinbefore described, connected at one end to ground at the upper spring of vertical off-normal springs 207, and at the other end over two parallel paths, one extending through the winding of relay 449 to ground battery, and the other extending through the winding of relay 415, conductor 416, through the winding of relay 304 to grounded battery. Relay 415, in operating, prepares a circuit for operating relay 410, but the latter relay cannot operate until cut-through relay 417 operates.

Relay 406, in operating, closes a circuit from grounded positive battery, back contact and armature of relay 406, conductor 418, back contact and outermost upper armature of relay 417, conductor 419, through the winding of relay 420 to ground. Relay 420 operates and causes slow-to-release relay 421 to operate. Relay 421, in operating, connects a substitute ground to the sleeve conductor 218 whereby the line finder and relays 415, 449 and 304 are maintained operated after the ground and vertical off-normal springs 207 are disconnected by the release of relay 203. It also opens the operating circuit for the release magnet 438 and prepares the operating circuit for the vertical magnet 422. Relay 203 being of the slow-to-release type does not release until after relay 421 has operated, although its operating circuit was opened when relay 205 operated.

When the cut-through relay 224 of the line finder operated and grounded negative battery 409 and grounded positive battery 407 are connected to the line circuit as hereinbefore stated,

relay 105 at station A operates thereby causing lamp 116 to become extinguished indicating to the subscriber that the circuit is cut through and ready to receive dialing impulses.

Dialing

At each interruption of the dial 104 at station A which is now operated to transmit the current impulses corresponding to the code number of station B, pulse relay 420 releases due to the de-energization of the upper winding of relay 406 whereby the relay armature is actuated to its associated front contact. At the first interruption the pulsing circuit is closed extending from ground at its armature and back contact, inner right armature and front contact of relay 421, contact 423 of vertical off-normal spring 456, through the winding of slow-to-release relay 424 and vertical magnet 422, in series to grounded battery. The vertical magnet 422 operates on each interruption of the dial to step the hunting connector shaft (not shown) and brush set 434 carried thereon to the desired level. Slow release relay 421 remains operated during this stepping operation. Relay 424 also being of the slow-to-release type operates on the first interruption but does not release on the subsequent interruptions caused by the dial returning to normal. On the first step of the shaft, the vertical off-normal spring 456 transfers the pulsing circuit from contact 423 to contact 425, but relay 424 being in an operated position retains at its armature and front contact the pulsing circuit through the vertical magnet 422 during the dialing of the first digit of the called number for station B. When the impulses from dial 104 cease, relays 420 and 421 remain operated and relay 424, after a short interval, releases. Relay 424 transfers the pulsing circuit of the vertical magnet 422 to the rotary magnet 426, the pulsing circuit now being traceable from contact 425, armature and back contact of relay 424, conductor 427, make-before-break contact of relay 428, conductor 429, outermost lower armature and contact of relay 417, conductor 430, then over two parallel paths one extending over contact and outermost lower armature of relay 414, conductor 431, through the winding of rotary magnet 426 to grounded battery, and the other extending through the winding of slow-to-release relay 432 to grounded battery. On the next series of interruptions caused by dialing the second digit of the called number, pulse relay 420 operates the rotary magnet 426 in parallel with relay 432. Relay 432 being of the slow-to-release type, operates on the first interruption and remains operated for the duration of the second series of interruptions. The rotary magnet in responding to the second series of interruptions steps the connector shaft and brushes around to the terminals of the line extending to station B. Relay 432 in operating, prepares the busy test circuit and shunts the make-before-break contact of relay 428 through which the rotary magnet circuit was taken, so that the operation of relay 428 while the sleeve brush passes over the busy contact, will not open the rotary magnet circuit.

On the completion of the dial interruptions of the last digit of the code number at the called station B, relay 420 is held operated over the circuit extending from grounded battery at the back contact and armature of relay 406 over the back contact and outermost upper armature of relay 417 to ground at the winding of relay 420, as hereinbefore traced. Relay 421 is also maintained operated. The operating circuit for the rotary magnet 436 and relay 432 is opened at the armature and back contact of relay 420. Relay 432, being of the slow-to-release type, remains operated a short time after the brush set 434 makes contact with the terminals of the called line during which time a busy test is made.

Assuming, however, that the line extending to station B is idle at the time of the completion of the dial interruptions of the last digit and that, after a short time, slow-to-release relay 432 has released, a circuit is closed extending from ground at the left armature and contact of relay 421, conductor 440, inner lower armature and back contact of relay 428, conductor 435, through the lower winding of relay 417, conductor 458, back contact and lower armature of relay 432, conductor 436, sleeve brush of set 434 on terminal 454, conductor 437, through the winding of cutoff relay 601 to grounded battery. Relay 417 operates through its lower winding in series with the cutoff relay in the line circuit of station B. Relay 417 operates sufficiently to close its contact and innermost upper armature thereby energizing its upper winding to cause the relay to become fully operated. The full operation of relay 417 places a direct ground on the sleeve brush of set 434 for the purpose of operating the cutoff relay 601 in the line circuit of station B. The same ground places a busy condition on the sleeve terminal in the hunting connector multiple bank, so that should a third station initiate a call for station B at the time that station B is engaged in an established connection, the third station would receive a busy signal. Relay 417, in operating, also opens the rotary magnet circuit so as to prevent further stepping of the brushes if the calling party at station A should again operate his dial. Relay 417, in operating, furthermore substitutes grounded battery 448 for grounded battery 461, thereby maintaining relay 420 in an operated position.

The operation of relay 417 closes a circuit extending from ground at the outer right armature and contact of relay 421, conductor 441, next to the innermost upper armature and contact of relay 417, conductor 442, then over two parallel paths, one extending through the lower winding of relay 414 to grounded battery and the other extending over contact and armature of relay 415, conductor 443, through the winding of relay 410 to grounded battery. Relays 414 and 410 operate. Relay 410 in operating, reverses the polarity on both the calling and the called lines.

Starting of motor at station A

Reversal of polarity on the calling line is effected over a circuit extending from grounded positive battery 444, front contact and upper armature of relay 410, through the lower winding of relay 411, armature and contact of relay 412, ring conductor 402, middle upper armature and contact of relay 224, ring conductor 229, ring brush of set 221 on ring terminal 236, ring conductor 114, through the winding of polarized relay 113, upper right spring of key 101 in engaging with contact 112, right normal contact of dial 104, through the winding of relay 105, lower right spring of key 101 in engagement with contact 106, conductor 107, tip conductor 108, tip terminal 222, tip brush of set 221, tip conductor 228, contact and outer upper armature of relay 224, tip conductor 401, through the upper winding of relay 411, lower armature and front contact of relay 410 to grounded negative battery 409. The current flowing in one winding of relay 411 neutralizes the magnetic effect of the current in

the other winding so therefore the relay does not operate. Relay 105 being of the neutral type remains operated to maintain lamp 116 extinguished. Relay 113 is polarized and is designed to operate on a reversal of current. Relay 113, in operating, closes an obvious operating circuit for the motor start relay 120. Relay 120 operates and is held in an operated condition by a circuit traceable from grounded battery, through the winding, lower armature and contact of relay 120, emergency stop contacts 121, to ground at the motor control contacts 122. Relay 120 in operating, also closes a circuit for starting printer motor 123, which is traceable from grounded battery, upper armature and contact of relay 120, conductors 124 and 125, through the motor 123, governor control contacts 126 to ground. The operating circuit for motor 123 has four parallel paths, one extending through the winding of relay 102 to ground; the second extending through the lower winding of the pulsing polarized relay 127 to ground; the third extending over the armature and back contact of relay 127, through the winding of the printer magnet 131 to ground; and the fourth extending over the contacts and lower armature of relay 128, through the buzzer 129 to ground. Relay 102 operates and thereby permits the closure of the loop circuit through the station transmitter as soon as key 101 is released. Relay 127 is energized by the current in its lower winding and thereby tends to hold its armature against its front contacts so as to open the operating circuit of the printer magnet 131. Buzzer 129 operates and serves to indicate to the subscriber at station A that the motor 123 is started. The starting of the buzzer and the motor serves as signals for the subscriber to operate non-locking key 101 from its right-hand, or call, position to the left, or buzzer position, the operation of the key to the buzzer position being momentary as the key is immediately released to its normal position. The momentary operation of the key 101 to its buzzer position causes relay 128 to operate and lock up for the duration of the connection between station A and the called station B. The release of key 101 disconnects the dial 104 and lamp 116 from the line circuit and closes the loop circuit through the transmitter at station A and the upper winding of relay 127. The current flowing through the upper winding of relay 127 predominates over the current flowing through the lower winding and therefore moves or holds the armature against its back contact so that with the key 101 in its normal position, the motor 123 operating and no signal being transmitted, the printer magnet is energized.

In areas wherein it is desirable to use alternating current for starting and operating the printer motors, the motor start relay such as relay 120 at station A, may be of the alternating current type. In this case a motor generator set or rectifier would be provided and one or the other, depending on which is preferable, would start in parallel with the motor which would be of the alternating type. The direct current supply from the generator set or rectifier would be used for supplying the direct current electromagnets such as relays 127 and 102 and magnet 131. An alternating current supply is disclosed in a co-pending application of G. A. Locke, Serial No. 646,368, filed December 9, 1932.

The reversal of polarity on the called line, that is, the line circuit of station B, is effected over a circuit traceable from grounded positive battery 444, front contact and upper armature of relay 410, ring conductor 445, contact and middle upper armature of relay 417, ring brush of set 434, ring terminal 446, ring conductor 447, contact and middle upper armature of relay 601, ring conductor 602, through the winding of polarized relay 603, uppermost left spring of key 604 in engagement with break contact 615, to ground at the armature of contact of relay 605. Relay 603 operates on the reversal of polarity and closes an obvious operating circuit for the motor start relay 606. The equipment at station B is identical with that at station A and relay 606 operates and performs functions at station B similar to those performed by relay 120 at station A. The non-locking call key 604, however, is in its normal position and the attendant at station B, in response to the operation of buzzer 611, merely operates the key momentarily to its buzzer, or right, position so as to cut off the buzzer.

The reversal of polarity on the calling and the called line is only momentary because relay 414 operates and opens at its middle lower armature and contact the operating circuit for slow-to-release relay 415 which after a short time releases and consequently causes the release of relay 410, whereby the normal transmitting polarities of the calling and the called line are restored. Relay 414, in operating, closes at its outermost upper armature and contact the repeater circuit extending to station B, and at its next to the outermost upper armature and contact the artificial line circuit of the line extending to station B. The remaining armatures and contacts of relay 414 are employed for establishing circuits required when the called station line is busy or when testing called line groups and will be hereinafter described. The established connection is now ready for transmission of messages.

Busy condition

Should station B be busy at the time brush set 434 engages the terminals to which the line circuit of station B is connected, ground would be found on the sleeve terminal in the multiple bank. The ground and sleeve terminal would be connected by the sleeve brush of set 434, over conductor 436, lower armature and front contact of relay 432, contact and armature of magnet 426, through the winding of busy relay 428 and release magnet 438 in series, conductor 439, through the left winding of relay 305 to grounded battery. Relay 428 would therefore operate before slow-to-release relay 432 releases and immediately upon the release of relay 432 would lock up in a circuit traceable from ground at the left armature and front contact of relay 421, conductor 440, inner lower armature and front contact of relay 428, through the left winding of relay 412, through make-before-break contact of relay 432, contact and armature of rotary magnet 426, through its own winding and the winding of release magnet 438, conductor 439, through the left winding of relay 305 to grounded battery. This locking circuit would energize the left winding of relay 412 and the relay would operate and it in turn would open the ring side of the line extending to station A. Opening the ring side of the line would cause lamp 116 to light indicating that station B is busy. The lighting of the lamp for a prolonged period serves as a signal for the subscriber at station A to release key 101 and the line finder and

the hunting connector switches remain in their operated condition until key 101 is released.

Repeater operation

When the established connection is ready for the transmission of the message, the repeater which is made up of two differential polar duplex repeaters such as polar relays 406 and 403, operates in two circuits arranged to repeat signals from one to the other in opposite directions but in one direction at a time. The established connection for the line circuit of station A is traceable from grounded negative battery 409, back contact and upper armature of relay 410, through the lower winding of relay 411, armature and contact of relay 412, ring conductor 402, middle upper armature and contact of relay 224, conductor 229, ring brush of set 221, on terminal 236, ring conductor 114, through the winding of relay 113, upper right spring of key 101 in engagement with contact 133, armature and front contact of relay 102, transmitter at station A, break key 135, through the upper winding of pulse relay 127, tip conductor 108, terminal 122 engaged by tip brush of set 221, tip conductor 228, contact and outermost upper armature of relay 224, tip conductor 401, through the upper winding of relay 441, armature and back contact of relay 410, through the upper winding of relay 406, armature and back contact of relay 403 to grounded positive battery 407. The current from battery 407 is simultaneously flowing through the lower winding of relay 406 but in opposite relation to that in the upper winding. The current, however, in the upper winding has double the strength and opposite polarity of that in the lower winding and therefore predominates to hold the armature of the relay in engagement with its back contact.

The established connection for the line circuit of station B is traceable from grounded negative battery 409, back contact and upper armature of relay 410, ring conductor 445, contact and middle upper armature of relay 417, ring brush of set 434 on terminal 446, ring conductor 447, contact and middle upper armature of relay 601, ring conductor 602, through the winding of relay 603, uppermost left spring and break contact 615 of key 604, armature and front contact of relay 605, transmitter at station B, break key 617, through the upper winding of pulse relay 610, tip conductor 618, outermost upper armature and front contact of relay 601, tip conductor 619, terminal 460 engaged by tip brush of set 434, next to the outermost upper armature and contact of relay 417, through the uppermost winding of relay 403, contact and outermost upper armature of relay 414, armature and back contact of relay 406, to grounded positive battery 461. The current from battery 461 is simultaneously flowing through the middle winding of relay 403 but in opposite relation to that in the uppermost winding. The current, however, in the uppermost winding has double the strength and opposite polarity and therefore predominates to hold the armature of the relay in engagement with its back contact. A third winding, that is, the lowermost, is provided for relay 403 and it is energized in the same direction as the uppermost winding. The third winding serves to normally hold the relay armature against its back contact when relay 417 is in its normal condition.

When transmitting from station A to station B, relay 127 at station A operates, relay 113 at station A does not operate and relay 406 at the central office operates. Relay 127 in operating, opens and closes the energizing circuit for printer magnet 131 which operates to set up a record of the transmitted message. Relay 113 being polarized does not operate on the current received over the tip side of the line circuit. Relay 406 in response to each break in the line circuit of station A causes its armature to move, under the influence of the currents in the lower winding, to its front contact. The movement of the armature of relay 406 between its front and back contacts causes current impulses of positive and negative polarities, corresponding to the "no current" and "current" impulses incoming from station A to be repeated by batteries 461 and 404 alternately over the front and back contacts of the relay through the uppermost and middle windings in parallel of relay 403 to the line circuit of station B.

The outgoing impulses of positive polarity in the uppermost winding of relay 403 hold the armature of the relay against its back contact and those of negative polarity of the same winding have no magnetic effect on the relay because of like polarities being connected to both ends of the line circuit. However, the negative impulses flowing through the middle winding of relay 403 have a magnetic effect, but now this effect is to hold the relay armature against its back contact. Therefore, the repeated impulses of positive and negative polarities are received at station B as "current" and "no current" impulses, respectively, which cause the alternate release and operation of the printer magnet 613 for printing a record of the received message, the operation of the printer magnet 613 being effected by the operation of pulse relay 610. Relay 603 like relay 113 at station A, does not respond to the message impulses.

When transmitting from station B to station A, relay 403 becomes responsive to the incoming message impulses and moves its armature between its front and back contacts to connect negative battery 462 and positive battery 407 for repeating the signals through the windings of relay 406 to the line circuit of station A. Relays 403 and 406 operate in a manner similar to relay 406 and 403 respectively, when transmitting from station A to station B as described above.

Release

On the completion of the message the line finder and hunting connector switches are held in place due to the fact that relay 411 has not operated. In order to restore the switches to normal, the subscriber at either of stations A or B transmits a stop signal, usually the upper case H, whereby the motor control contacts 122 at station A and motor control contacts 608 at station B are opened causing the release of their respectively associated motor start relays 120 and 606. The release of relay 120 causes the release of relay 128 and 102 and the deenergization of the lower winding of pulse relay 127 and the single winding of printer magnet 131. Likewise, the release of relay 606 causes the release of relays 620 and 605 and the deenergization of the lower winding of pulse relay 610 and the single winding of printer magnet 613. Relay 102 in releasing, connects ground at its armature and back contact whereby the lower winding of relay 411 is reenergized and the upper winding deenergized. The release of relay 102 allows relay 406 to be operated to the position shown in

the drawings. Relay 411 now having only one of its windings energized, operates, thereby causing the release of relay 449. Relay 449 on releasing, causes the release of relay 420, which in turn will allow the slow-to-release relay 421 to release. Relay 421 on releasing opens the locking circuit for relay 417 and the operating circuit for relay 414. Relay 417 on releasing, causes the cut-off relay 601 for station B to release and relay 403 to be operated to the position shown. On the release of relays 420, 421 and 417 a circuit is closed traceable from ground at the back contact and armature of relay 420, inner right armature and back contact of relay 421, conductor 451, contact and next to the outermost lower armature of relay 417, conductor 452, contact and upper spring of vertical off-normal springs 456, through the winding of release magnet 438, conductor 439, through the left winding of relay 305 to grounded battery. Release magnet 438 operates and thereby allows the switch shaft of the hunting connector switch to return to its normal position. When the hunting connector switch is returned to its normal position, the operating circuit for the release magnet is opened at the contacts and upper spring of vertical off-normal springs 456. Simultaneously with the release of the hunting connector switch, the line finder switch is released because when relay 421 releases it removes at its left armature and contact ground from the sleeve conductor 218 thereby allowing relay 224 to release. The release of relay 224 closes a circuit extending from grounded battery through the winding of the release magnet 238, contact and lower spring of vertical off-normal springs 207, outermost lower armature and contact of relay 215, back contact and outer lower armature of relay 224, conductor 231, back contact and outer upper armature of relay 203, conductor 217, upper spring and uppermost contact of vertical off-normal springs 207 to ground. Release magnet 238 operates and thereby allows the line finder switch shaft to return to normal. When the line finder switch shaft returns to its normal position ground at the uppermost contact and upper spring of vertical off-normal springs 207 is removed, and then the circuit extending through the upper winding of relay 205 is opened so that the relay releases. The purpose of the lower winding on relay 205 is to hold the relay operated, if the finder switch shown is returned to normal at a time when the start lead is advanced through this finder switch circuit and has started a succeeding finder switch, until the finder switch so started has found the calling line. The return of the finder switch to normal opens the locking circuit for the cutoff relay 110 and the relay releases thereby restoring relay 111 to its normal position on the line.

Premature release of line finder switch

When the calling subscriber A releases the non-locking key 101 before the line is found, relays 111, 117 and 201 release, allowing relay 203 to release. Relay 203 on releasing, closes the operating circuit for the release magnet 238 which is hereinbefore described.

If this call is abandoned before the brushes have reached the calling line terminal, the finder switch continues to step during the release time of slow-to-release relay 203, in which case it might go to the limit of its rotary motion. In such a case, the rotary shaft spring 204 operates on the eleventh rotary step and thereby opens the operating circuit for relay 203. Relay 203 releases to close the release magnet circuit.

If for any reason, such as an open sleeve circuit, the finder switch fails to cut through, that is, to effect the complete operation of relay 224 which is caused only when the locking circuit extending through the upper winding is closed, it will continue stepping until it reaches the eleventh contact in the tenth level at which point the rotary spring 204 will operate to open the operating circuit for relay 203. Also, the rotary springs in their operated position close a shunt path across the interrupting armature and contact of rotary magnet 210 thereby preventing the rotary magnet from deenergizing until relay 205 operates. After an interval following the operation of rotary spring 204, relay 203 releases causing relay 205 to operate and relay 215 to release. Relay 215 on releasing, closes at its outermost lower armature and contact the operating circuit for release magnet 238 and the release magnet operates causing the line finder switch shaft to return to normal.

If the calling line is waiting on the tenth rotary terminal in the tenth level, relay 224 will operate before relay 203 releases and the connection to the hunting connector will be completed.

GROUP CIRCUIT

Grounded start lead

If the series start conductor 206 of the line finder switch becomes permanently grounded, each line finder switch in a group will step in turn to the eleventh terminal set of the tenth level. The contact spring sets corresponding to spring set 204, shown in Fig. 2, on the line finder switches will open in turn, thereby opening the operating circuits for relays, corresponding to relay 203 in Fig. 2. The release of relay 203 at this time closes the operating circuit for the release magnet 238 and the magnet, on releasing, restores the line finder switch shown in Fig. 2 to normal. In like manner each of the other line finder switches in the group are restored to normal. After the line finder switches have been restored, each of the relays, corresponding to relay 205, will be maintained operated over the lower winding, and the multiple chain circuit extending in multiple over the outer upper armature of each of these relays, which normally hold the relays 303 and 310 operated, will be opened thereby causing relays 303 and 310 to release. With relays 303 and 310 in their non-operated position, relay 301 is operated thereby disconnecting ground from all the subgroup relays (one of which is relay 201, common to the ten lines terminating on the tenth level of the line finder switch shown in Fig. 2) to prevent further grounding of the start conductor 206 and close a path from the start conductor on the first subgroup relay 239 to relay 311, the circuit being traceable from the ground connection which happens to be at this time maintained on the start conductor 206, over inner right armature and contact of relay 239, conductor 241, left armature and contact of relay 301, through the winding of relay 311 to grounded battery. Relay 311 operates causing relay 312 to operate. Relay 312 operates and locks itself to ground at the alarm release key 313. Relay 311 in operating causes relay 302 to operate, lamp 314 to light and relay 345 to operate. Relay 302 in operating disconnects grounded battery from the lower winding of each of the relays, corresponding to relay 205,

thereby causing all the latter relays, except the one last operated, to release. Relays 303 and 310 then reoperate and cause the release of relay 301 allowing calls to proceed in the regular manner. Relays 311 and 302 also release. If the start conductor is still grounded the cycle will be repeated but any line calling will receive service as the relay in the subgroup including relays 239 and 201, grounds the level at which the calling line is rotated and allows the line finder to cut in on that level. The alarm will remain locked as indicated by lamp 314 until the maintenance man has cleared the trouble and released relay 312 by means of key 313.

Balanced potential on chain circuit

The chain circuit normally holds relays 303 and 310 operated through the outer upper armatures of all the relays, corresponding to relay 205, in the line finder switches. If the conductors 242 and 243 become crossed with ground or battery, one of the relays 303 and 310 will release and the other will hold operated. When either of the relays releases lamp 315 is lighted indicating the trouble.

Chain circuits—All line finders busy

When all the line finders become busy, both relays 303 and 310 release thereby operating relay 301. Relay 301 in operating, disconnects ground from the start conductor to prevent, if another line calls, an alarm as described above under "Grounded start lead".

ALARMS

Fuse alarm

When one of the alarm type of fuses shown at bus bar sections 316 and 317, operates, that is, burns out, the defective fuse causes at the bus bar a connection for operating either relays 318 or 319. The operation of either of these relays causes the fuse alarm lamp 320 to light and the extension alarm circuit to open. The extension alarm circuit extends from grounded positive battery 321, make-before-break contact of relay 308, conductor 322, right armature and contact of relay 323, outer right armature and contact of relay 319, outer right armature and contact of relay 318, conductor 324, contact and left armature of relay 325, inner right spring of key 326, conductor 327, to a distant point (shown enclosed in block 328) where the conductor 327 is connected through the winding of a neutral relay 329 and the winding of the polarized relay 330, in series, conductor 331, inner left spring and innermost left contact of spring 326, right armature and contact of relay 325, conductor 332, contact and inner right armature of relay 318, contact and inner right armature of relay 319, contact and left armature of relay 323 to ground. Relay 329 is normally held operated by the extension alarm circuit, but relay 330 does not operate inasmuch as it is polarized to operate only on a reversal of current. The opening of the extension alarm circuit at the armatures and contacts of either relay 318 or 319 causes the release of relay 329 whereby a circuit is closed for operating the major alarm lamp 333.

Release magnet alarm

When the release magnet, corresponding to release magnet 238 in any line finder circuit is energized, a circuit is closed from ground at the armature and contact of the operated magnet, conductor 244 through the winding of relay 334 to grounded battery. Relay 334 operates and thereby prepares the operating circuit for release lamp 335 and energizes the dash-pot relay 336. Under normal conditions the line finder switch in response to the operation of its release magnet will return to normal and open the release magnet circuit before the dash-pot relay 336 which requires several seconds to operate, becomes fully operated. If a line finder switch fails to return to normal, its release magnet and the relay 334 remain in operated position and the dash-pot relay 336 fully operates. Relay 336 in operating causes the release lamp 335 to light and relay 323 to operate. Relay 323 in operating opens the extension alarm circuit as hereinbefore traced and thereby causes the major alarm lamp 333 at the distant point to light.

Call block alarm

When a call is blocked, a subgroup relay, such as relay 201, is in an operated position and connects ground over its outer left armature and contact, supervisory release conductor 245, through the winding of relay 337 to grounded battery. Relay 337 operates and closes at its left armature and contact an operating circuit for relay 336. Relay 336 as stated above, requires several seconds after its operating circuit is closed to operate. If the trouble which blocks the call persists long enough, the relay 336 will operate and thereby close at its right hand armature and contact a circuit for lighting the "call block" lamp 339, and at its left hand armature and contact a circuit for operating relay 323. Relay 323 operates and thereby opens the extension alarm circuit which in turn causes the major alarm lamp 333 at the distant point to operate.

Permanent signal

The permanent signal conductor 416 is grounded from the moment that the line finder switch operates in its first step until dialing of the called code number has been completed. This ground connection at the vertical off-normal spring 207 causes relay 304 to operate which in turn will energize the dash-pot relay 306 which requires several seconds to operate and if the conductor 416 continues to be grounded, as for example, when slow-to-release relay 421 is maintained operated, as hereinbefore described, relay 306 fully operates and energizes the second dash-pot relay 307. The latter relay requires several seconds more before it fully operates and closes contacts to light the permanent signal lamp 309. It was hereinbefore stated that grounded positive battery 321 was connected in the extension alarm circuit at the make-before-break contact of relay 308, but now when relay 307 operates, an operating circuit for relay 308 is closed whereby the make-before-break contacts are operated to substitute grounded negative battery in place of the grounded positive battery in the extension alarm circuit. This reversal of polarity causes a polar relay 330 at the distant point to operate thereby causing lamp 340 to light. When lamp 340 lights it indicates a minor alarm.

Power failure alarm

Whenever anything occurs in the power supply to cause either or both the generators to stop, either or both relays 341 and 342 will release and in turn cause relay 325 to release. The release of relay 325 will open the extension alarm circuit thereby operating the major alarm at the distant point.

Line finder alarm

When trouble occurs on the line finder, start conductor 206, for example, with ground connection is maintained thereon, or when all the line finder switches are busy, either of relays 310 or 303 is released and relay 312 is operated thereby connecting ground to the conductor 343 to operate relay 345. Relay 345 in operating causes relay 323 to operate and to thereby open the extension alarm circuit which, in operating, causes the major alarm lamp 333 to light.

Shutting down power

When it is desired to shut down the power as for example at the close of a day's business, an alarm cutoff key 326 is operated after the shutdown occurs. The key 326 in an operated position disconnects the extension alarm circuit from the major and minor alarms at the distant point which prevents giving an alarm at the time the power is shut down. If the key is operated before the power is shut-down, a circuit will be closed for operating buzzer 344 which gives a signal that the power is still connected.

Called line groups—Testing

When it is desired to group called lines together so that the dialing of a particular number will connect the calling station to the first idle line in the group, this is done by arranging the lines on adjacent points on the hunting connector bank shown in Fig. 4 and by connecting together at the bank terminals the sleeve "S" and hunting "H" conductors of all the lines, except the last line, in the group. If the first line is busy a ground from the "S" terminal operates relay 428 before the release of relay 432, the circuit being traceable from grounded battery, through the left-hand winding of relay 305, conductor 439, through the winding of release magnet 438, through the winding of relay 428, armature and contact of rotary magnet 426, front contact and lower armature of relay 432, conductor 436 to the grounded "S" terminal. On the release of relay 432, relay 414 will operate through its upper winding and the right-hand winding of relay 412 to ground on the "H" sleeve of the hunting connector switch. Relay 428 now locks under control of relay 414 and the armature and contact of a rotary magnet 426, to ground at relay 421. It also locks up in a path extending over the make-before-break contact of relay 432, through the left winding of relay 412, to ground at relay 421. Relay 412 being differentially connected and energized in both windings, does not operate. Relay 414 will close a circuit for operating relay 432 which, when operated, will cause the rotary magnet 426 to operate in parallel. The operation of rotary magnet steps the shafts and brushes to the terminals on the next line and also releases relay 428. The reason for having the locking circuit for relay 428 under control of the rotary magnet is for the purpose of locking relay 428 until the rotary magnet is fully operated, at which time the brushes of the hunting connector switch are centered on the terminals so as to prevent false operation due to the breaking of the circuit at the above terminal before the mechanism has completed a full step. Similarly relay 414 is locked in series with resistance 474 under control of relay 428. The reason for having the rotary magnet operation delayed until relay 432 operates is to give time for relay 432 to become fully energized before its circuit is opened by the relay 428 after the rotary magnet operates in order to insure holding relay 432. The release of relay 428 will cause the rotary magnet to release. If the sleeve terminal of this line is grounded due to the line being busy, relay 428 will again operate which again will cause the rotary magnet to operate and step the brushes to the terminals of the next line, relay 414 holding operated through resistance 474 to ground on the "H" terminal. This operation continues until the terminals of an idle line or the terminals of the last line in a group are reached, when the circuit functions the same as described above. In the case of the first line or an intermediate line being idle, the operation of the cut-through relay 417 opens the "H" conductor to prevent the locking up of relay 428. When all the lines of the group are busy and the terminals of the last line in the group are reached, relay 414 will release on the release of relay 428. The ground from the "S" terminal, however, will again operate relay 428 before the release of relay 432. On the release of relay 432, relay 428 will be locked up from ground at relay 421, to battery through the release magnet 438. A busy indication will now be given as described above. The circuit will remain in this position until the non-locking key at the calling station is released. The purpose of operating relay 414 in series with resistances 475 and 474 and locking it in series with resistance 476 is to prevent overheating relay 414 and also to prevent putting a direct ground on terminal "H" on the last line of the group and operating relay 414 in another switch which may be connected to this terminal.

Broadcasting

The broadcasting arrangement provides for establishing connection to a predetermined group of other stations from any station outside of the group, so that the stations included in a group may simultaneously receive a message from the station originating the connection. A group is comprised of a maximum of ten stations, there being provided for each subgroup of five stations or less a master relay for simultaneously repeating the message to the terminating station. The master relays also serve to reverse the polarity momentarily on the line circuit in the group whereby the motors at the terminating station are started simultaneously.

The broadcast group is arranged on a non-seizure basis and should any station in a broadcast group be busy at the time a call is made for an individual connection to a station in that group, the subscriber at the calling station would receive a busy signal in the same manner as described above in the establishment of an individual connection. Upon the receipt of the busy signal the subscriber releases the call key so as to restore to normal the equipment at the central office.

The broadcast connections are established in the same manner as individual connections except that certain terminal sets of the hunting connector switch bank are set aside for the broadcast circuits. These broadcast terminal sets may be assigned numbers 91 to 100 on a 100-point switch bank wherein the numbers 1 to 90 are reserved for establishing individual connections. In response to the dialing of one of the numbers 91 to 100 the calling line is automatically connected

to the desired terminal set and the stations included in the desired group will be automatically connected to the calling line. In the connector switch bank shown in Fig. 4 terminals 460, 446, 454 and 456 represent a set reserved for an individual connection to station B as described above, terminal set 463 is reserved for station C (represented diagrammatically by oblong 141 shown below the equipment for station A in Fig. 1) for an individual connection, and terminal set 464 represents a set reserved for a broadcast group in which station C of Fig. 1 is included.

Referring now to Fig. 5, the upper half of the drawing represents one broadcast group comprising more than five stations, say ten stations for the sake of illustration, and the lower half represents another broadcast group which may include five or less stations. The broadcast group shown in the upper half of the figure 5 comprises a busy relay such as any one of relays 501 to 510 and a cut-through relay, such as any one of relays 511 to 520, for each of the stations in the group, the reference characters designating the relays indicating that there are a maximum of ten stations in the group. A start relay 521, a current reversal relay 522, a slow-acting relay 523 and a slow-to-release relay 524 are provided and are common to the group. A pair of master relays 525 and 526 are also provided, one for each subgroup of five or less stations. The broadcast group shown in the lower half of the figure is substantially the same as that shown in the upper half except that, in the case where five or less stations constitute the group, one master relay only is provided, and the conductors 527, 528 and 529 corresponding to conductors 457, 465 and 466, respectively, for the group shown in the upper half, are connected to another set of terminals (not shown) reserved on the hunting connector switch bank for establishing a connection to the group shown in the lower half of Fig. 5.

Operation of the broadcast circuit

Assuming that station A desires to call a group of other stations including station C for broadcast purposes, the subscriber at station A operates call key 101 and the call is automatically established through the line finder shown in Fig. 2, to the hunting connector switch shown in Fig. 3 in a manner hereinbefore described for establishing the individual connection to station B. When the hunting connector switch is seized and the subscriber receives the signal, such as the extinguishing of lamp 116 indicating that the system is prepared to receive the dialing impulses, the dial 104 is operated to send the broadcast code number of the desired group. Assuming that the desired group is connected to terminal set 464 in the hunting connector switch bank the code number corresponding to this terminal set is dialed and the hunting connector switch brush will, in response to the dialing impulses, come to rest on terminal set 464. The grounded conductor 436 is immediately connected in the circuit extending over the sleeve contact 467 of terminal set 464, conductor 457, armatures and contacts of relays 501 to 510 in series, conductor 529, through the winding of start relay 521 to grounded battery. Relay 521 operates and closes a locking circuit for itself extending from grounded battery, through the winding and inner upper armature and contact of the relay, conductor 530, to the grounded conductor 457. Relay 521, in operating, closes (1) at its outer upper armature and contact an obvious operating circuit extending in parallel paths through the windings, in parallel, of the cut-through relays 511 to 520 to grounded battery, and (2) at its lower armature a circuit extending from grounded battery, lower armature and front contact of relay 521, conductor 531, make-before-break contacts of relay 523, through the winding of relay 524 to ground. Relays 511 to 520 operate and thereby cut through the tip and the ring conductors extending from each of the stations in the desired group to grounded positive battery 532 and grounded negative battery 533, respectively. The grounded negative battery 533 is now connected in a circuit extending to ground at the armature and back contact of a relay corresponding to relay 102 at station A, at each of the stations in the desired group. At the front contact of the relay corresponding to relay 102 at station A, the circuit extending to the grounded positive battery 532 is opened. The tip conductor 136 and ring conductor 137 extending from station C which is included in the desired group, are shown in detail, connected to the outer upper and inner upper armatures respectively of relay 511 and the operation of relay 511 actuates these armatures into engagement with their respectively associated front contacts to close a circuit extending through the batteries 532 and 533. Relays 511 to 520, in operating, close at their respectively associated lower armatures and contacts, circuit for operating the cut-off relay of each of the individual lines extending to each of the stations in the desired group, the cut-off relay 138 associated with station C being operated over the circuit including conductor 534. The cutoff relay in operating makes the line extending to the station in the desired group busy to subsequent calls.

Relay 524 operates in response to the operation of relay 521 described above, and closes a circuit extending through the left winding of relay 523 and the winding of relay 522 to grounded battery. Relay 523 is made slow operating in order to ensure the complete operation of relay 522 before relay 523 operates. Relays 523 and 522 operate. Relay 522 in operating, disconnects grounded negative battery 533 and connects in its place grounded positive battery 535 to the ring conductors extending to the stations in the desired group and this reversal of current operates a polarized relay corresponding to relay 113 at station A, at each of the desired stations. This reversal, like that described above for the establishment of the individual connections to station A and station B, is only momentary because of relay 523 in operating causes relay 524 to release. However, the release of relay 524, being of the slow-to-release type, is retarded sufficiently to regulate the duration of reverse current. The operation of the polarized relay at each of the desired stations, causes the printer motors thereof to start operating simultaneously.

The engagement of the sleeve brush of the hunting connector switch with contact 467 of terminal set 464 causes relays 417 and 410 to operate in a manner hereinbefore described whereby relay 417 causes the tip and the ring conductor of the line extending to station A to be connected through to the hunting connector brushes, and relay 410 causes a reversal of current on the line extending to station A to thereby start the motor thereof. The starting of the motor at station A operates buzzer 129 which serves as a signal for the subscriber to release call key 101. Upon the release of the key the subscriber starts sending the message to the de-

sired stations, which is transmitted over brush set 434 which, in engagement with terminal set 464, completes the last circuit over conductor 465, through the right winding of relays 525 and 526, and back over the conductor 466. Relays 525 and 526 respond to the message impulses. Relay 525 repeats the message impulses over conductors 536 and 537 through the printer magnet at each of the five stations in the first subgroup of the stations in the desired group, and relay 526 repeats the same impulses over conductors 538 and 539 to the printer magnet at each of the five stations of the second subgroup. The circuit for repeating the message to station C which is included in the desired group is traceable from grounded positive battery 532 or grounded negative battery 539, conductor 536, front contact and outer upper armature of relay 511, conductor 136, through the equipment (not shown but identical with that of station A) at station C, back over conductor 137, inner upper armature and back contact of relay 511, conductor 537, armature and back contact of relay 522 to grounded negative battery 533. The release of the equipment in the broadcast circuit is effected by transmitting a "stop" signal from the calling station only.

Individual connection from station A to station C

Assuming that it is desired to establish a connection from station A to station C, the subscriber at station A operates call key 101 to its right hand position and after the line circuit of station A is connected through to the connector switch shown on Fig. 4, transmits by means of dial 104 the code number assigned to station C whereby brush set 434 of the hunting connector switch is stepped into engagement with terminal set 463. The engagement of sleeve brush of set 434 with terminal 470 connects the grounded conductor 436 in a circuit extending over conductor 471, through the winding of cutoff relay 138 to grounded battery. Cutoff relay 138 operates and closes at its lower armature, a circuit traceable from ground, lower armature and front contact of relay 138, conductor 139, through the winding of relay 501, conductor 540, lower armature and back contact of relay 521 to grounded battery. Relay 501 operates and being in the broadcast group shown in the upper part of Fig. 5, prevents seizure of the broadcast group for broadcast operation during the time that this station is connected in an established individual connection because ground is applied to conductor 457. Likewise, if any other station in the broadcast group is busy such as the station associated with relay 510 ground will also be applied to conductor 457 and prevent seizure of the broadcast group.

The engagement of brush set 434 of the hunting connector switch with the terminal set 463 also connects the line circuit now extending through the line finder and the hunting connector switches to the tip conductor 473 and the ring conductor 472 which are at this time respectively extending over the outermost upper and the middle upper armatures of cutoff relay 138 in an operated position, conductors 140 and 141, outer upper and inner upper armatures of relay 511 in a non-operated position, tip conductor 136 and ring conductor 137 to the station equipment at station C.

The grounded battery connected to the winding of cutoff relay 138 operates cut-through relay 471 and the relay 471 in operating, causes relays 410 and 414 to operate. Relay 410 in operating causes a momentary reversal of current on the line circuit established between station A and station C in a manner described above for the established connection between station A and station B. The printer motors at both stations A and C start. Relay 414 in operating releases relay 415 whereby the operating circuit for relay 410 is opened. Relay 410, on releasing causes the polarity on the established line circuit between stations A and C to be restored to normal so that the line circuit is now ready for message transmission. The established circuit connection is released by either station sending a stop signal, such as upper case H as hereinbefore described.

What is claimed is:

1. In a telegraph exchange system, a plurality of subscribers' stations, a main station, printing telegraph equipment and a source of power therefor at each of said subscribers' stations, said source being normally disconnected from its associated equipment, a normally open line circuit connecting each of said subscribers' stations to said main station, switching means at each of said subscribers' stations for closing its associated line circuit, pulsing means at each of said subscribers' stations for transmitting an intermittent current over its associated line circuit, automatically operated means at said main station responsive first to said switching means and then to said pulsing means for interconnecting one of said subscribers' stations with any other of said subscribers' stations, and means responsive to said automatically operated means for operatively connecting the power source of each of said subscribers' stations operatively interconnected, to its associated printing equipment.

2. In a telegraph exchange system, according to claim 1, wherein said automatically operated means comprise calling line finding apparatus and called line hunting apparatus interconnected by a link circuit, each of said link circuits comprising a two-relay, single-line repeater.

3. In a telegraph exchange system, according to claim 1, wherein said automatically operated means provides for operatively engaging at one set of contacts a plurality of line circuits.

4. In a printing telegraph exchange system comprising a plurality of subscribers' stations, a connection initiating device and an impulse sender at each of said stations, printing telegraph transmitting and receiving mechanisms and a source of driving power therefor at each of said stations, a main station, a source of current at said main station for operating said mechanisms, a normally deenergized circuit connecting each of said stations with said main station, said circuit including a normally deenergized control circuit for each of said subscriber's stations, an automatically operable switching device at said main station responsive to the operation of any one of said initiating devices, a second automatically operable switching device at said main station responsive to two or more sets of impulses transmitted from the impulse sender at the subscriber's station at which the initiating device is operated, for completing a connection between a plurality of stations, means connected to the current source and arranged to be momentarily operated automatically as soon as a connection between two or more subscribers' stations is established for reversing the current on said interconnecting circuit, said reversal of current being effective to energize the normally deenergized circuit at the station whereat the call terminates and

to operate the source of driving power, at each station connected and means for energizing said normally deenergized circuit at the station initiating the call when said initiating device is restored to normal.

5. In a printing telegraph exchange system according to claim 4 wherein each of the transmitting and receiving mechanisms involved in a connection extending through the main station is provided with means to transmit a "stop" signal for disconnecting the sources of driving power from said mechanisms and for restoring the automatically operable switching devices engaged in the connection to normal.

6. In a telegraph exchange system according to claim 4 wherein the second automatically operable device includes a repeater one side of which is automatically connected to the calling subscriber's station and the other side, automatically connected to the called subscriber's station.

7. In a telegraph exchange system according to claim 4 wherein the connection initiating device at a called subscriber's station is arranged when momentarily operated, to disconnect an incoming call indicating device at the called subscriber's station.

8. In a telegraph exchange system according to claim 4 wherein the second automatically operable device includes a repeater arranged to be automatically connected in an established connection as soon as the connection to the called subscriber's station is completed.

9. A printing telegraph exchange system comprising a plurality of subscribers' stations, a connection initiating device and an impulse sender at each of said stations, printing telegraph transmitting and receiving mechanisms and a source of driving power therefor at each of said stations, a main station, a source of current at said main station for operating said mechanisms, a normally deenergized circuit connecting each of said subscribers' stations with said main station, a calling line finder switch at said main station responsive to any one of said connection initiating devices, a called line hunting connector switch at said main station arranged to select, in response to the operation of the impulse sender at the subscriber's station whereat the connection initiating device is operated, a terminal in the hunting connector switch capable of selection by the impulse sender at the calling subscriber's station for establishing a connection between the calling subscriber's station and a group of called subscribers' stations for broadcasting purposes.

10. A printing telegraph exchange system according to claim 9, wherein the called subscribers' stations of a group are arranged in subgroups, each subgroup comprising separate repeating devices adapted to operatively connect the source of driving power to said mechanism at each of the stations in the subgroups and to repeat the receiver message impulses to said mechanism.

11. In a printing telegraph exchange system according to claim 9 wherein the called subscribers' stations of a group are provided with a starting device common to the group and responsive to the connection of the calling line to the desired broadcast terminal in the hunting connector switch, for operatively connecting simultaneously the sources of driving power at all of the stations in a group.

12. In a printing telegraph exchange system according to claim 9 wherein each of the called subscribers' stations of a group is provided with means for preventing any other subscriber's station from interfering with the connection established for boadcasting.

13. In a printing telegraph exchange system according to claim 9 wherein the connection established between the calling stations and a group of called subscribers' stations for broadcasting purposes is arranged to prevent any interference from another of said subscribers' stations.

14. In a printing telegraph system wherein each of a plurality of stations is connectible to the other by automatic switches controlled by impulse senders, equipment at a central office comprising calling line finding apparatus and called line hunting apparatus for connecting a calling to a called station for telegraph communication and a telegraph repeater connected between said line finding and line hunting apparatus for relaying the telegraph impulses between two connected lines.

15. A system according to claim 14, wherein the repeater consists of local circuits having reduced current flow when idle and devices controlled by the establishment of a connection over said line finding and said line hunting apparatus to supply full operating current to said repeater.

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