Jan. 14, 1941. C. W. LUCEK 2,228,279

TELETYPEWRITER EXCHANGE SYSTEM

Filed March 16, 1939 26 Sheets-Sheet 1

FIG. 1

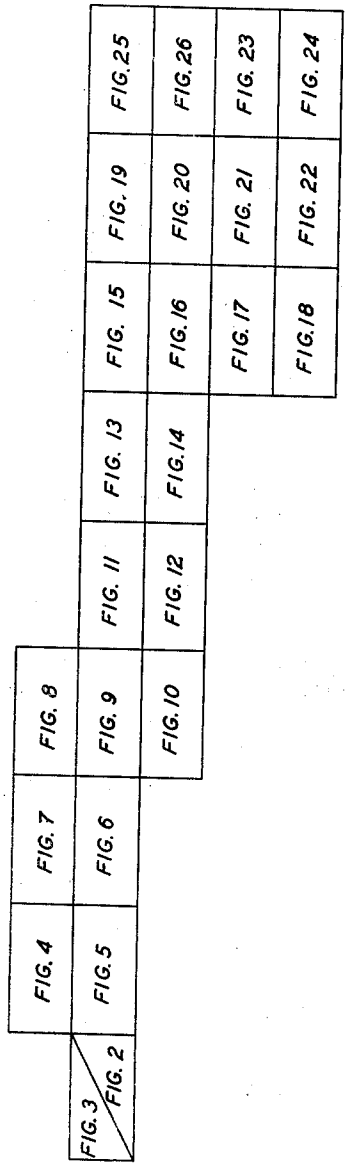
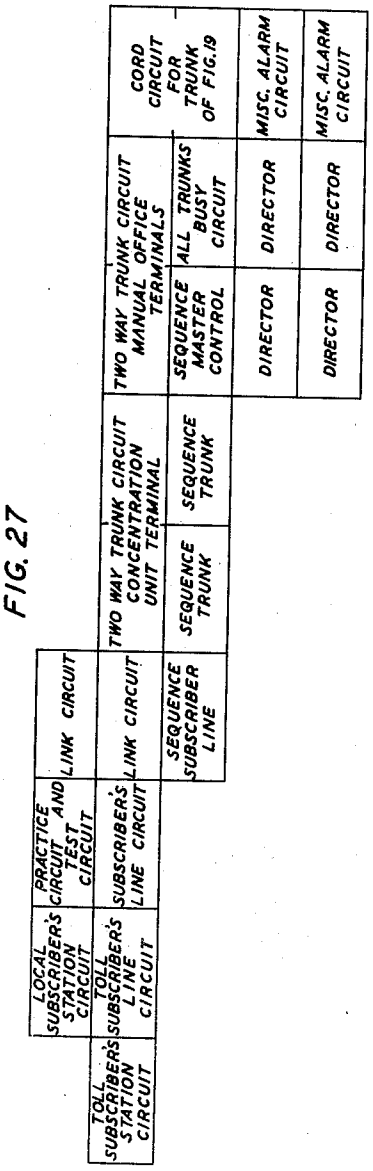


FIG. 27



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TELETYPEWRITER EXCHANGE SYSTEM

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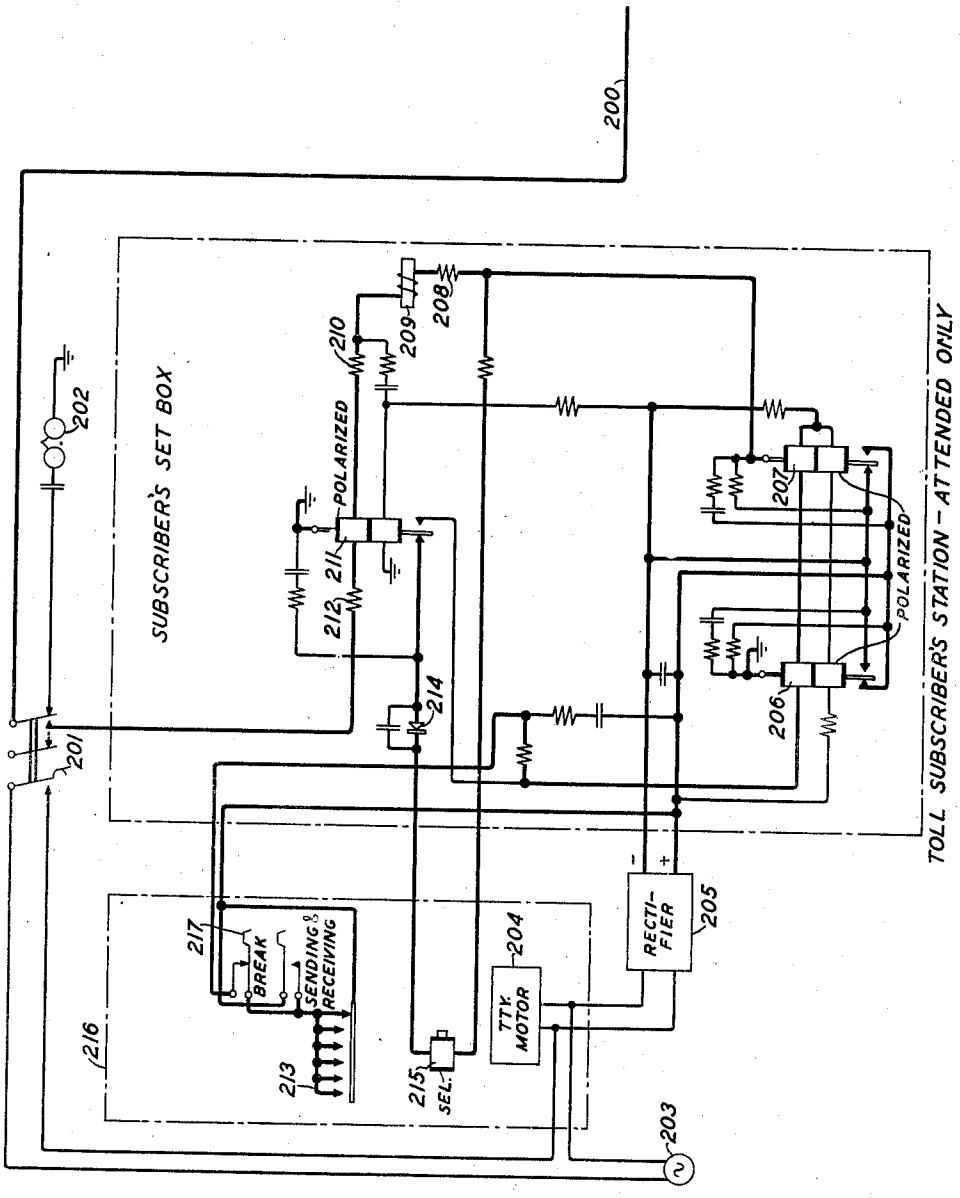

FIG. 2

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TELETYPEWRITER EXCHANGE SYSTEM

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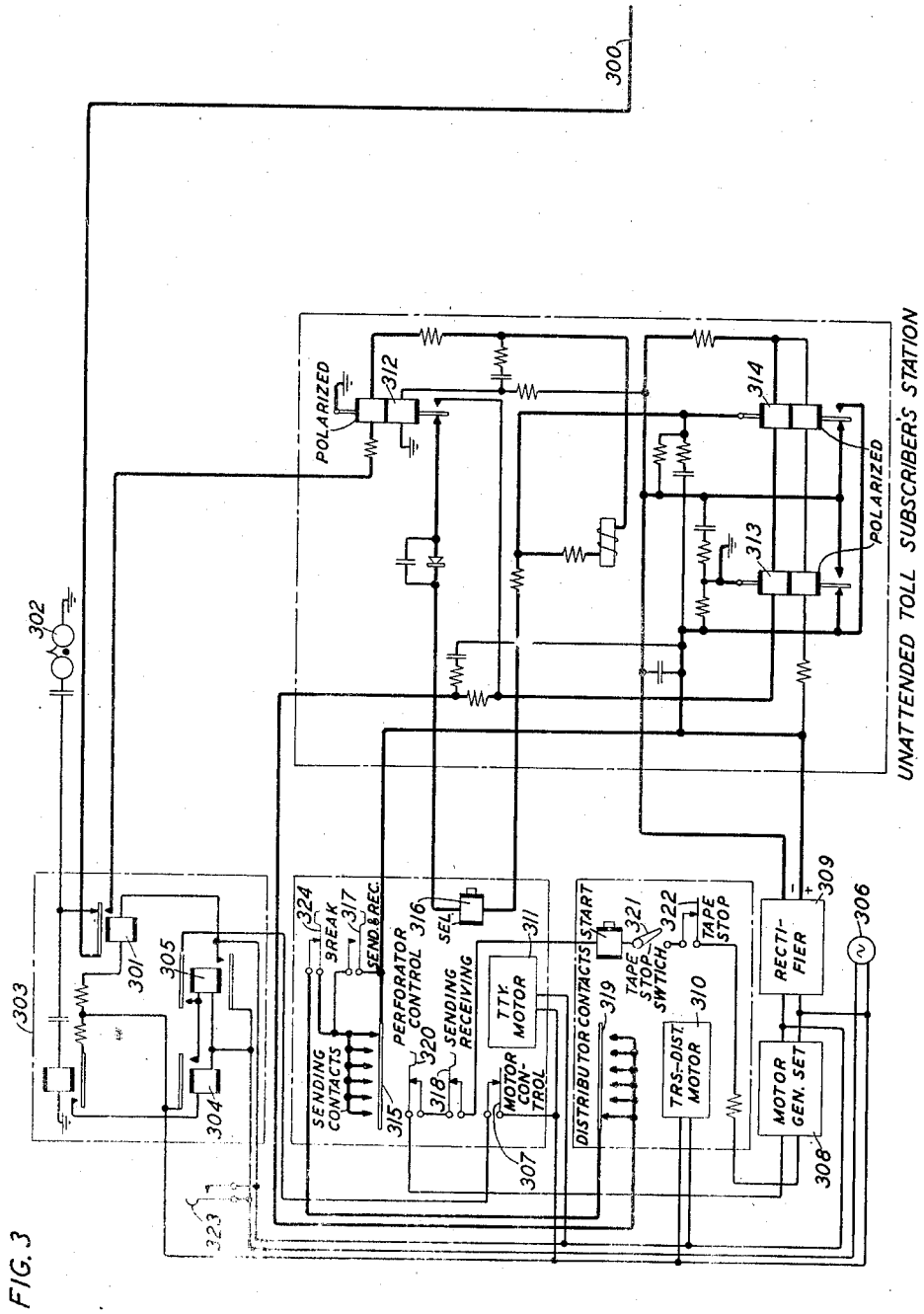

FIG. 3

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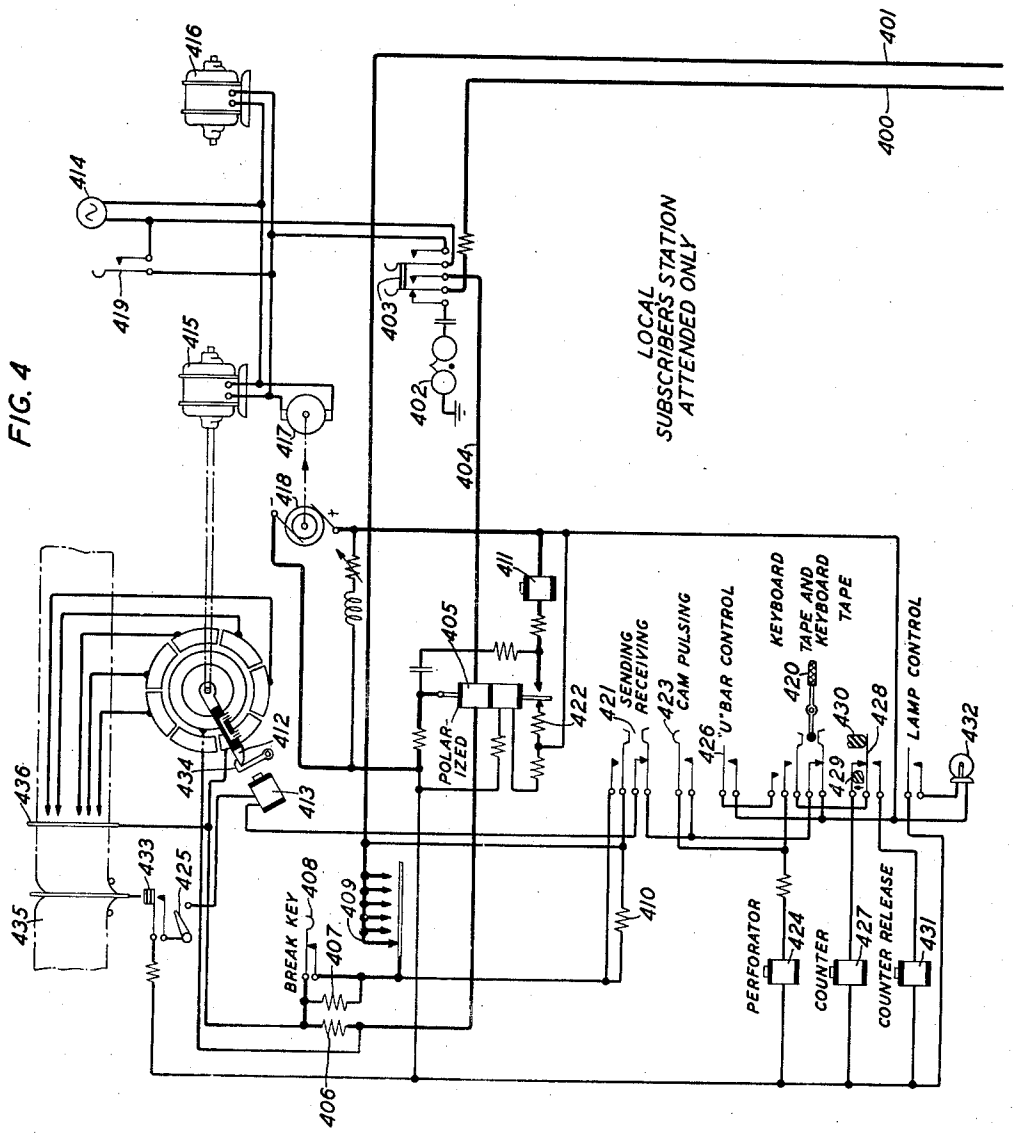
FIG. 4



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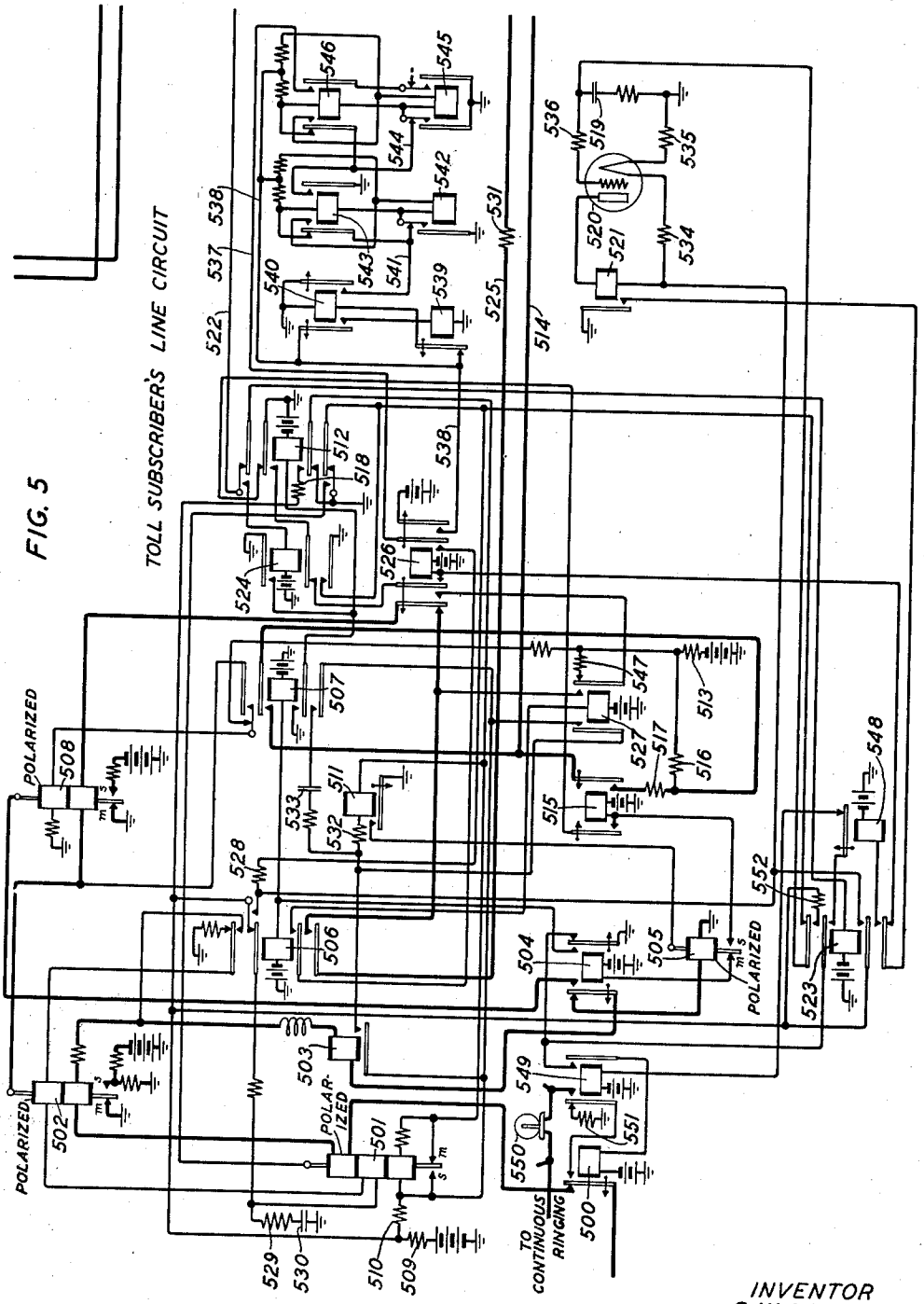

FIG. 5

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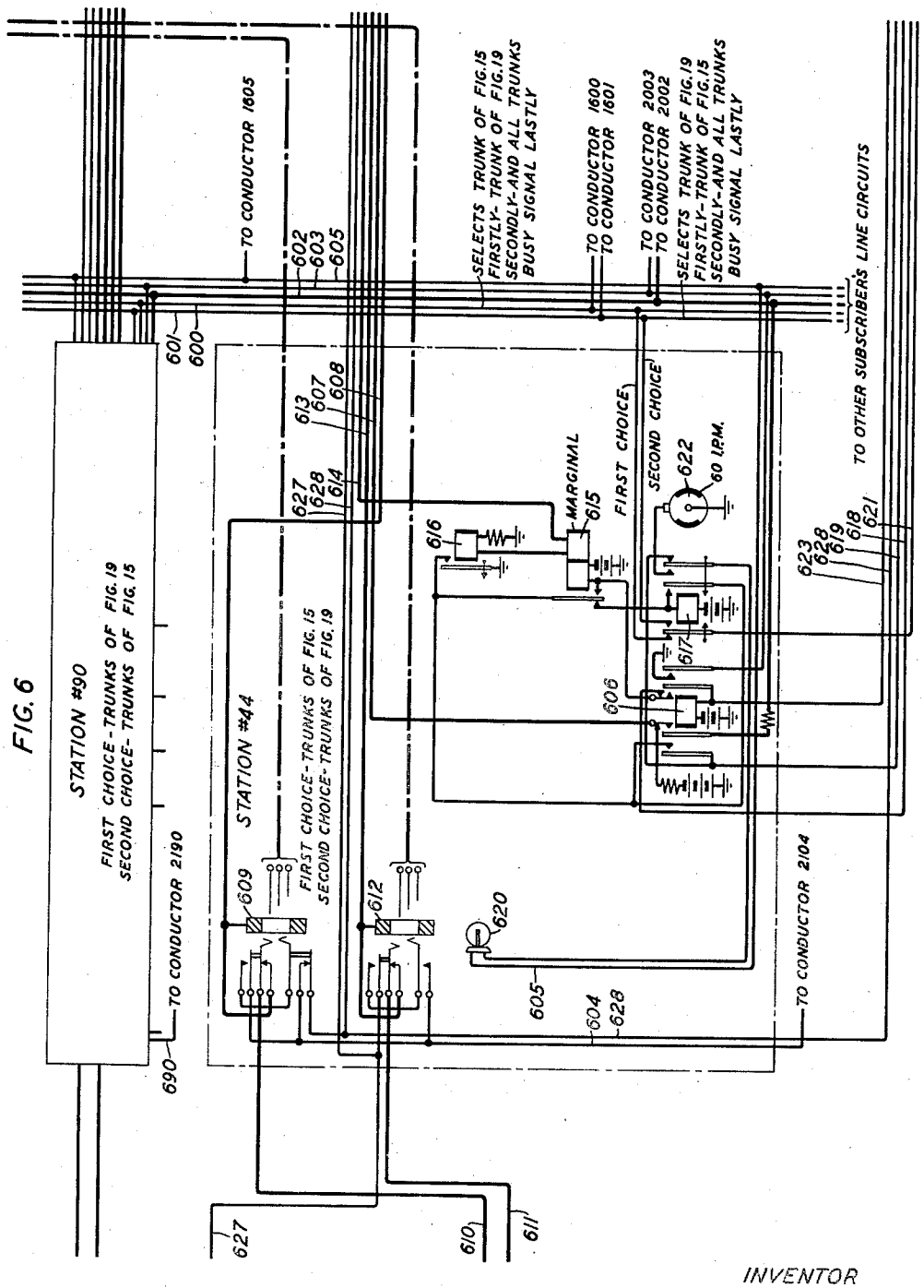

FIG. 6

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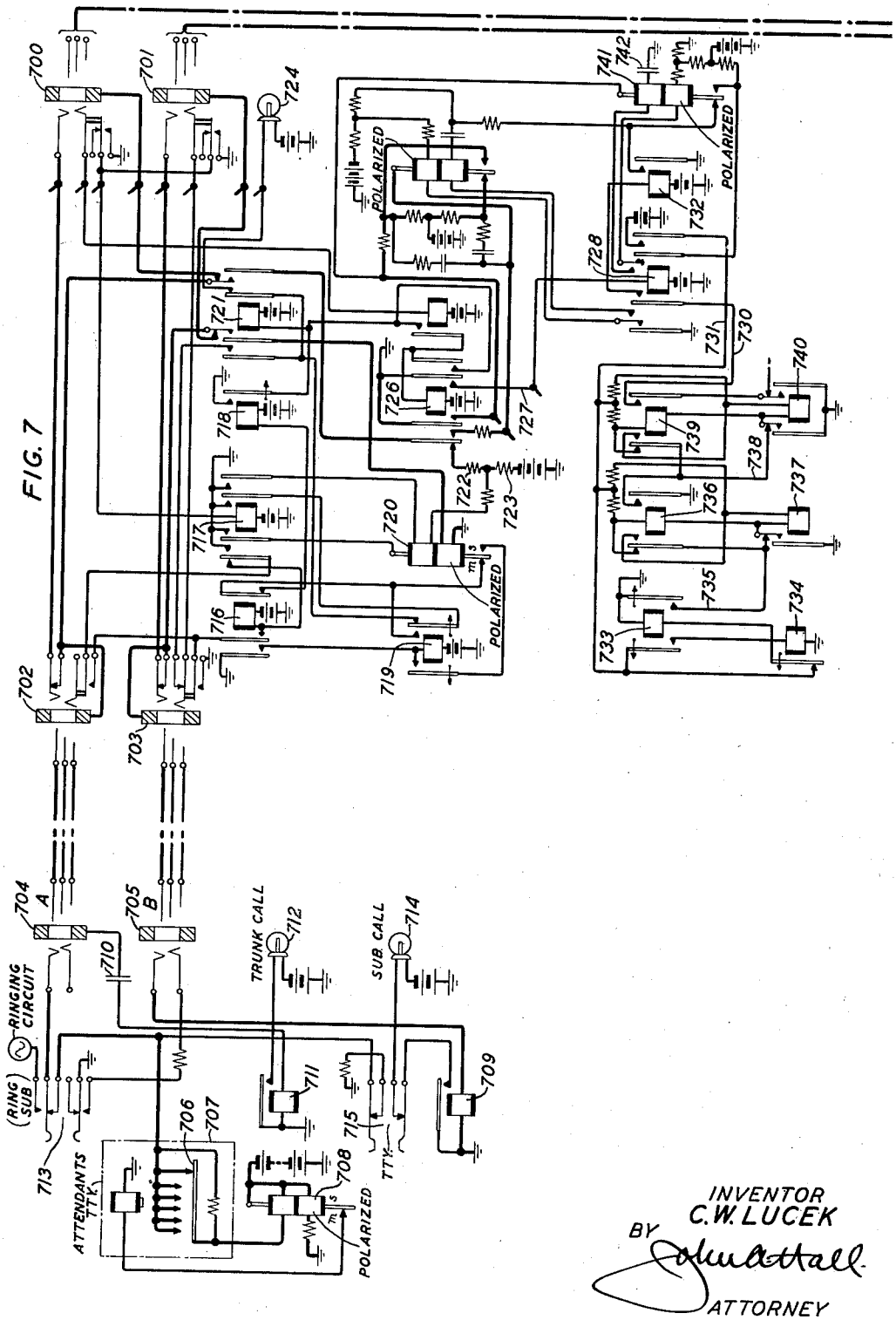

FIG. 7

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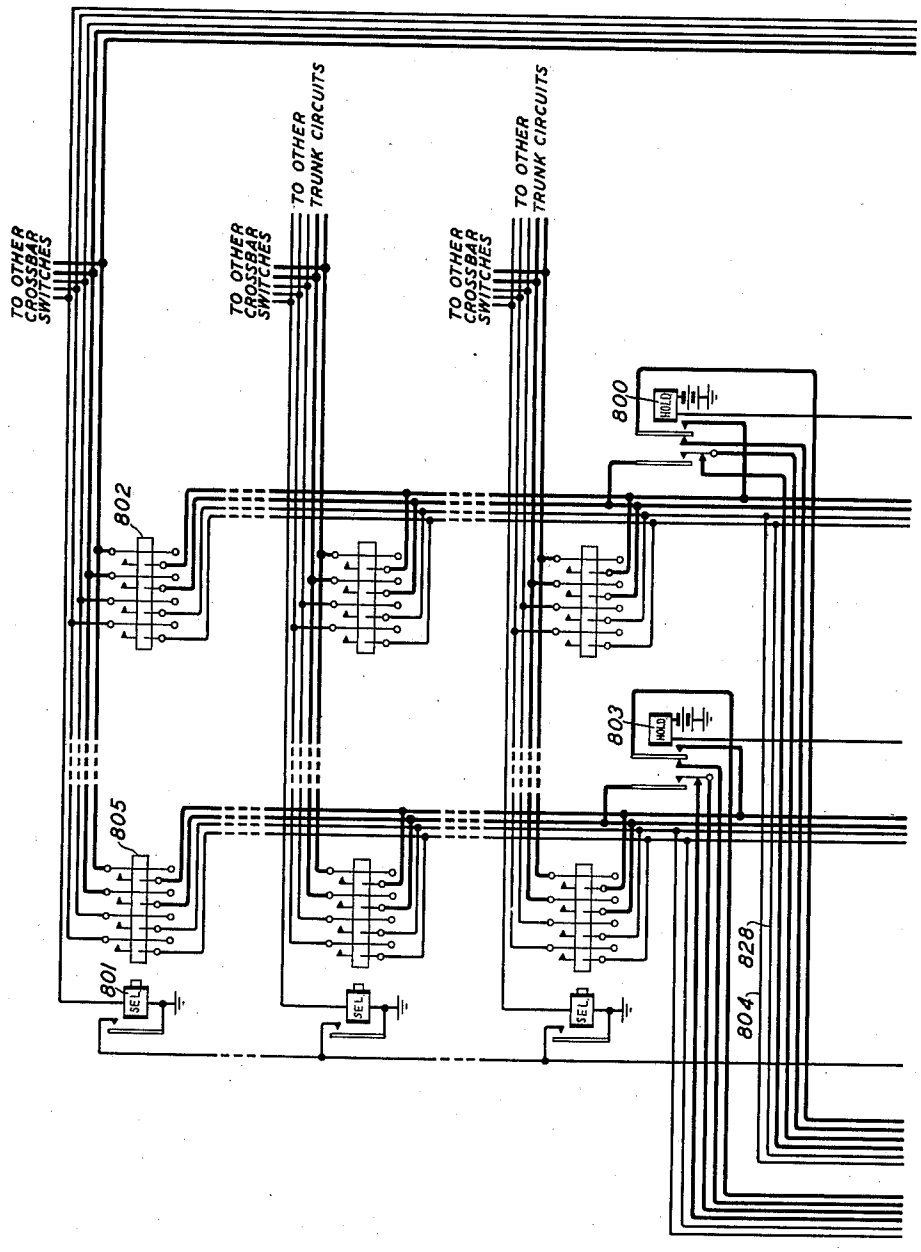

FIG. 8

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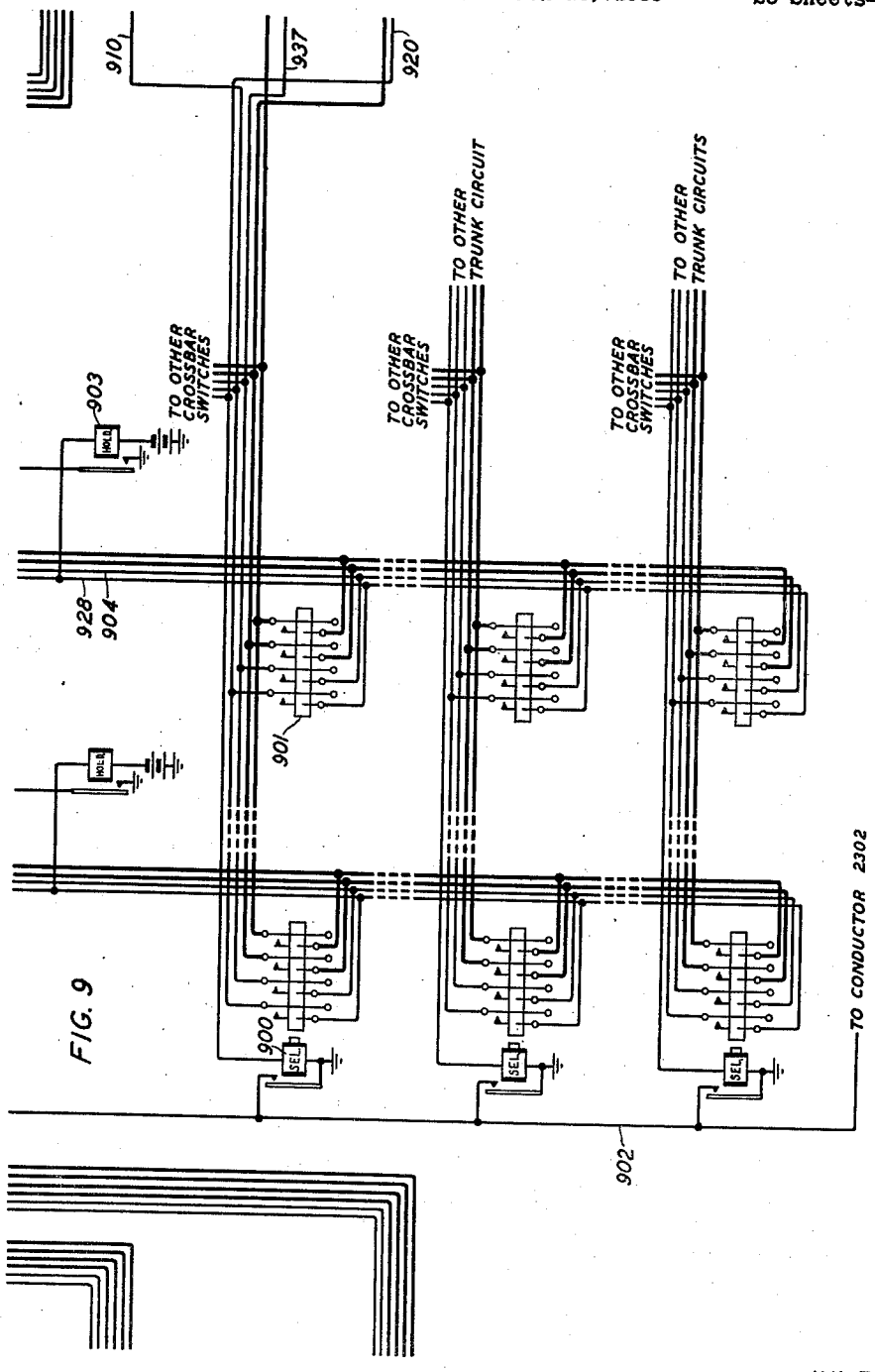

FIG. 9

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TELETYPEWRITER EXCHANGE SYSTEM

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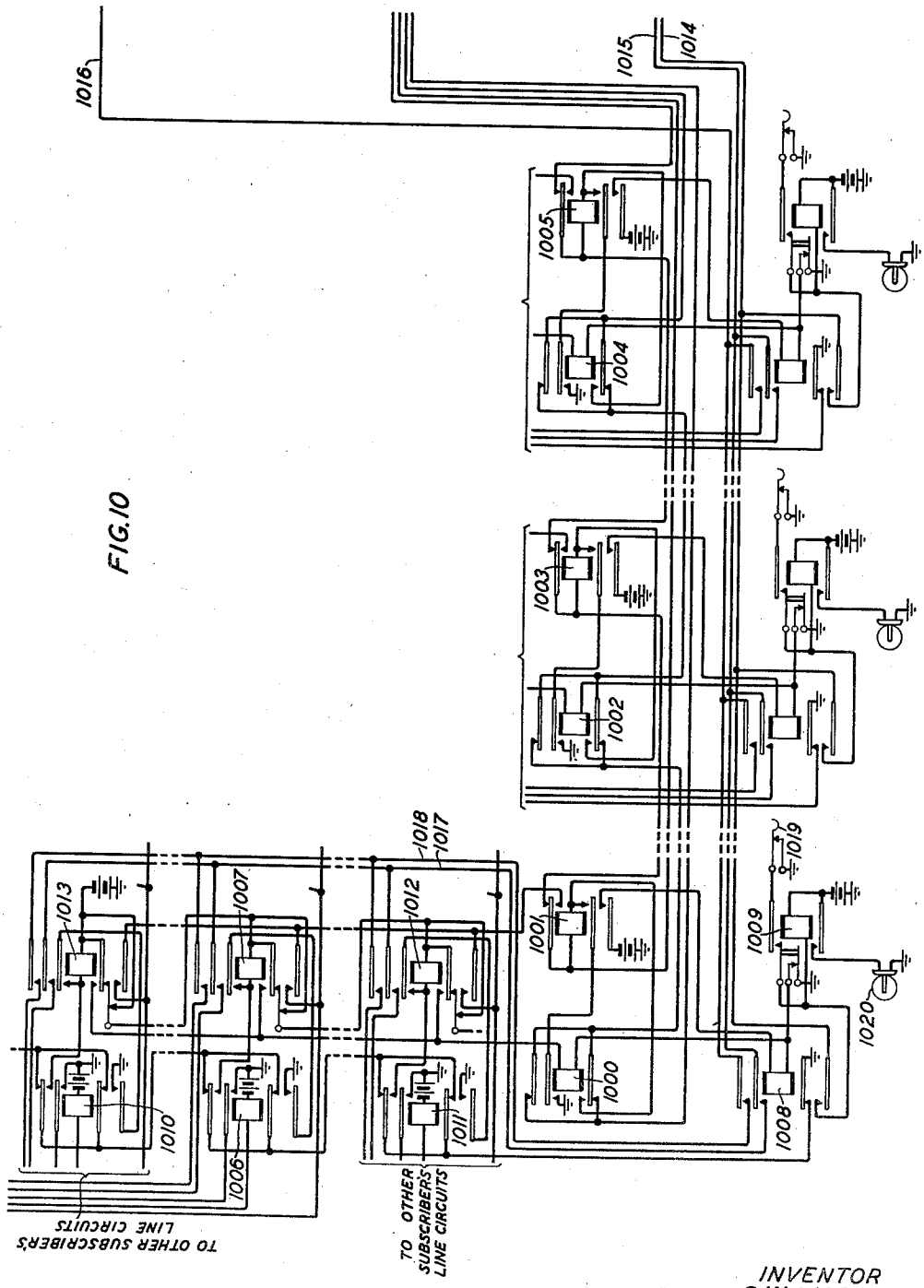

FIG. 10

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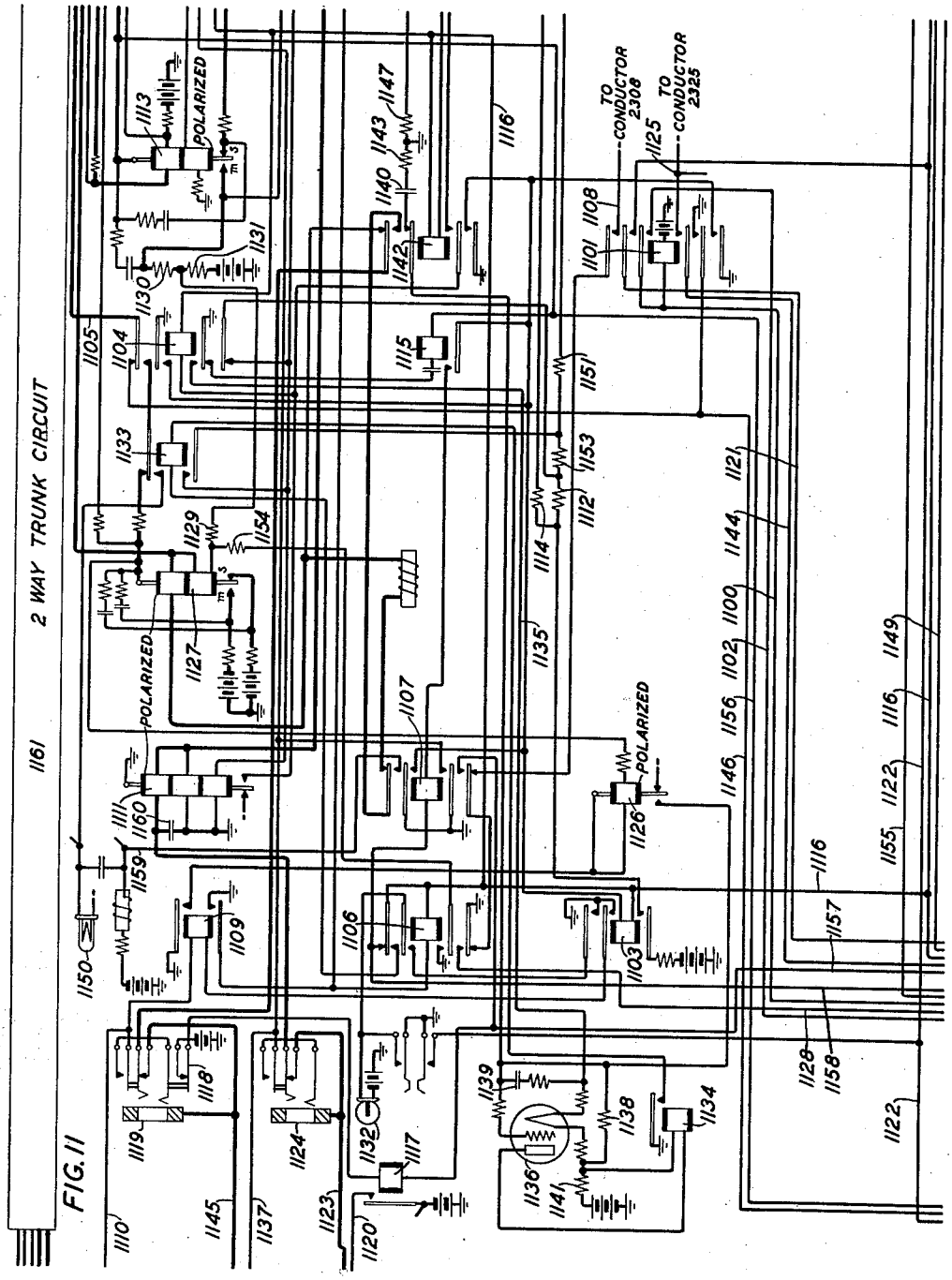

FIG. 11

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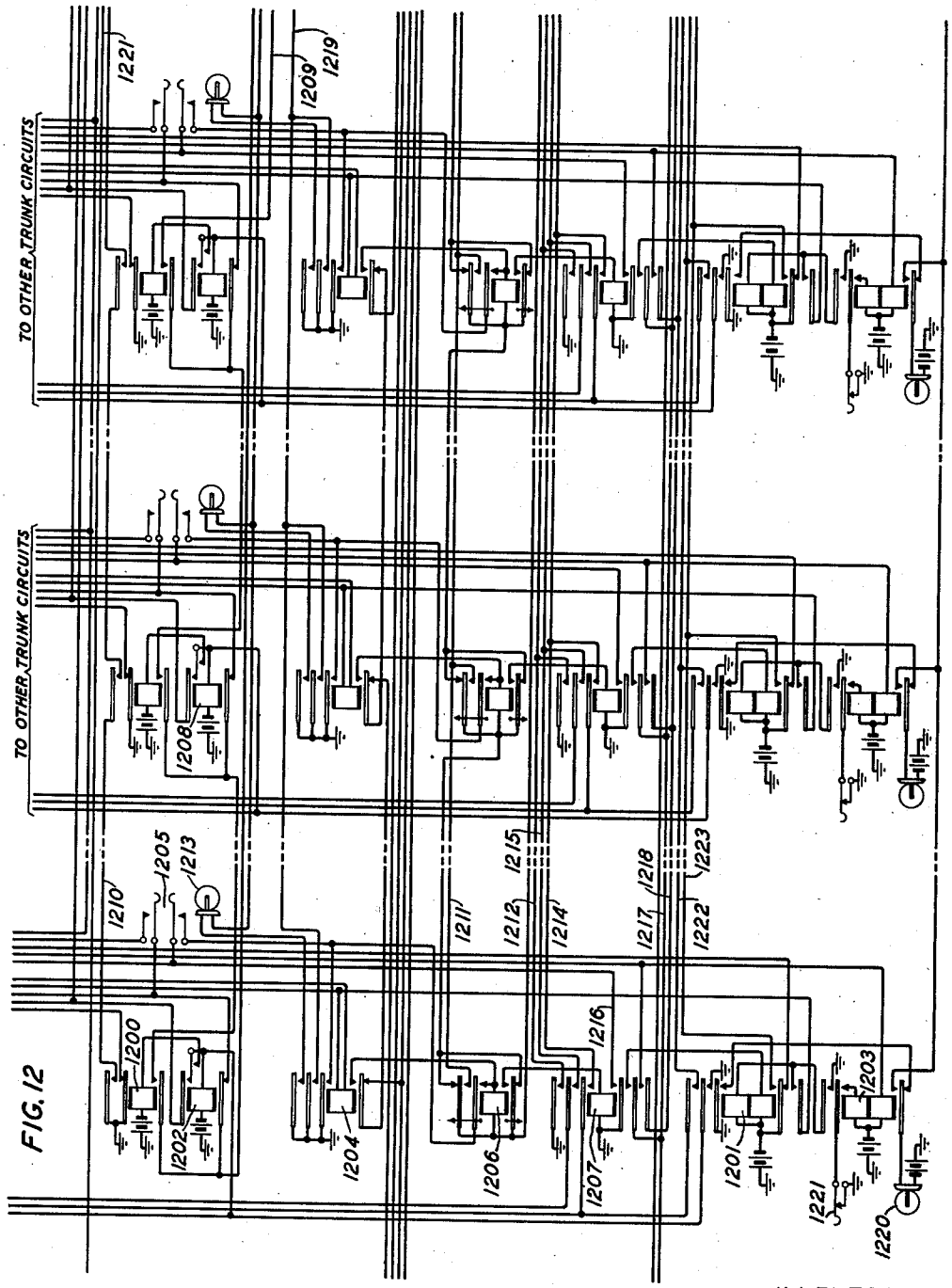

FIG. 12

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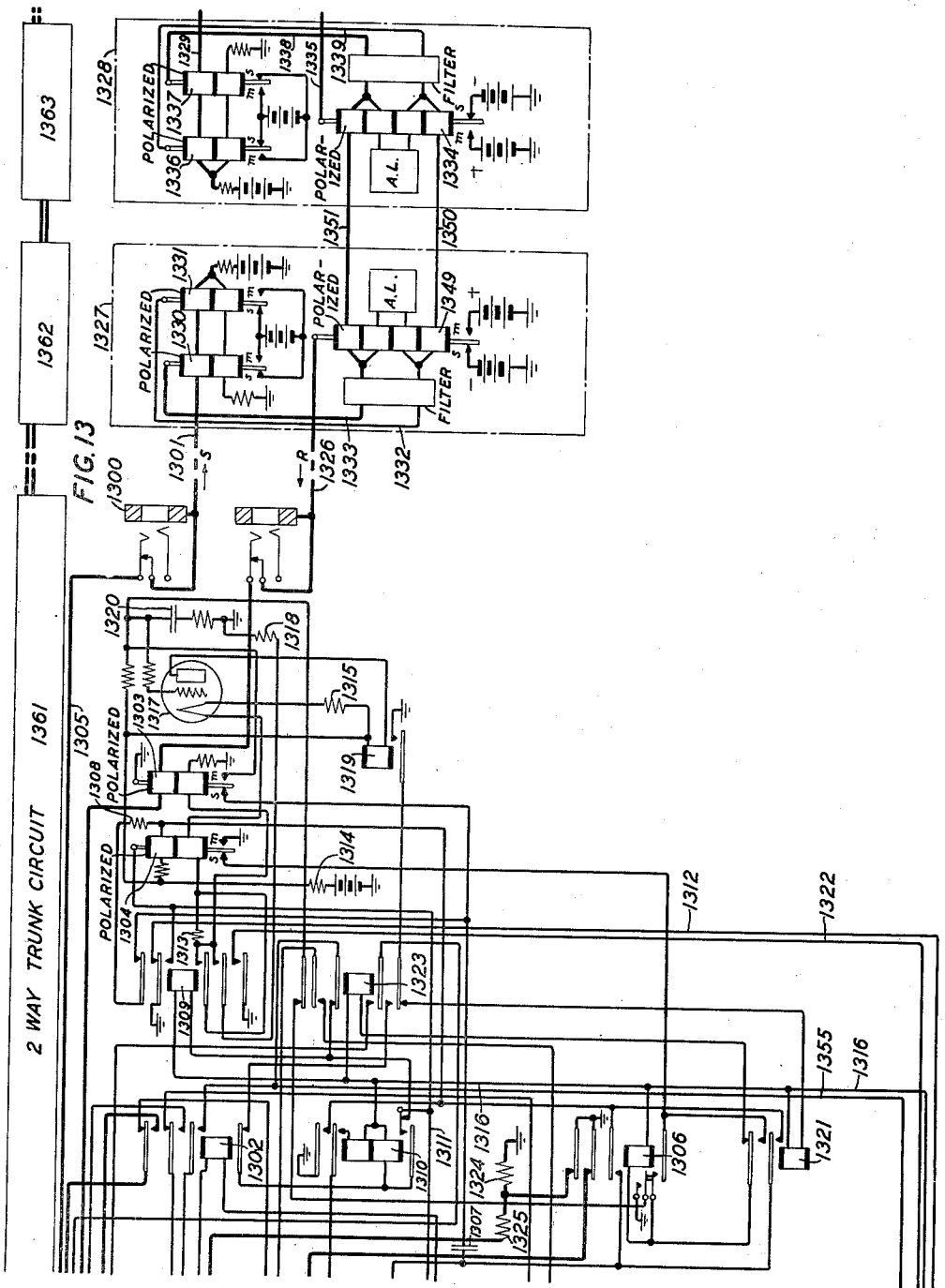

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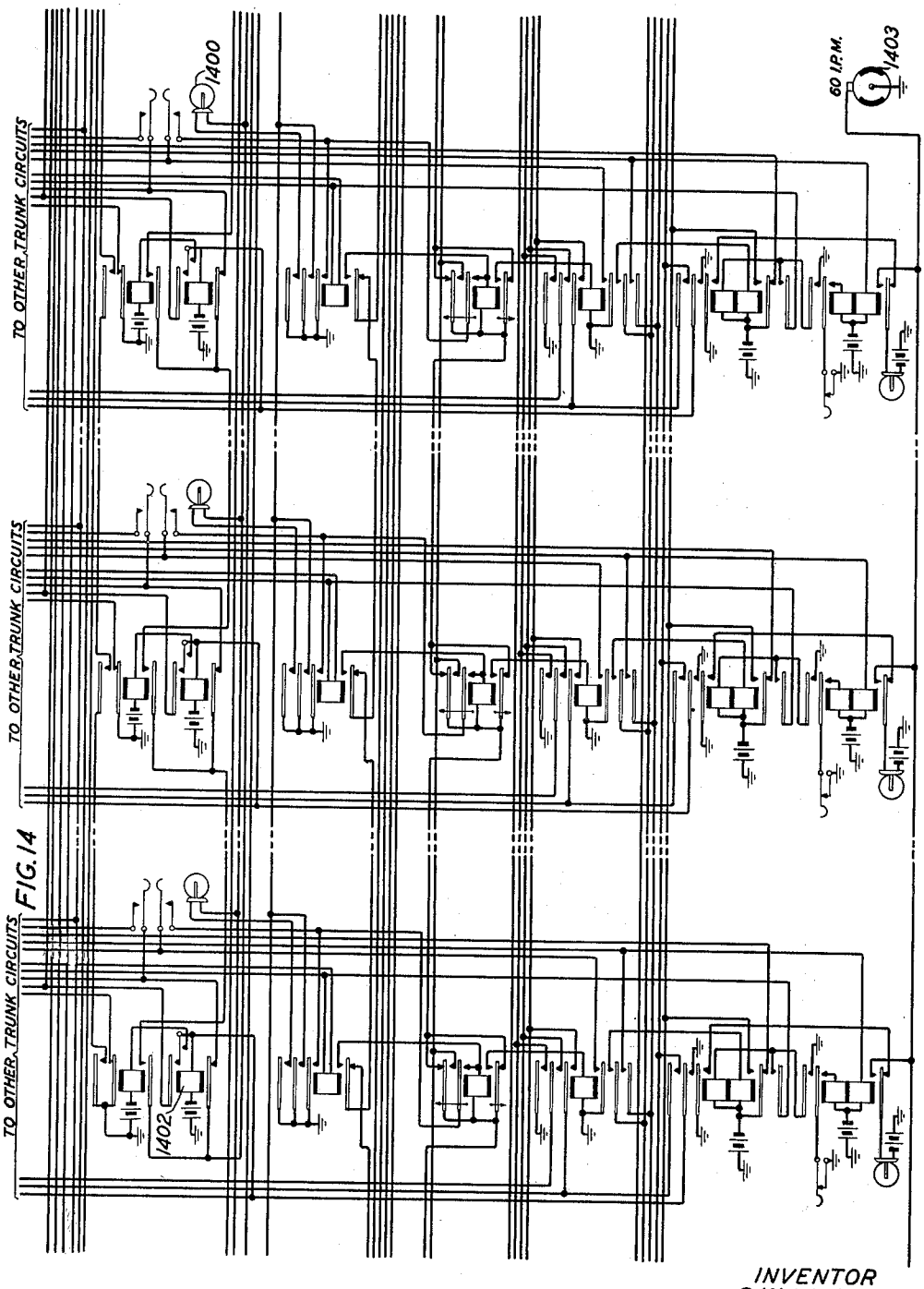

FIG. 14

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TELETYPEWRITER EXCHANGE SYSTEM

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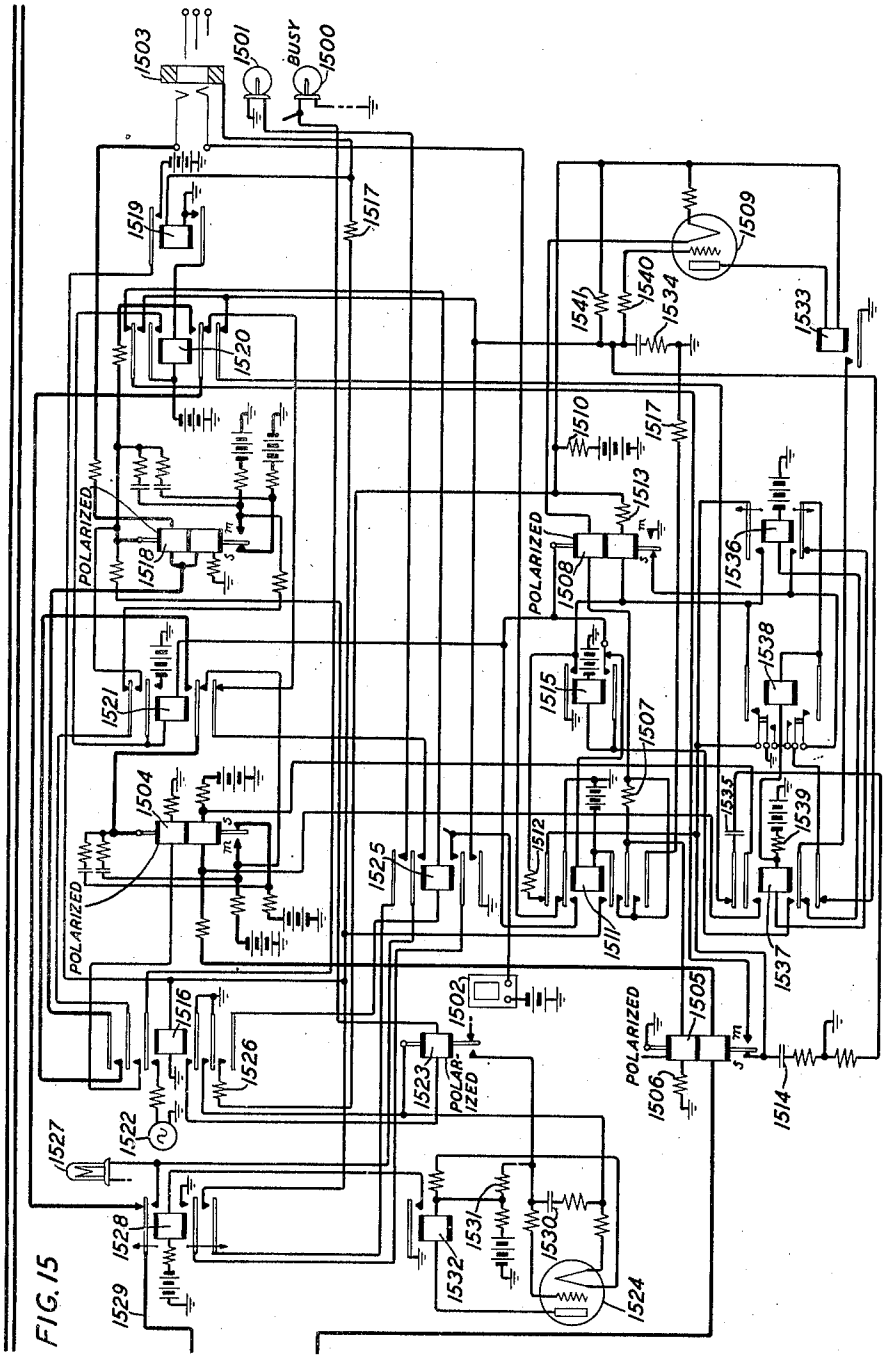

FIG. 15

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TELETYPEWRITER EXCHANGE SYSTEM

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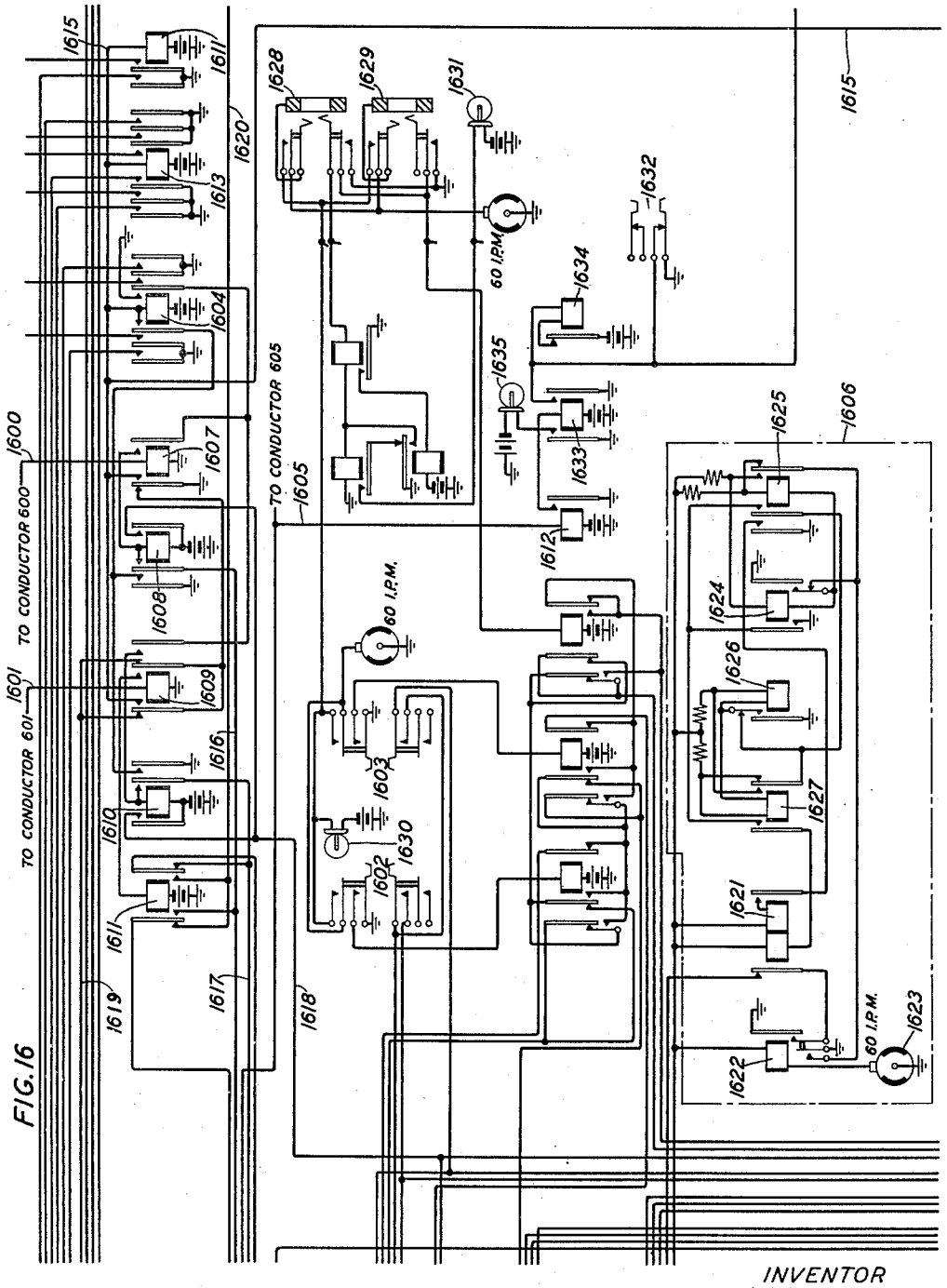

FIG. 16

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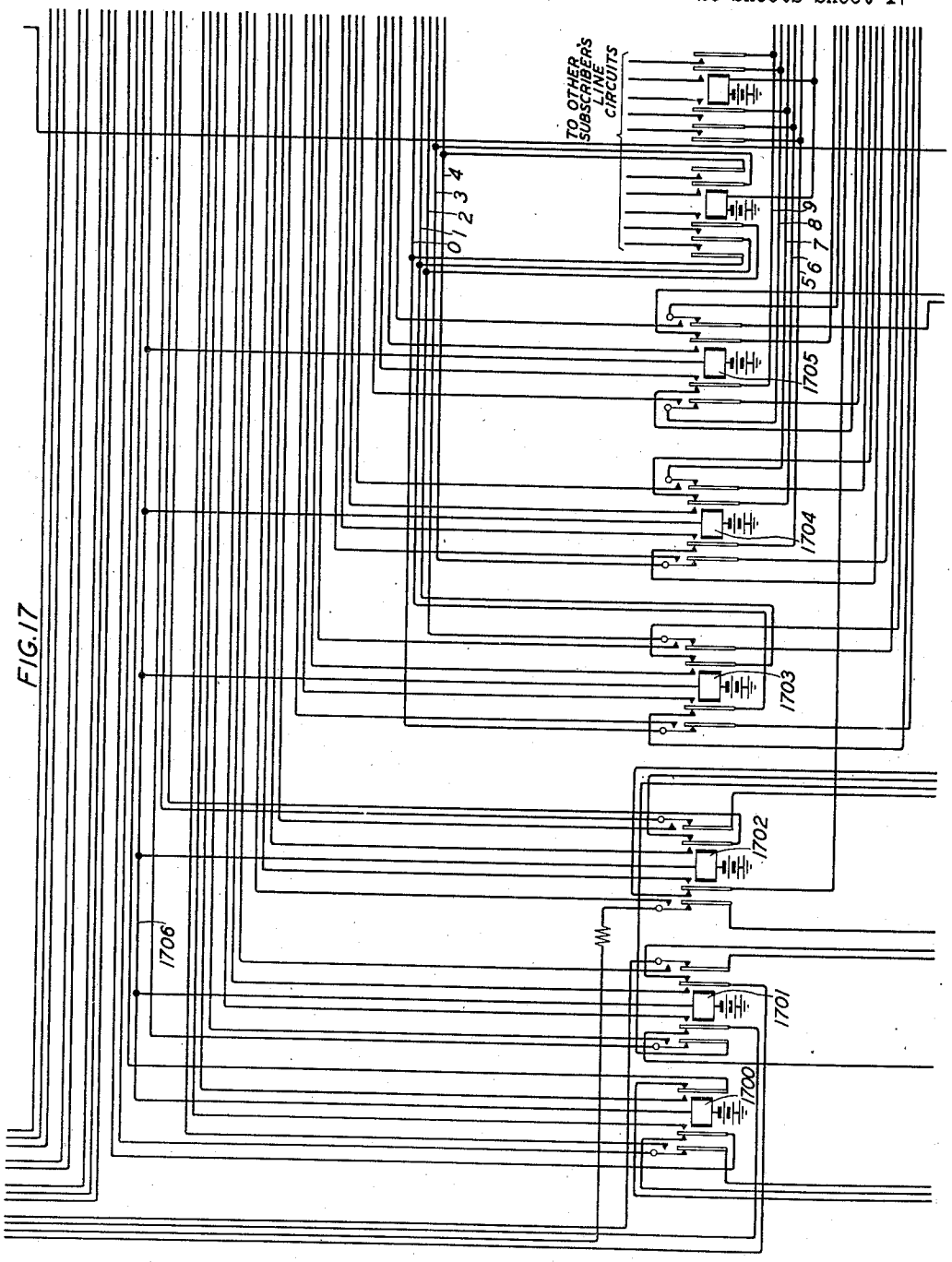

FIG. 17

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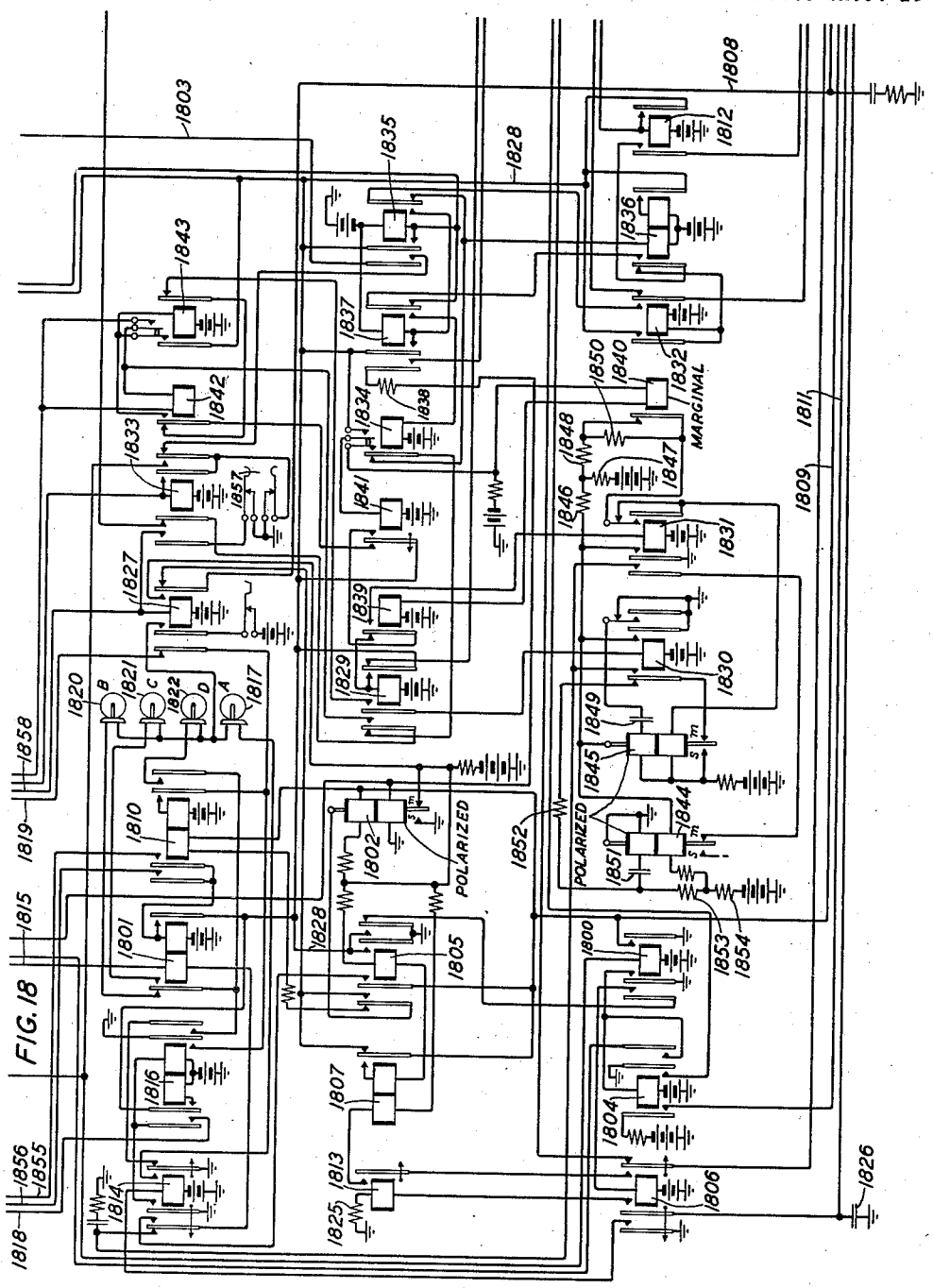

FIG. 18

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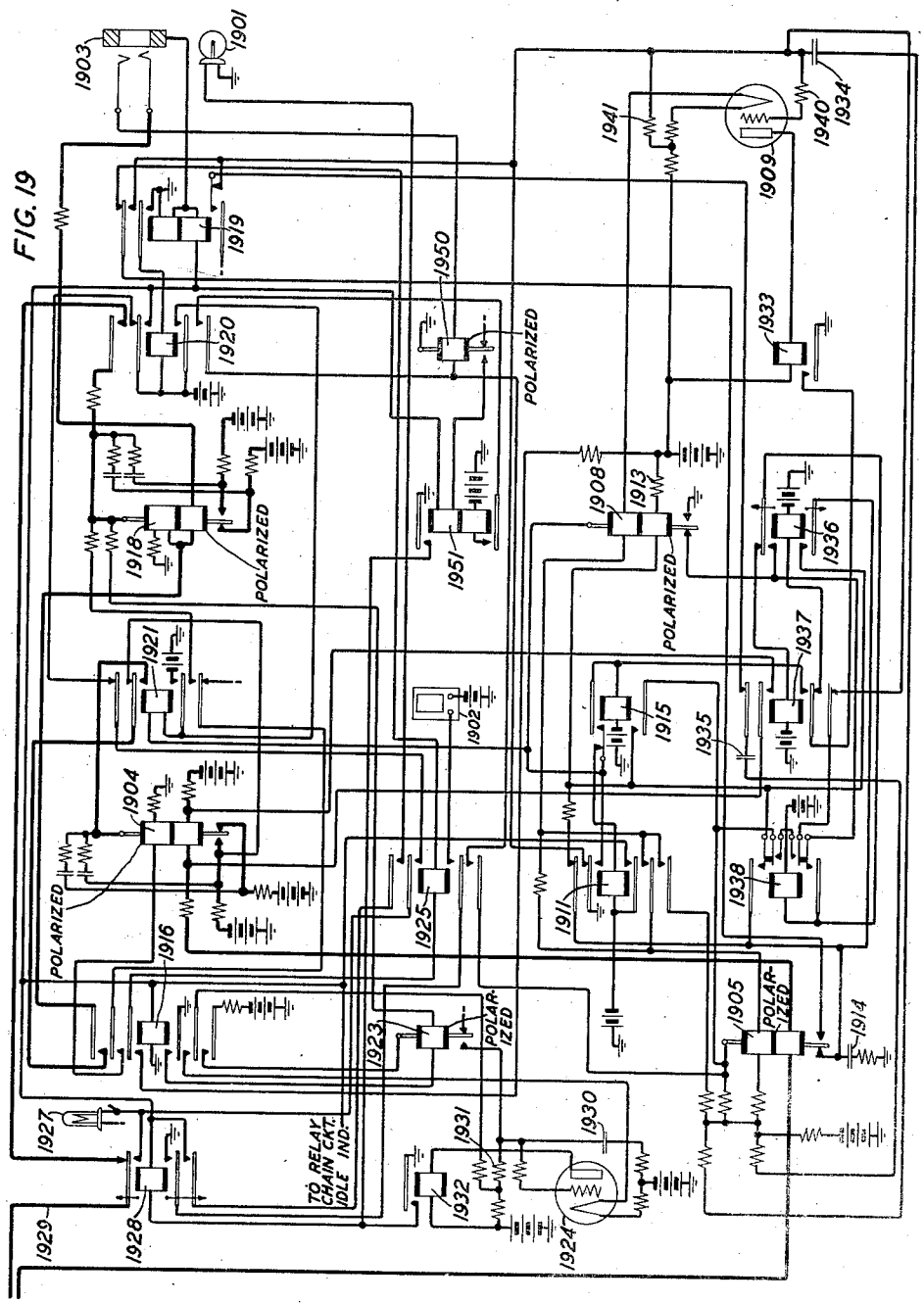
FIG. 19



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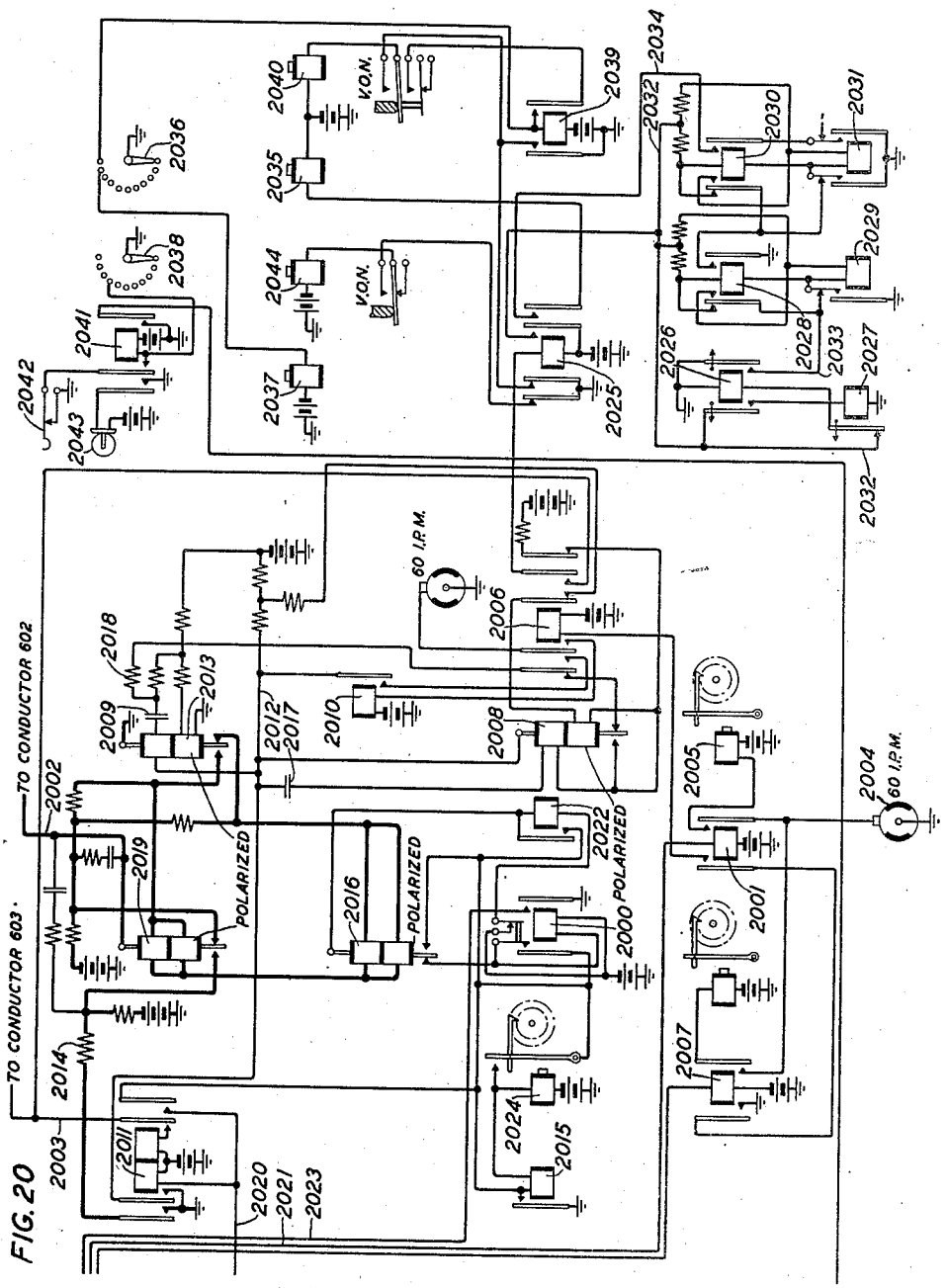

FIG. 20

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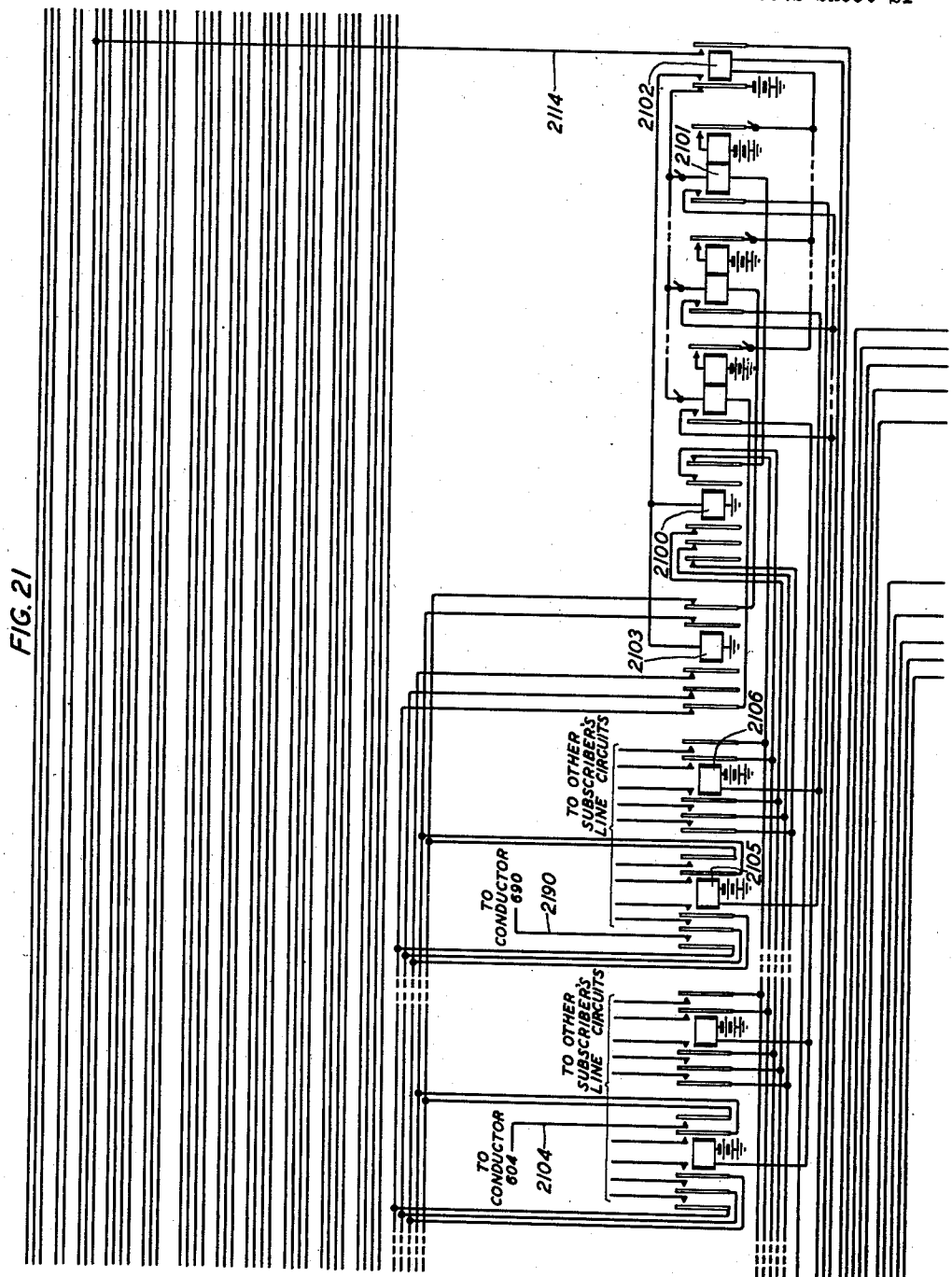

FIG. 21

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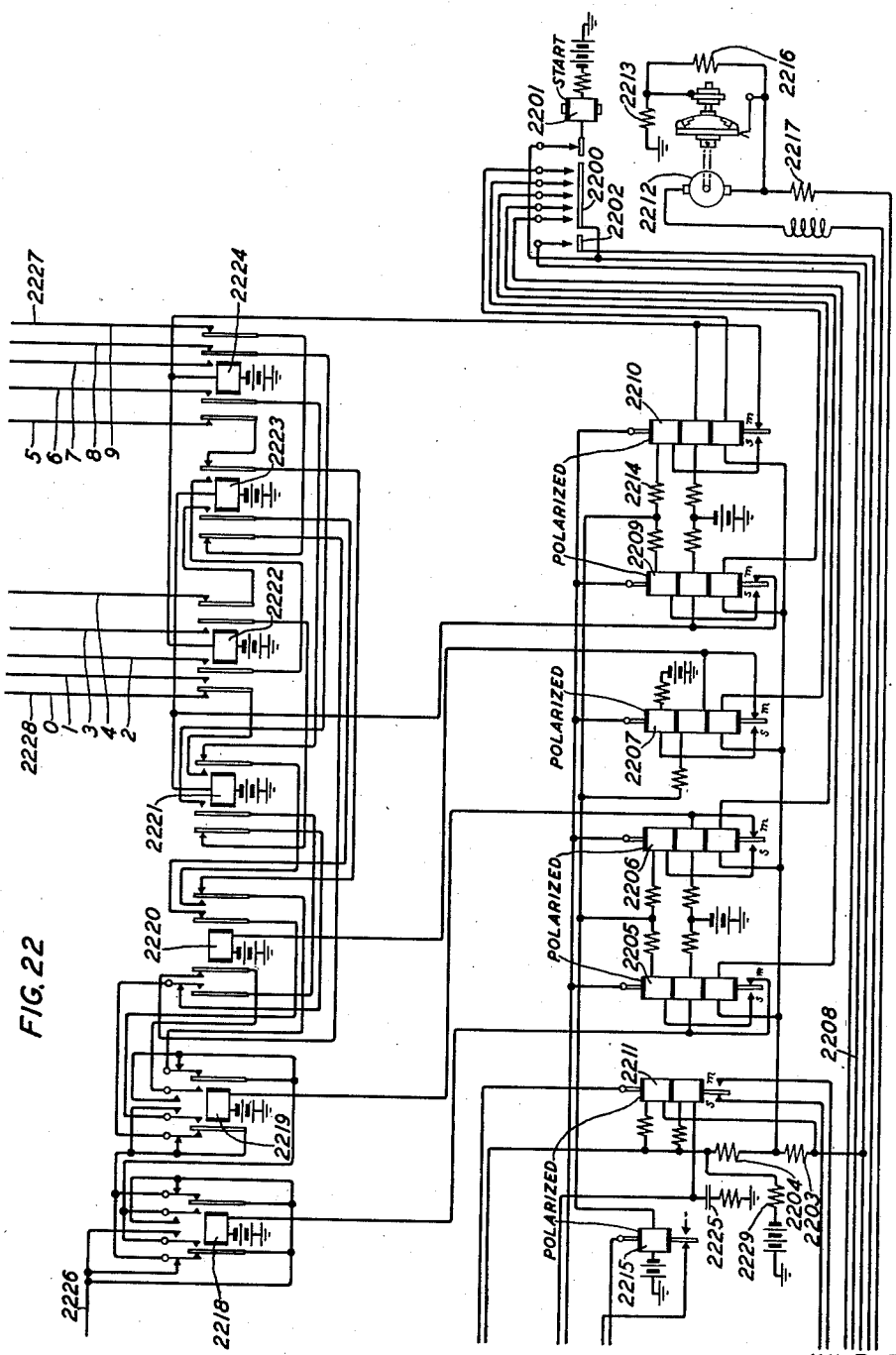

FIG. 22

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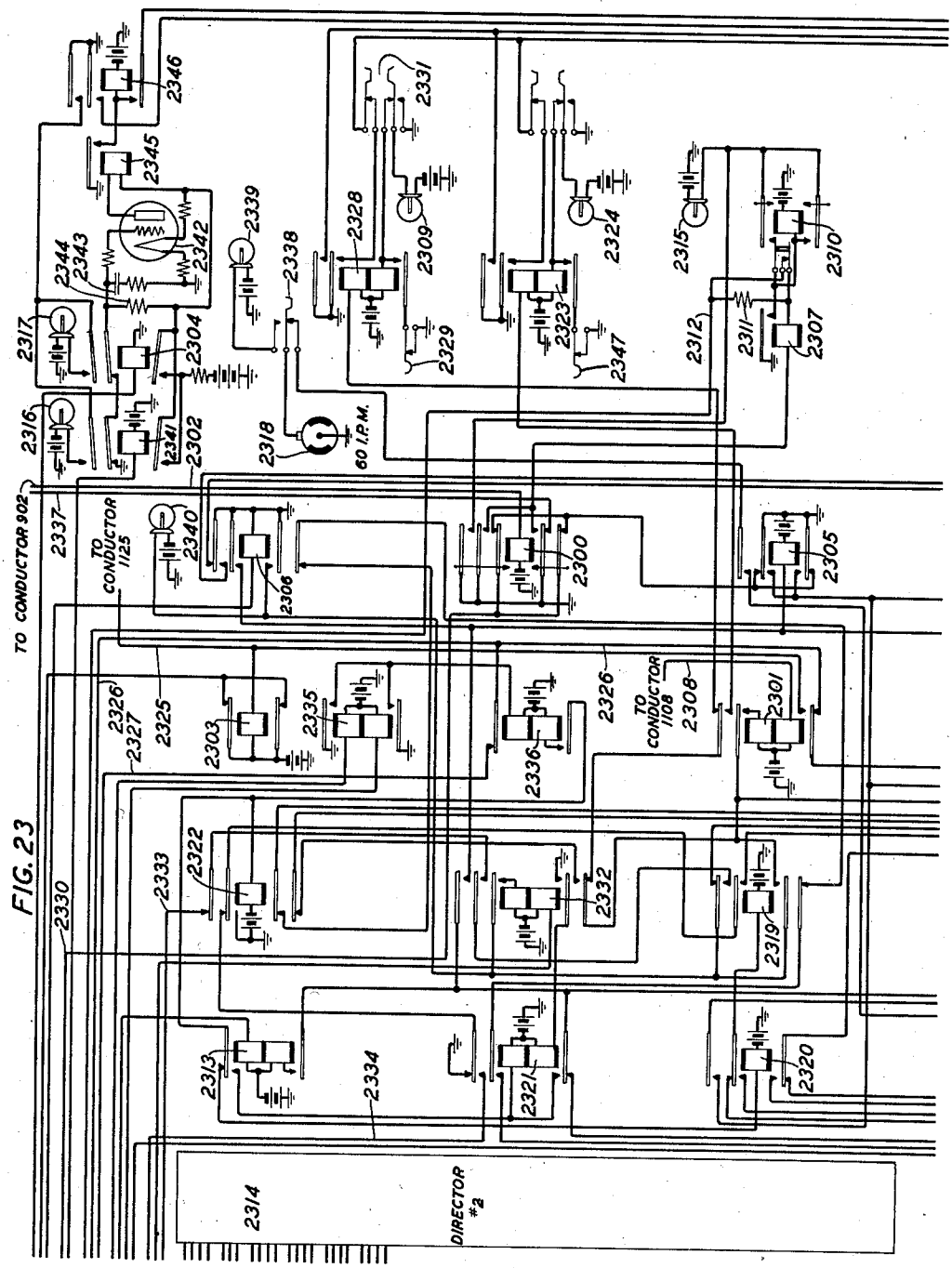

FIG. 23

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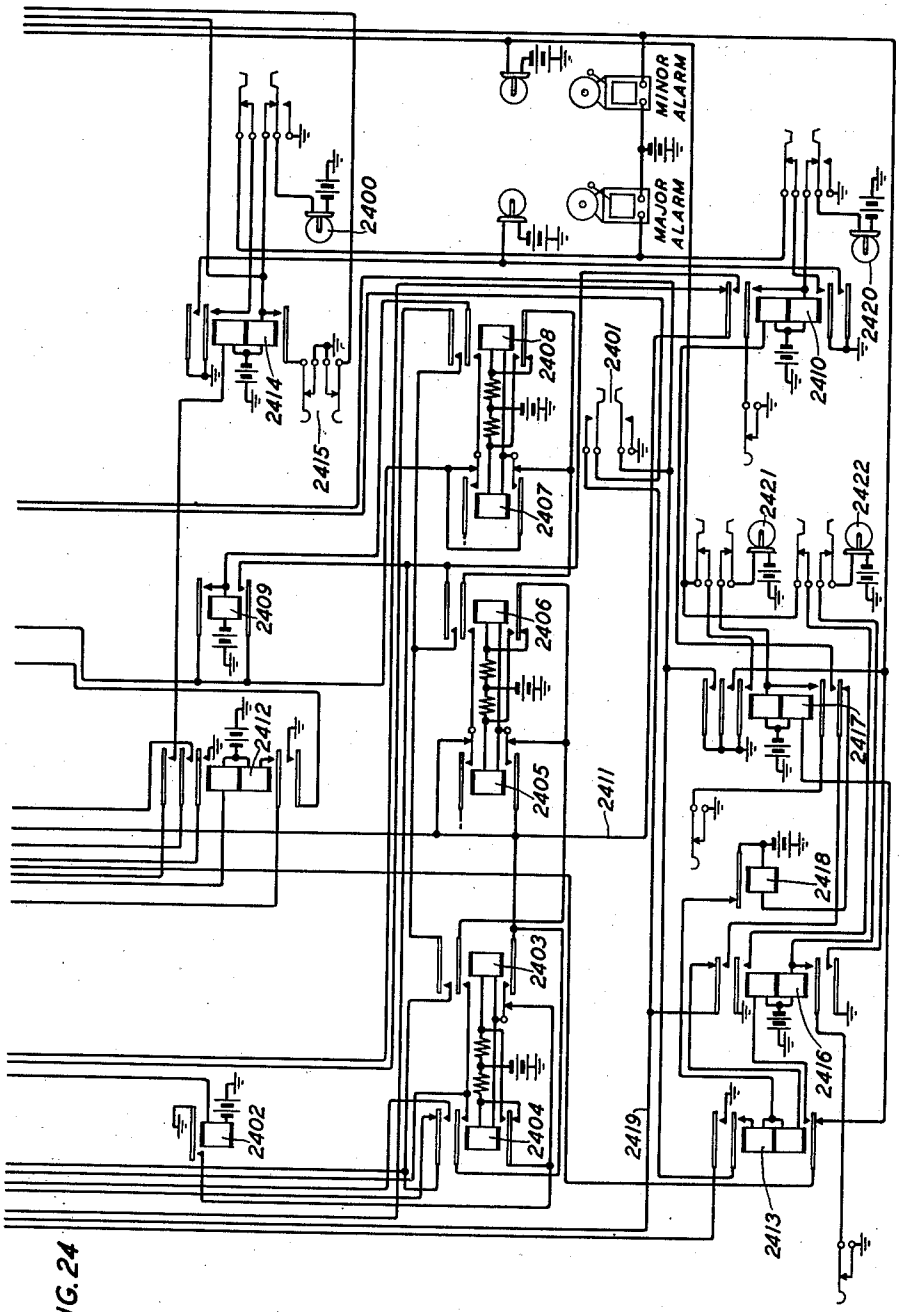

FIG. 24

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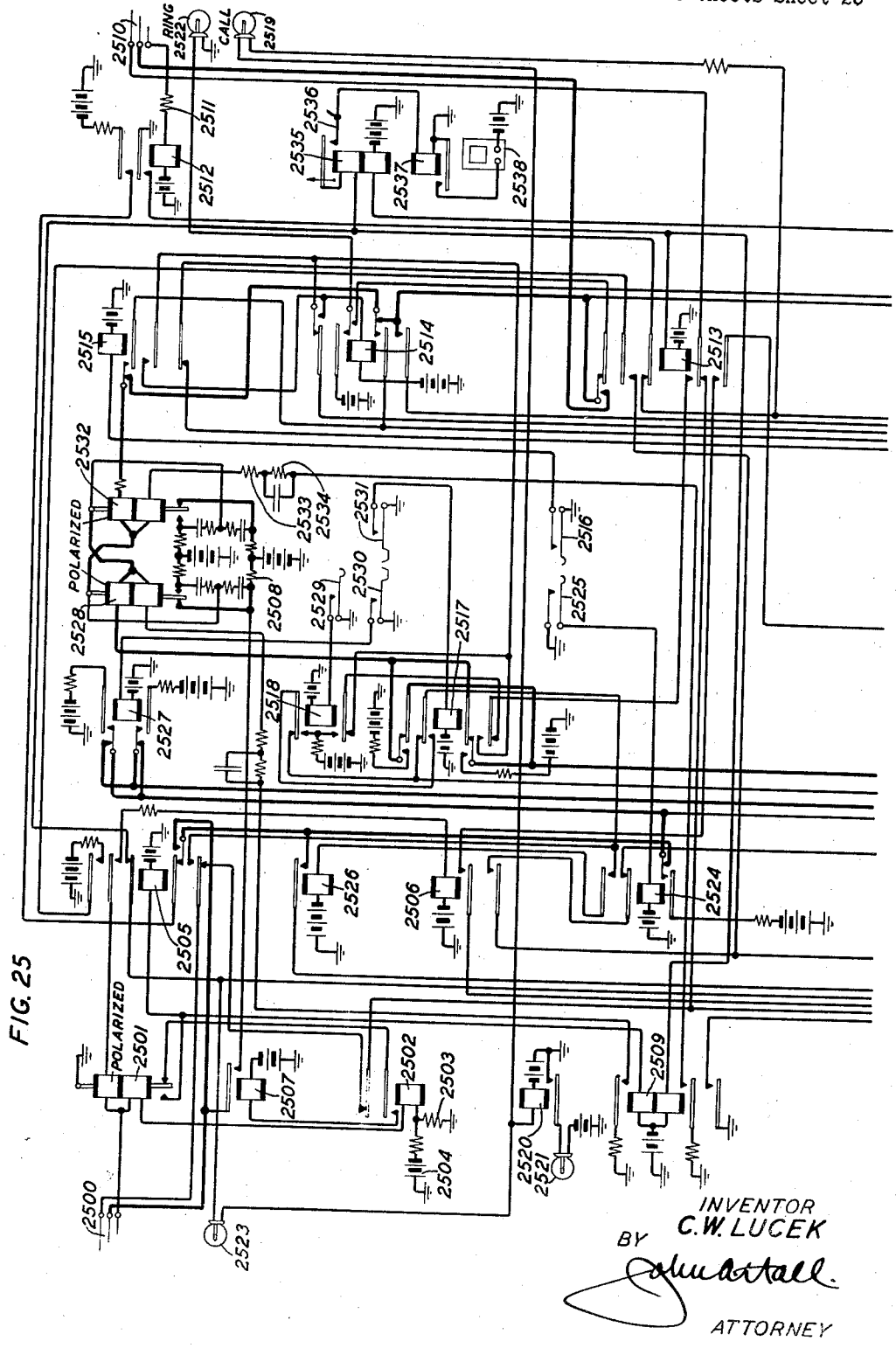

FIG. 25

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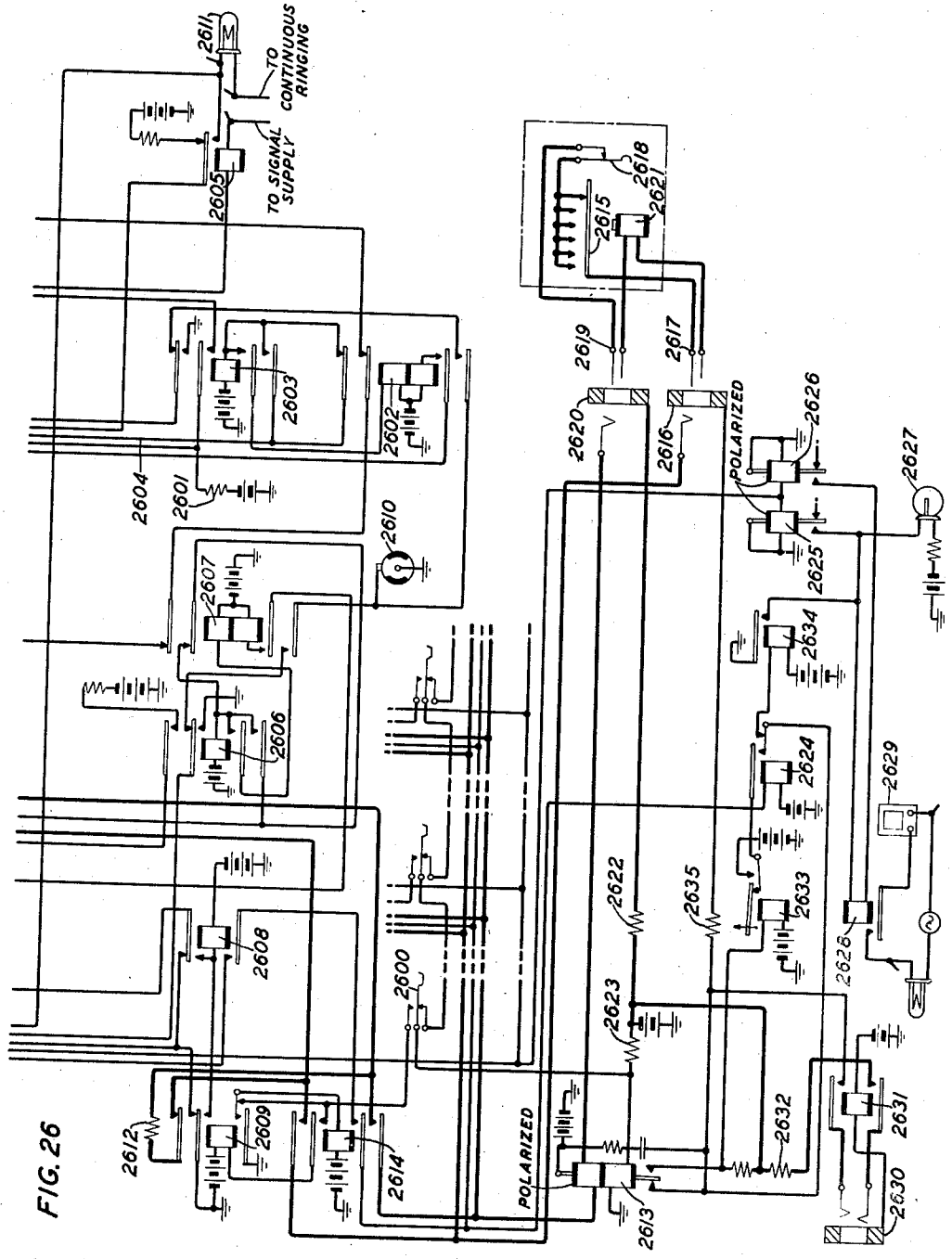

FIG. 26

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Patented Jan. 14, 1941

2,228,279

UNITED STATES PATENT OFFICE

2,228,279

TELETYPEWRITER EXCHANGE SYSTEM

Charles W. Lucek, Port Chester, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

Application March 16, 1939, Serial No. 262,158

37 Claims. (Cl. 178—2)

This invention relates to teletypewriter exchange systems and may be considered an improvement on the system shown and described in the application of Fitch et al., Serial No. 173,958, filed November 11, 1937.

The system in which the features of the present invention are embodied consists in general of—

(1) A plurality of (or one) central offices with telegraph trunks.

(2) A satellite office at which switching is automatically accomplished to connect said trunks to subscribers over subscribers' lines.

(3) Subscribers' stations.

The subscribers' lines may be local lines ordinarily designated as loops or long lines including repeater stations commonly designated subscribers' toll lines.

A feature of the invention is a new trunking arrangement. A subscriber's line enters a concentration unit where his call will be automatically extended to a central office to be dealt with according to well-known methods. There are a plurality of such central offices to which the call may be extended but the subscriber's line is so arranged that his call will normally be extended to a particular one or first choice office. However, if all lines to this office are busy then the call will be automatically extended to another, or second choice, office. In addition, the subscriber has under his control means to change this order so that if he wishes he may cause his call to be initially extended to his normal second choice office and it is only when all lines thereto are busy that his call will be automatically extended to his normal first choice office regardless of the fact that he performed an act designed to extend the call to the office of normal second choice.

Another feature of the invention is new means for and method of signaling a subscriber when all central office lines are busy. Heretofore this was done by causing a given character to be typed on his machine repeatedly whereupon the subscriber, after what he might believe to be an appropriate interval, would initiate a new call. In the present instance more definite information is given. When an all-lines-busy condition is encountered a signal at a slow rate is sent back to the machine. This may be any sort of signal which could be received by the subscriber's teletypewriter, but the preferred way is to transmit a non-character printing signal which will manifest itself through the operation of certain mechanical parts of the machine as an audible signal. This, as has been stated, is at a slow rate, say sixty times per minute, which rate has been found in practice to be adequate to hold the subscriber's attention without annoyance. When the all-lines-busy condition ceases then the signal is changed and now a character printing signal is sent so that a series of a given character is rapidly printed. This gives the subscriber the definite information that a line is now available so that he may with confidence initiate a new call.

There is further provided a new and improved practice circuit and a new method of signaling a practicing subscriber. The new practice circuit will respond to permutation codes as heretofore and in addition will receive and translate break signals without being separated from the circuit. It may be used by local subscribers' lines as heretofore and in addition now by toll subscribers' lines. If a call for the practicing subscriber comes in, a set of relays in a circuit provided with elements having given electrical characteristics will be energized and these relays will then automatically operate to generate signals which will simulate the permutation code of a given character, which character will then be typed on the practicing subscriber's teletypewriter. These relays will be periodically energized so that the signal appears as a periodically interrupted series of the given character and this new characteristic signal will convey definite information to the practicing subscriber. Such subscriber may then transmit a disconnect and recall signal which will effectively disconnect the practice circuit and allow the call to be properly received. In addition, a disconnect signal will be given at the concentration unit and an attendant will take down the now ineffective connection from the subscriber's line to the practice circuit.

Should the practicing subscriber wish to make a call he may transmit a disconnect signal and thus free his line to make a call in the regular manner.

The director circuit has been improved by the use of polar relays whose armatures remain in the position last placed until the relays are again energized. Such relays operate with greater speed that other relays heretofore used in such a combination and the new circuit arrangement making possible the use of such high speed relays provides greatly improved and more reliable operation of the director circuit, especially when used in combination with the disclosed means for interconnecting subscribers' lines and central office lines.

Another advantage is the elimination of in-

ternal distortion caused when neutral relays are used by unequal rates of travel from marking to spacing and from spacing to marking.

A further feature is the improvement in trunk signaling means and methods. Whereas heretofore certain transient conditions and conditions depending on fine distinctions in different circuits were used the new trunk signaling is of a positive character whereby the chance for error in failure to recognize and respond is reduced as compared to the chance in systems relying upon such fine and transient conditions.

Other improvements and features will become apparent as the description of the system proceeds.

In this new trunk circuit a change from spacing to marking denotes a call and a change from marking to spacing denotes the completion of a call. The trunk employs improved timing devices in the form of condenser and vacuum tube circuits for timing the duration of a spacing condition and thus differentiating between spacing conditions of code signal length and those of break signal or disconnect signal length. After a spacing condition has by such means been recognized to be other than a normal code signal space another test is made to determine whether such longer spacing signal is a break or a disconnect. If it is a break then the signal is relayed to the distant end of the trunk as a short space followed by ringing current, which the terminal repeaters can pass along, lasting for the duration of the break. If it is a disconnect then the signal is relayed to the distant end of the trunk as a continuous space. Thus no transient or marginal conditions are set up which must be recognized by finely adjusted highly sensitive and expensive testing apparatus.

The drawings consist of twenty-five sheets. The first sheet contains Fig. 1 and Fig. 27.

Fig. 1 is a diagram showing how Figs. 2 to 26 shall be placed to form a complete circuit diagram illustrating the invention;

Fig. 27 is a like representation of the placing of the various figures, with certain designating captions placed in the corresponding positions;

Figs. 2 and 3 show two varieties of toll subscribers' station circuits;

Fig. 4 shows a local subscriber's station circuit;

Fig. 5 shows a toll subscriber's line circuit;

Fig. 6 shows a subscriber's line circuit which will operate with either a local subscriber's station circuit or the toll subscriber's line circuit;

Fig. 7 is a representation of the practice circuit with a skeleton form of test circuit showing only so much as is necessary to properly condition the practice circuit when the latter is to be used;

Figs. 8 and 9 show the link circuit, in other words the cross-bar type switch used to establish connections between subscribers' circuits and trunk circuits extending to distant TWX offices;

Figs. 11 and 13 show the concentration unit termination of a two-way trunk circuit extending to a distant TWX office;

Fig. 15 shows the central office termination of such a two-way trunk to one type of office;

Fig. 19 shows the termination of such a two-way trunk at another type of office;

Figs. 25 and 26 show the details of a cord circuit suitable for cooperation with the trunk termination shown in Fig. 19;

Figs. 10, 12, 14 and 16 together show a sequence circuit. Fig. 10 shows the subscriber line sequence, Figs. 12 and 14 show the trunk sequence, and Fig. 16 shows certain common controls;

Figs. 17, 18, 21 and 22 show a director circuit;

Fig. 20 shows an all-trunks-busy circuit; and

Figs. 23 and 24 show a miscellaneous alarm circuit.

The numbering of the various pieces of apparatus and parts of the circuit shown on the various figures has been kept to a rigid plan. Thus all numerals on Fig. 2, for instance, are numerals between **200** and **299**, the hundred numeral designating the figure. Likewise, for example, all of the numerals in Fig. 18 lie between **1800** and **1899** and thus begin with the designating numeral **18**.

In some cases in order to avoid the tracing of a conductor through many sheets, it is terminated in one sheet with a label. Thus conductor **609** in Fig. 6, which extends to Fig. 23, is labelled in Fig. 6 "To conductor **2309**" (a number corresponding to **609**). Similarly, in Fig. 23 this conductor is labelled "To conductor **609**."

The complete operation of the system is set forth hereinafter under various headings, as follows.

Local subscriber's station

In Fig. 4 there is illustrated in schematic form a local subscriber's station connected with the concentration unit by a pair of lines **400** and **401**. In idle condition, line **400**, known as the tip, is connected to a ringer **402** so that incoming calls to this station will be indicated by the sounding of the ringer **402** through the application of ringing current to the tip **400** at the concentration unit. When the station is in use, the switch **403** is operated to connect the tip conductor **400** through to conductor **404** and thence through the loop comprising upper winding of relay **405**, resistance **406** and brush arm **412**, resistance **407** and break key **408**, pulsing contacts **409** and resistance **410** to the ring side of the line **401**. Under circuit conditions to be explained hereinafter, current will flow through this circuit at two values, about 25 milliamperes for a marking condition and 5 milliamperes for a spacing condition. These figures are given by way of example. With steady marking current established by the conditions at the concentration unit the operation of the pulsing contacts **409** in introducing a resistance **410** in series with this circuit will reduce the current to the spacing value.

The biasing winding of relay **405** has a current of an intermediate value flowing therethrough so that with spacing current flowing through the upper winding, the armature will remain on its spacing contact, but with the increased marking current flowing through its upper winding the biasing winding will be overcome and the relay will move to its marking contact. Incoming marking and spacing signals will therefore operate the printing magnet **411** in the proper manner and these same current variations caused by the operation of pulsing contacts **409** will cause the operation of relay **405** to again operate the printing magnet **411** for the purpose of making local copy.

Under idle condition of the distributor **412**, the resistance **406** is short-circuited. Therefore, when the magnet **413** is operated and the distributor arm **412** begins to travel over its segments, spacing signals will be created by the inclusion of resistance **406** in the circuit and marking signals will be created by the short-circuiting of resistance **406**.

The important point to be noted in connection with this subscriber's station is the manner in which a call may be originated from the station. The key 403 may be operated to close the loop, whereupon current of the marking value will be established which will cause an operation of one kind at the concentration unit. On the other hand, the break key 408 may be first operated and held operated for a short space of time until the switch 403 has been operated. In this case current of the spacing value will first be established so that an operation of a different nature will take place at the concentration unit.

From the subscriber's point of view the operation will be as follows. Commercial arrangements have been made so that this subscriber will ordinarily be connected with a certain distant office. Therefore, when the subscriber initiates a call by throwing the starting switch 403, the call will be automatically directed toward this specified distant office. However, there may be occasions when the subscriber wishes to have his call directed toward a different distant office. In this case he knows that by operating the key 408 and holding it operated until he has operated the start key 403 his call will be automatically directed toward this secondary choice office. The manner in which his call is directed to one or another office under these conditions will be explained more fully hereinafter.

In somewhat more detail the operation of the local subscriber's station in Fig. 4 will now be described. For a full and complete understanding of these circuits and the detail means by which they are operated, reference may be had to the following prior art:

Patent No. 1,904,164 to S. Morton et al., Apr. 18, 1933.
Patent No. 1,965,572 to C. W. Burckey et al., July 10, 1934.
Patent No. 1,965,602 to R. A. Lake, July 10, 1934.
Patent No. 1,969,891 to R. A. Lake et al., Aug. 14, 1934.
Patent No. 2,019,505 to A. H. Reiber, Nov. 5, 1935.

The operation of switch 403 besides closing the tip through to the station circuit also effectively connects the local source of power 414 to three motors 415, 416 and 417. Motor 415 operates the distributor designated by its arm 412. Motor 416 operates the teletypewriter unit comprising the pulsing contacts 409 and the mechanism under control of the printing magnet 411. Motor 417 operates a generator 418 which supplies local power to the teletypewriter apparatus. It should be noted also that a switch 419 will start these three motors while leaving the tip conductor 400 connected to the ringer 402 so that should the subscriber desire, he may be perforating tape preparatory to transmitting at some later time, while holding the station in a condition to receive an incoming call. This station is equipped with a keyboard transmitter as well as a tape transmitter and means is provided for either sending permutation code pulses directly from the keyboard or for sending such permutation code impulses from the keyboard and at the same time perforating tape, or for perforating a tape alone. In case it is desired to employ only the keyboard transmitter, the switch handle 420 is operated in its upper position, marked "Keyboard," where it interrupts the circuit through its lower contacts. This operation breaks the circuit of the start magnet 413 of the tape-controlled transmitter-distributor 412. In order to transmit, the subscriber must also operate the sending and receiving switch 421 to the position shown so that the transmission circuit extends through the pulsing contacts 409. When the subscriber operates the keyboard, pulsing contacts 409 transmit telegraph signaling impulses in accordance with the keys operated by the subscriber by opening and closing the line to include or exclude the resistance 410 in the transmission circuit.

The line relay 405 will follow the signal impulses and repeat them to the printer magnet 411 which records the transmitted signals on the local teletypewriter and provides a home copy for the subscriber. Relay 405 in its spacing position connects resistance 422 between the positive and negative terminals of the generator 418 to compensate for the load of the printer magnet 411 and thus maintain the load on the generator substantially constant when relay 405 is in both its marking and spacing conditions.

In case the subscriber wishes to perforate tape at the same time the message is transmitted from the keyboard, key 420 is left in its intermediate position so that the lower contacts of this key are closed. This completes a circuit from the positive terminal of the generator through the lower contacts of key 420 to the cam pulsing contacts 423. These cam pulsing contacts are controlled by the cams which actuate pulsing contacts 409. Thus during each rotation of the cams during which the impulses representing a particular character are transmitted, the cam pulsing contacts 423 are closed once. When these contacts are closed a circuit may be traced through them for the operation of the tape perforating magnet 424 from the positive terminal of generator 418, lower contacts of key 420, the cam pulsing contacts 423, through the winding of perforator magnet 424 to the negative terminal of generator 418. This causes the perforator magnet to operate and perforate a series of holes in the tape in accordance with the particular key depressed.

When the subscriber wishes to transmit from the keyboard it is essential that the transmitter-distributor switch 425 remain open so that the brush arm 412 of the distributor will remain at rest and not interfere with the transmission from the pulsing contacts 409.

Means is also provided for permitting the subscriber to perforate tape and then transmit from the perforated tape. In case the subscriber wishes to merely perforate tape, he operates key 419 which, as hereinbefore mentioned, causes the connection of the local power supply to the motors at the substation but does not connect the line to the concentration unit. In order to perforate the tape the key 420 is operated to its lower position, marked "Tape," where all of the contacts of the key are closed. In this position a mechanical connection between key 420 and the cams controlling the pulsing contacts 409 functions to prevent the operation of these pulsing contacts 409. Consequently, the cam pulsing contacts are unable to operate for each depression of a key. Instead, the U-bar contacts 426, which operate each time a key is depressed, are employed. Such U-bar contacts are only effective upon the operation of key 420 to the tape position.

Under these conditions the line relay 405 and the printer magnet 411 are maintained in their spacing positions since the operating circuit for the line relay 405 is opened at the switch 403 and

the relay 405 is held to its spacing contact through its biasing winding. Inasmuch as the pulsing contacts 409 do not function at this time, no copy of the symbols recorded on the tape will be printed on the teletypewriter. This necessitates the use of a counter to count the characters transmitted in each line. This is operated by a magnet 427 which is energized in a circuit from negative terminal of generator 418, winding of counter magnet 427, counter contacts 428, upper contacts of key 420 and U-bar contacts 426 to the positive terminal of the generator. Thus every time the U-bar contacts are operated by one of the keyboard keys, counter magnet 427 is operated to count the character. However, in case a shift or unshift signal or certain other signals are transmitted, the lever 429 moves in the direction indicated and mechanically opens the counter contacts 428 so as to interrupt the circuit of the counter magnet 427, since these particular signals do not cause any character to be printed on the teletypewriter and therefore do not require space in a line of characters. When sufficient characters to constitute a line have been recorded counter contacts 428 are operated by lever 430 in response to a carriage-return signal and thus cause the operation of release magnet 431 which restores the counter to zero.

The counter lamp 432 is provided to give a visible signal when sufficient characters have been recorded to form a line so that a carriage-return signal may be sent as soon as a convenient opportunity arrives.

In this way a supply of tape may be perforated without transmitting the information over the line to the concentration unit. If it is desired to return the equipment to normal without transmitting the information at this time, switch 419 is returned to normal and the power supply cut off.

When it is desired to transmit from the tape the transmission circuit is established by the operation of switch 403, as heretofore described. Key 420 is operated to the tape position and switch 425 is closed. This completes a circuit from the negative terminal of generator 418 through the tape control contacts 433, key 425, winding of start magnet 413, sending-receiving contacts 421 and lower contacts of key 420 to the positive terminal of generator 418. Start magnet 413 operates in this circuit and withdraws the stop latch 434 from engagement with the brush arm 412. The brush arm is thus driven through a friction clutch (not shown) from motor 415 and as it carries its brush over the various segments of the distributor, the line circuit extending to the concentration unit is affected by the inclusion or short-circuiting of resistance 406 in accordance with the perforations of tape 435 under the tape control contacts 436. So long as the supply of perforated tape is available, tape control contacts 433 remain closed and the transmitter-distributor continues to transmit over the line to the concentration unit. Transmission relay 405 follows the signals transmitted by the distributor 412 and repeats them to printer magnet 411 of the teletypewriter where they are recorded.

It is also possible for the subscriber to perforate additional tape at this time by the operation of the keyboard. The perforation of the tape at this time is just the same as described above when no signals were transmitted from the subscriber's station.

In case the supply of perforated tape 435 becomes exhausted the tape control contacts 433 will open and interrupt the circuit of magnet 413 which will in turn release latch 434 to engage the brush arm 412 and interrupt the transmission over the line to the concentration unit.

Toll subscriber's station—Attended only

In Fig. 2 there is shown a toll subscriber's station which by connecting to a toll subscriber's line circuit (Fig. 5) will ultimately operate a subscriber's line circuit (Fig. 6) in the same manner that the local subscriber's station (Fig. 4) operates such a subscriber's line circuit (Fig. 6). The toll subscriber's station is connected with the concentration unit by a single line conductor 200 and the toll subscriber's line circuit (Fig. 5) acts as a translating medium to translate the operations at this subscriber's station into operations equal to those at the local subscriber's station.

Under the idle condition conductor 200 is connected through the off position of switch 201 to the bell 202 and no current flows through the line. When the switch 201 is thrown to the on position, a current will flow through the line 200 which may, for example, be —30 milliamperes. This will be the marking condition. When permutation code impulses are being sent from the concentration unit as will be more fully explained hereinafter, the marking impulse will be as stated, that is, —30 milliamperes and the spacing current will be —80 milliamperes or thereabouts. Thus the transmission from the concentration unit will be a low value of current for marking and a high value of current in the same direction for spacing. Transmission in the opposite direction, that is from this station to the concentration unit, will be of a different nature. Marking current will be —30 milliamperes but spacing current will be +30 milliamperes.

Assuming the switch 201 to be in its on position, the local source of power 203 will be connected both to the teletypewriter motor 204 and to the rectifier 205. The rectifier supplies direct current to the local circuit, for example, 75 volts. The plus and minus poles of this direct current source are indicated coming from the rectifier 205. Under line-closed conditions marking current is established through a circuit from ground, the armature of relay 206 and its marking contact, the plus lead of rectifier 205, the minus lead of rectifier 205, the marking contact of relay 207, armature of relay 207, resistance 208, inductance coil 209, resistance 210, upper winding of polarized relay 211, resistance 212, contacts of switch 201 to the line 200. The application of —75 volts in series with this circuit to what will later appear to be a ground connection at the concentration unit, causes the flow of —30 milliamperes.

The relays 206 and 207 respond to the pulsing contacts 213, being held in the position shown for marking and having their armatures driven to their alternate positions by the biasing current in their lower windings when the circuit through their upper windings is broken at the pulsing contacts 213 for a spacing condition. With the armatures of relays 206 and 207 in their alternate positions, the plus and minus poles of the rectifier are effectively reversed so that now a +75 volts is included in series with the line and meeting, as will later appear, a ground connection at the concentration unit a current of +30 milliamperes will flow.

The means for causing currents of different

value for marking and spacing to flow over this line under control of the concentration unit will be described hereinafter. The effect of this, however, can be seen at once. The polarized relay **211** is biased in such a manner that the —30 milliampere current does not move the armature from the position shown. However, when the current is increased to —80 milliamperes the bias is overcome and the relay moves to its spacing contact.

Under marking conditions a circuit is established from ground, the armature of relay **211** and its marking contacts, through the rectifier **214**, the selecting magnet **215** of the teletypewriter, the armature and marking contact of polarized relay **207**, the minus pole of rectifier **205**, the positive pole of this rectifier to ground at the armature of relay **206**. When the relay **211** moves to its spacing contact the above-described circuit is broken. Thus as relay **211** responds to incoming permutation code impulses the selector magnet **215** will respond and operate the teletypewriter generally indicated in the broken-line rectangle **216**.

When the subscriber wishes to transmit from this substation he will operate the keyboard which will in turn operate the pulsing contacts **213**. This will affect the relays **206** and **207** and send different permutation code impulses in accordance with the characters selected on the keyboard.

The important point to be noted in connection with this station is that the subscriber in initiating the call to the concentration unit may do so by merely closing the switch **201** whereby a marking current condition will be established or he may, alternatively, first operate the break key **217** and hold it operated until he has operated the key **201** whereby a spacing condition will be first established. In accordance with the call being initiated by either a marking or a spacing current condition the toll subscriber's line circuit (Fig. 5) will respond and translate this into a condition similar to that described in connection with the local subscriber's station (Fig. 4).

Unattended toll subscriber's station

The subscriber's station shown in Fig. 3 operates on the same principle as that shown in Fig. 2 and works into the circuit shown in Fig. 5. The transmission line **300** extends to the armature of the relay **301**. This is one of a set of relays for controlling the subscriber's station. If the station is not in operating condition and a call is extended from the concentration unit, the line **300** will extend through the armature and back contact of relay **301** to a ringer **302** and an alternating current relay **303**. The ringer **302** is for the purpose of notifying the subscriber of an incoming call but even if no subscriber is present, relay **303** will become energized and, through the movement of its armature, will cause the energization of relays **304**, **305** and **301** in succession. Relay **304** operates from one side of the local supply of power **306** through the armature of relay **303**, the winding of relay **304** to the other side of the local supply of power. Relay **304** is slow to operate and after a time of approximately ten seconds brings up its armature and connects the relay **305** across the power supply wires and relay **305** locks itself through its front contact and upper armature and thence through motor control contacts **307** to the other side of the power supply. Relay **305** closes a circuit through its lower armature and front contact to connect the local supply of power **306** to the motor generator set **308**, the rectifier **309**, the transmitting distributor motor **310** and the teletypewriter motor **311**. At the same time, relay **301** becomes energized by this same connection and it operates its armature to cut off the line **300** from the bell **302** and the alternating current relay **303** and connect the line **300** to the transmission circuit of the station. With the rectifier, the motor generator set and the various other motors connected to the source of power, the apparatus at the substation comes into active operation.

The transmission circuit is the same and functions in the same manner as that in Fig. 2 and hence it need only be necessary here to mention certain of the pieces of apparatus, such as the polarized line relay **312** which responds to incoming permutation code impulses, the two transmitting relays **313** and **314** which respond to the pulsing contacts **315** to reverse the potential of the current supply to make the difference between marking and spacing impulses, and the selector magnet **316** operated from the contacts of the line relay **312**. The various sending and receiving contacts, such as **317**, **318** and **319**, the perforator control contacts **320**, the tape stop switch **321** and the switch **322** all operate in a well-known manner as described heretofore in connection with the local subscriber's station in Fig. 4 and the various patents of the prior art mentioned.

The operation of the apparatus at this station while unattended may be stopped by the transmission of a predetermined sequence of code signals, such for instance as those for "blank," "shift" and "H," whereupon the motor control contacts **307** will be operated to unlock relay **305** and cut off the local supply of power.

Should the subscriber at this station wish to initiate a call through the concentration unit, he will operate switch **323** which will have the same effect as the operation of relay **305**, that is, it will cause the rectifier, the motor generator set and the various motors to come into operation and will energize relay **301** so that the line **300** will be cut through to the transmission circuit of the station. Again, especial attention is drawn to the fact that the subscriber may initiate the call with either a marking or a spacing condition on the conductor **300** whereby he will automatically route his call either to the office normally reached or the second choice office which he may wish to enter under other circumstances. Should the switch **323** be operated alone, then the call will be initiated in the concentration unit under a marking condition, that is, with a current of —30 milliamperes flowing over the conductor **300**. Should he, on the other hand, wish to reach his second choice office, then he will first operate the break key **324** and, while holding this operated, then operate the switch **323**.

Toll subscriber's line circuit—Fig. 5

The transmission system used with the subscribers' stations shown in Figs. 2 and 3 is arranged so that leakage does not cause bias in the received signals at the substation or at the concentration unit, thus eliminating the necessity of readjustment for varying weather conditions on open-wire lines. This is accomplished as follows: From the substation to the concentration unit transmission is on a polar basis from ±75 volts at the substation to ground in Fig. 5. The usual received current is about 30 milliamperes, depending on the length of line and the effect of leakage which decreases the marking

and spacing currents equally. From the toll subscriber's line circuit the transmission is ground for marking and +130 volts for spacing, which meets —75 volts marking at the substation. This results in a marking received current of about 30 milliamperes and a spacing current of about three times the marking current in the same direction. The receiving polar relay at the substation has a biasing circuit adjusted to oppose both marking and spacing currents of a value about mid-way between them. Therefore, the armature will follow incoming signals. The effect of leakage is to increase the marking current and decrease the spacing current equally but this does not cause a bias in the receiving relay since the net effect on the relay is always equal and opposite. Therefore, as long as leakage is not great enough to cause the marking and spacing currents to become nearly equal to each other and equal to the current in the biasing winding the receiving relay will follow signals unbiased.

Toll subscriber's line circuit—Idle condition

During the idle condition the line conductor may be traced through the back contacts of relay **500**, the upper winding of polarized relay **501**, the lower winding of polarized relay **502**, winding of relay **503**, armature and back contact of relay **504**, winding of relay **505** to ground. Relay **506** when non-operated separates the line winding from the bias winding of the receive relay **502** and relay **501** by its uppermost outer armature and connects ground to one side of the bias winding through the back contact associated with this armature. Relay **506** also connects battery through the back contact and inner upper armature of relay **506** with the middle winding of polarized relay **501** to the other side of the bias winding of relay **502**. This holds relays **501** and **502** in a marking condition. Relay **507** when non-operated separates the line winding from the bias winding of the send polarized relay **508** by opening the connection between its upper outer armature and front contact and at the same time through the alternate contact associated with the upper outer armature, relay **507** connects battery to the bias winding of relay **508**, thus holding send relay **508** in a marking condition.

Toll subscriber's line circuit—Call from subscriber

A call is originated at the subscriber's set by the closure of the power supply circuit of the set. If the call is for the normal routing for which the subscriber has arranged, the above operation only is used. If the call is for the alternative routing for which the subscriber has arranged, the subscriber as hereinbefore noted operates the break key of his set first and holds it operated while the power supply is closed. In the first case negative marking polarity is connected to the line and in the second case positive spacing polarity is connected to the line. In either case relay **503** operates.

The operation of this relay closes a circuit from battery through resistances **509** and **510**, armature and contact of relay **503**, resistance **532**, winding of relay **511**, inner lower armature and back contact of relay **512** to ground. The operation of relay **511** closes a circuit from ground, its armature and contact, to the armature of relay **505**. If the call has been originated at the subscriber's station in the normal manner, that is, through the operation of the power switch only and negative marking polarity is applied to the line, then relay **505** being polarized remains in the position shown and the ground now applied to the armature of this relay causes the operation of relay **504**. Relay **504** switches the transmission circuit from the winding of relay **505** to the armature of send relay **508** where it finds a ground. Relay **504** through the operation of its right-hand armature connects ground to the windings of relays **506** and **507** in parallel and relay **507** connects negative 130-volt battery through resistances **513** and **516** and through the upper inner armature and front contact of relay **507** to the ring conductor **514** leading to the subscriber's line circuit (Fig. 6) to signal the switchboard operator at one of the distant manual offices in a manner to be hereinafter described.

If the call has been made through the operation of the break key at the subscriber's substation before the operation of the power supply switch, then positive spacing polarity is applied to the line at the subscriber's set and relay **505** operates as well as relay **503**. Relay **505** is held operated only as long as the break key at the subscriber's set is held operated and releases as soon as the break key is released, thereby applying negative marking polarity to the line. Relay **503**, as before, operates relay **511**. Relay **503** releases and reoperates when the break key at the subscriber's station is released, thereby changing the polarity on the line from positive to negative, but relay **511** being slow to release holds operated. Relay **505** operated operates relay **515** from relay **511** and relay **515** locks to ground over the back contact and inner upper armature of relay **512**. Relay **515** applies negative battery through resistances **513**, **516** and **517** to the R lead **514** of the associated subscriber's line circuit. As soon as relay **505** releases, relay **504** operates through the back contacts of relay **505** to ground from relay **511**. Relay **504** through its operation operates relays **506** and **507** in parallel. Relay **507** connects negative battery through resistances **513** and **516** only to the R lead **514** to the concentration unit which functions to signal the switchboard operator at the distant office. As will be explained hereinafter, the connection of negative battery through resistances **513** and **516** directly in one case through the contacts of relay **507** to R lead **514** and through the resistance **517** in the other case causes a marginal operation at the subscriber's line circuit (Fig. 6) to differentiate between the routing of the call through its normal channel or through its alternate channel.

Relay **507** through its upper outer armature and front contact closes a circuit from the bias winding of relay **508** to the left-hand terminal of the operating winding of this relay, this point forming the apex of the send relay. Relay **507** also operates relay **512** over its front contact and inner lower armature and at the same time closes a path for operating relay **511** from current reversals. The operation of relay **512** transfers the marking contact of relay **501** from ground to positive battery through resistances **518** and **509** and removes ground from grid condenser **519** of vacuum tube **520** to prepare for timing a break, as will be described hereinafter. Relay **512** also connects ground to the armature of relay **501** through the alternate contact of its lower outer armature. Relay **512** further releases relay **515** and supplies locking ground for relay **521** over a circuit from the armature of relay **501**, its marking contact, the inner lower armature and front contact of relay **512**, resistance **518**, the alternate contacts of the inner upper armature of relay **506** to relay **521** for the purpose of maintaining this relay

non-operated and vacuum tube **520** non-operated. Relay **512** also transfers the sleeve lead **522** from a circuit leading through the winding of relay **523** to the winding of relay **524**. Relay **506** closes the connection between the right-hand terminals of both windings of relay **502** to form the apex of this receive relay **502**.

Relay **506** also connects +130-volt battery through resistance **509**, the alternate contacts of the inner upper armature of relay **506** to the filament and plate circuits of vacuum tube **520** and through the resistance **528** and the back contact and outer upper armature of relay **523** to the grid circuit of this tube. This is for the purpose of preparing for timing a break, as mentioned above. Relay **506** also closes the tip conductor **525** leading from the concentration unit through the lower outer armature and front contact of relay **506**, the back contact and outer left-hand armature of relay **526** to the operating winding of relay **508** and thence to the armature of relay **502**. Relay **506** also extends the circuit from relay **527** through the front contact and inner lower armature of relay **506** to a contact on relay **526** for purposes which will appear hereinafter. Negative battery on the tip lead **525** from the concentration unit holds the send relay **508** to marking. Ground on the sleeve lead **522** after the concentration unit circuits have functioned as will be hereinafter described, causes relay **524** to operate and this in turn connects ground to condenser **519** through its lower outer armature and front contact, the back contact and upper outer armature of relay **523** to prevent condenser **519** from being charged from positive battery through resistance **528** at this time. Relay **524** also supplies a holding ground for relay **512** through its upper armature and front contact. The circuit is now prepared for the transmission of signals when the switchboard operator answers.

Toll Subscriber's Line Circuit—Transmission of Signals

Concentration unit to subscriber's set

The send relay **508** follows signals from the concentration unit and is operated to marking by a current of approximately 25 milliamperes. A spacing signal reduces the current to approximately 5 milliamperes and the relay is operated to spacing by a current of approximately 15 milliamperes through its bias winding. The operation of the send relay transmits a marking signal of approximately 30 milliamperes to the subscriber's station and increases the current about three times, to approximately 80 milliamperes, for a spacing signal. This circuit may be traced from the armature of the send relay **508**, through the front contact and left-hand armature of relay **504**, winding of relay **503**, the operating winding of relay **502**, the operating winding of relay **501**, back contact and armature of relay **500** to the line leading to the subscriber's station. A branch path may also be traced from the apex point of the receive relay **502**, that is, a point between the operating winding of relay **502** and the winding of relay **503**, through the front contact and upper outer armature of relay **506**, the bias winding of relay **502**, the middle bias winding of relay **501**, through resistance **529** and condenser **530** to ground. This prevents the relay **501** and the receive relay **508** from operating on capacity surges when transmitting to the subscriber's substation. Relay **503** holds operated, since the current is always in the same direction through its winding and relay **501** holds to marking through its upper operated winding for the same reason.

Subscriber's station to concentration unit

A negative marking signal and a positive spacing signal of approximately 30 milliamperes is transmitted from the subscriber's set as before described. Relay **501** and receive relay **502** follow these signals. The receive relay **502** retransmits the signals to the concentration unit, transmitting ground for marking and negative battery for spacing. The transmission path may be traced from the armature of receive relay **502**, through the operating winding of relay **508**, through the outer left-hand armature and back contact of relay **526**, the front contact and outer lower armature of relay **506**, through resistance **531** in the tip lead **525** to the concentration unit. Relay **503** may or may not follow the signals but relay **511** is held operated through its slow releasing characteristics and in turn holds relays **504**, **506** and **507** operated. The holding paths for relay **511** are as follows: When relay **503** is operated and relay **501** is marking, a path may be traced from battery through resistance **509**, resistance **510**, the armature and front contact of relay **503**, resistance **532**, winding of relay **511**, marking contact of relay **501**, alternate contacts of the lower, outer armature of relay **512** to ground. When relay **501** is spacing and current is in the reverse direction, then relay **511** is maintained energized from battery through resistance **509**, resistance **518**, front contact and inner lower armature of relay **512**, winding of relay **511**, resistance **532**, front contact and armature of relay **503**, spacing contact of relay **501**, the alternate contacts of the outer lower armature of relay **512** to ground. If and when relay **503** is released and relay **501** is marking, relay **511** is held operated by the charging current through condenser **533**, the path being from battery through resistance **509**, resistance **510**, lower outer armature and front contact of relay **507**, condenser **533**, resistance **532**, winding of relay **511** to ground on the marking contact of relay **501**. When relay **501** is spacing, the charging current is in the reverse direction from battery, through resistance **509**, resistance **518**, front contact and inner lower armature of relay **512**, the winding of relay **511**, resistance **532**, condenser **533**, front contact and outer lower armature of relay **507** to ground over the spacing contact of relay **501**. When relay **501** is marking, the current through its lower winding is in such a direction as to assist in holding it marking, and when the relay is spacing is in such a direction as to assist in holding it spacing. This winding is to prevent false operation of relay **501** due to cross-fire at the subscriber's line.

Break signal from the subscriber's station

When the subscriber operates his break signal key positive polarity will be applied to the line at the subscriber's set during the time the break key is operated. The receiving relay **502** will repeat this spacing condition to the loop circuit leading to the subscriber's line circuit (Fig. 6) and prevent transmission from such subscriber's line circuit. Relay **503** continues to hold relay **511** and its associated relays but relay **524** is released by the removal of ground from the sleeve lead **522** by the functioning of the subscriber's line circuit (Fig. 6) as will hereinafter be described. When the subscriber restores his break signal key, negative marking polarity will be again applied to the

line at the subscriber's set and relay 502 will operate to its marking contact. The circuit is then in condition for the transmission of telegraph signals. If the subscriber sends a break signal exceeding six seconds' time, tube 520 will function as described hereinafter but otherwise performs no useful function at this time.

Break signal to the subscriber

A break signal from the concentration unit will cause the send relay 508 to operate to spacing under influence of its bias circuit and this will transmit a spacing signal to the subscriber, thus preventing transmission by the subscriber. Relay 503 continues to hold relay 511 and its associated relays operated. The break from the concentration unit also causes the concentration unit circuits to function to release relay 524. Relay 524 released removes the ground from condenser 519, allowing it to charge from 130-volt battery through resistances 509 and 528. When the loop from the subscriber's line circuit (Fig. 6) is closed to marking, relay 524 reoperates and connects ground to condenser 519 to discharge it before it has time to charge to a sufficiently high potential to cause tube 520 to draw plate current.

Trouble break

The vacuum tube 520 and associated apparatus are designed to detect a break signal from the concentration unit lasting more than six seconds. With relay 506 operated, resistances 534 and 535 in the plate circuit cause the filament to operate at such a stage that with ground on condenser 519 the grid blocks the tube through current limiting resistance 536. As described above, a break signal removes ground from the condenser 519, allowing it to obtain a positive charge through timing resistance 528. After approximately six seconds the grid is nearly up to filament potential and the plate current operates relay 521 which in turn operates relay 526. Relay 526 locks to ground over its front contact and inner left-hand armature, the back contact and inner lower armature of relay 524, the front contact and inner upper armature of relay 512 to ground as long as the break is continued. Relay 526 also transfers the lead from the operating winding of the send relay 508 to the tip conductor 525, from such tip conductor to the right-hand armature of relay 527. Relay 526 also closes a path for operating relay 527 over the front contact and inner lower armature of relay 506, the front contact and inner right-hand armature of relay 526 to lead 537 to which interrupted ground is supplied as follows:

Relay 526 through its right-hand outer armature and front contact places battery on the conductor 538. This battery is connected through the back contact and armature of relays 539 to the winding of relay 540. Relay 540 becomes energized and through its left-hand armature and front contact extends this battery to relay 539. Relay 539 becomes operated and opens the circuit of relay 540 which, releasing, in turn opens the circuit of relay 539. Due to the slow-releasing characteristics of relays 539 and 540 these two relays will repeatedly go through this series of operations so that through its right-hand armature and front contact relay 540 supplies an interrupted ground to conductor 541. Relays 542 and 543 form a pair of counting relays well known in the art and these relays operate from the interrupted ground on conductor 541 and battery on conductor 538 so as to place a ground on conductor 544 periodically and at one-half the frequency of the application of ground to conductor 541. In the same manner, relays 545 and 546 form another pair of counting relays which are operated through the interrupted ground on conductor 544 and battery on conductor 538. These relays then, through the connection of ground to the right-hand armature of relay 545 and through the right-hand armature of relay 546, will supply interrupted ground to conductor 537 for one-fourth of the period of complete operation of this set of counting relays. This particular timing arrangement, as will be seen hereinafter, will operate a distant teletypewriter unit since the division of time between the application of ground to conductor 537 and the opening of this conductor simulates the permutation code for "letters." Thus upon the operation of relay 526 the set of relays 539, 540, 542, 543, 545 and 546 are set into operation and supply an interrupted ground over the inner right-hand armature and front contact of relay 526 for the operation of relay 527, as has already been pointed out.

Relay 527 operates and releases periodically in this circuit. The loop to the subscriber's line circuit (Fig. 6) is open while relay 527 is released. When relay 527 is operated it removes negative marking battery through resistances 513 and 547 from the operating winding of relay 508 and closes the loop through to the concentration unit by connecting the winding of relay 508 through the right-hand armature and front contact of relay 527, the front contact and outer lower armature of relay 506 to conductor 525. If the trouble break is still affecting the line, relay 524 remains released and relays 521, 526 and 527 remain operated as described, and the send relay 508 sends a spacing signal out to the subscriber's station. Through its left-hand armature and contact, relay 527 holds relay 511 operated during the spacing interval so that if the subscriber disconnects by shutting down the apparatus at his station, the relay 503 which may or may not release depending on the amount of leakage present on the line, will release when the send relay 508 next sends a marking signal out on the line. This takes place when relay 527 next releases under the influence of the interrupted ground and thus opens the holding path to relay 511, leaving it under control of relay 503. At this time the operating winding of relay 508 is again connected through the back contact of relay 527 and resistances 547 and 513 to negative marking polarity. This operates the send relay 508 to marking and ground is connected to the line leading to the subscriber's station. The operation and release of relay 527 cause the alternate sending of marking and spacing signals to the subscriber in order to show him there is trouble on the line.

It should be particularly noted that the characteristics of relays 539 and 540 are such that the interrupted ground supplied to lead 537 simulates the permutation code for "letters". Since relay 527 now operates periodically and causes the sending of marking and spacing signals at this rate, the teletypewriter apparatus at the substation will respond in the same manner as though the permutation code for "letters" were being continuously sent and this in turn will constitute an audible signal to the subscriber through the periodic and audible working of the teletypewriter apparatus.

The subscriber may, however, recall or discon-

nect in the manner to be presently described. If relay 527 is operated and the space signal changes to marking polarity in the loop circuit to the subscriber's line circuit (Fig. 6), then relay 524 will operate and in turn will release relays 521, 526 and 527 and the circuit will be ready for communication.

Disconnection by the subscriber

The subscriber disconnects by throwing his power switch to the off position. The set returns to the normal idle condition, that is, the line is opened to direct current and is connected through the condenser and ringer to ground. In the toll subscriber's line circuit the relay 503 releases and in turn releases relay 511. Relay 511 releases relay 504 which in turn releases relays 506 and 507 and at the same time breaks the connection between the relay 503 and the armature of relay 503. The return to normal of relay 504 also connects ground through the back contact and left-hand armature of relay 504 to the line leading to the subscriber's station. The release of relays 506 and 507 applies local battery to the bias windings of the send and receive relays 508 and 502 to hold them in a marking condition. Relay 503 opens the tip lead 525 to the concentration unit and the release of relay 507 removes battery from the ring lead 514 to the concentration unit. This functions to bring in a disconnect signal at the concentration unit. If the subscriber disconnects during a trouble break which has caused relays 521, 526 and 527 to operate, relay 503 will release on the first marking impulse, as heretofore described, and the relay 511 will release, thus releasing relay 504 which functions as just described. However, if the loop is still spacing when the operator receives the disconnect signal, relays 521 and 526 will be operated. Relay 507 returning to normal will release relay 512 which will cause relays 521 and 526 to return to normal.

Recall signal from the subscriber

A recall signal is given to the concentration unit and thence passed on to the distant central office switchboard operator by the subscriber set attendant momentarily opening the power circuit or operating the recall key of the subscriber's set. While the power switch is open or the recall key operated, the line is opened to direct current and relay 503 in the toll subscriber's line circuit released, in turn releasing relays 511, 504, 506 and 507. Relay 507 functions as described previously to remove battery from the ring lead 514 which causes the concentration unit to function to bring in a steady lamp at the distant central office as will be more fully described hereinafter. Relays 506 and 507 becoming released, open the path for operating relay 511 on reversals and furnish battery for holding the send and receive relays 503 and 502 in a marking condition. When the power switch is closed or the recall key is released at the subscriber's set, negative marking polarity will be applied to the line with the result that relay 503 operates and in turn again brings up relays 511, 504, 506 and 507. Relay 507 becoming operated, again connects battery to the ring lead 514 which causes the concentration unit circuits to function to give the switchboard operator a flashing supervisory lamp recall signal in a manner to be further explained hereinafter. Relays 506 and 507 restore the send and receive relays 508 and 502 to their transmitting condition.

The subscriber may send a recall or disconnect signal during the time the line is marking when a trouble break exists on the concentration unit side of the repeater comprising send and receive relays 508 and 502. When this condition exists the line circuit "times out" after approximately six seconds and causes the transmission from relay 508 of long marking and short spacing signals over the line to the subscriber. The subscriber may recall during the time the line is marking and this will cause the cord supervisory lamp to flash as previously explained. The operator will go in on the circuit and operate the split key in order to cut off the cord circuit through which the trouble break is coming. This will change the loop between the toll subscriber's line circuit and the subscriber's line circuit (Figs. 5 and 6, respectively) to the marking condition and the circuit will then function as hereinbefore described.

TOLL SUBSCRIBER'S LINE CIRCUIT—CALLING SUBSCRIBER'S STATION

Attended service—Fig. 2

When a calling cord is inserted in a line jack of the two-way trunk circuit to the line concentration unit as will hereinafter be more fully described and the ringing key thereat is operated, the concentration unit circuits will function to place ground on the sleeve lead 522, which will operate relay 523. Relay 523 closes a circuit from ground, the right-hand armature and back contact of relay 504, the inner upper armature and front contact of relay 523, the armature and back contact of relay 548, the winding of relay 549 to battery, whereupon this relay becomes operated and in turn connects the ground on the armature of relay 504 through the front contact and right-hand armature of relay 549 to the winding of relay 500. Relay 500 becoming operated, disconnects the line from the relay 501 and other relays connected thereto and connects instead the source of continuous ringing current, here designated by the current limiting lamp 550, through the front contact and left-hand armature of relay 549, the front contact and left-hand armature of relay 500 to the line leading to the subscriber's station. When the operator at the distant office releases the ringing key, relay 549 releases and this opens the ringing circuit and closes the line through resistance 551 to ground momentarily since relay 500 is slow to release. Resistance 551 tends to discharge the line before it is again connected to the relays 501, 502, etc. When the subscriber answers, relay 503 operates, operating in turn relays 511, 504, 506 and 507 as heretofore described. Relay 506 becoming operated, closes the tip conductor 525 through to the operating winding of send relay 508 and relay 507 becoming operated, closes the ring conductor 514 through to negative battery so that the circuits beyond in the concentration unit function to extinguish or flash the cord supervisory lamp at the distant office. Relays 506 and 507 function in the manner previously described and relay 504 closes the line to the subscriber's station through to the armature of send relay 508.

Calling subscriber's station—Unattended service—Fig. 3

When the calling cord is inserted in the line jack of the two-way trunk circuit to the concentration unit as will be more fully described hereinafter and the ringing key thereat is operated, the concentration unit circuits will function to

place ground on the sleeve lead 522 which will operate the relay 523. Relay 523 becoming operated, transfers the charging path for the condenser 519 from resistance 528 to resistance 552 for the purpose of lengthening the time measured by the tube 520 and its associated apparatus. Relay 523 operates the relay 549 as hereinbefore described, with the result that ringing current is transmitted to the subscriber's station (Fig. 3). Relay 523 also connects battery to the filament and plate circuits of tube 520 and transfers the contacts of relay 521 to the winding of relay 548. In this way the relay 523 has transferred the timing-out circuit from relay 526 to relay 548 to time the duration of ringing. When the relay 523 operates, the condenser 519 starts to charge from positive battery through the timing resistance 552. At the end of the ordinary ringing signal, lasting only a few seconds, relay 523 releases and ground at relay 512 discharges the condenser 519, restoring the circuit to normal. However, if the operator sends a long ring the unattended station will be automatically started as hereinbefore described and after approximately nine seconds the subscriber's station will be cut through to the concentration unit as follows: After nine seconds the condenser 519 is sufficiently charged to cause tube 520 to conduct, thus operating relay 521 which in turn operates relay 548. Relay 548 in operating opens the operating path for relay 549, causing it to release and in turn to release relay 500 which closes the line lead to the line side of the toll subscriber's line circuit. The application of ringing current to the line causes the unattended start circuit at the station set to function and to place negative marking current on the line. This in turn operates relays 503, 511, 504, 506, 507 and 512 and the circuit functions as previously described.

If the toll subscriber's station set has not been started by the time tube 520 operates, relay 503 will not operate when relay 500 is released and, therefore, after a reasonable time the operator should release the ringing key and then reoperate it. This in turn will release the relays 523 and 548 and then reoperate relay 523 which in turn operates relays 551 and 500 to send ringing current out over the line again. If after ringing several times the unattended station is not started, the failure of the distant operator to receive an answer signal will indicate that a trouble condition exists.

Subscriber's line circuit—Fig. 6

Fig. 6 shows the essential elements of the subscriber's line circuit connecting either to a local subscriber's line, such as that shown in Fig. 4, or to a toll subscriber's line circuit, such as that shown in Fig. 5, which extends to the toll subscriber's station, such as that shown in either Fig. 2 or Fig. 3. In Fig. 6 two subscribers' line circuits are indicated, one shown in full within the broken line and another indicated in the rectangle directly above and marked "Station #90." It will be noted that in the case of a local subscriber only the tip and ring conductors extend from the subscriber's line circuit toward the subscriber's station, while in the case of the toll subscriber a third conductor, the sleeve, extends from the subscriber's line circuit to the toll subscriber's line circuit. The function of the circuit is the same in each case. Since the toll subscriber has an additional circuit interposed, that shown in Fig. 5, the third or sleeve conductor is extended from the subscriber's line circuit for certain supervisory purposes in such additional circuit.

It has been shown hereinbefore that the transmission from a local subscriber's station is on a 5–25 milliampere basis whereas the toll subscriber's station works on a somewhat different basis. The toll subscriber's line circuit, however, is a translating medium so that the transmission into the present subscriber's line circuit is on a 5–25 milliampere basis.

Subscriber originates a call

The subscriber originates a call by operating the power switch associated with his substation to the on position. In the case of a local subscriber's station, this will close the loop through so that current flows from battery, the alternate contacts of the inner left-hand armature of relay 606, over the conductor 607 which may be traced through the back contact and inner left-hand armature of holding magnet 800, back over conductor 608, the normal tip contacts of jack 609 to the tip conductor 610, that is, over the station loop returning over conductor 611, the normal tip conductors of the jack 612, conductor 613 where it may be traced through the alternate contacts of the outer left-hand armature of holding magnet 800, back over conductor 614, through the right-hand winding of marginal relay 615, the winding of line relay 616 to ground. If the power switch key 403 only is operated, then both relays 616 and 615 will become operated. If the break key at the substation has been operated first, then relay 615 will not at once operate, giving an opportunity for the operation of relay 617 prior thereto.

In the case of a toll subscriber, if the call is originated in the normal manner then it will be remembered that a circuit was established from battery, resistance 513, resistance 516, the inner upper armature and front contact of relay 507 to the ring conductor 514 which would correspond to conductor 611 and which could be traced through the windings of relays 615 and 616. The current flowing through resistances 513 and 516 in this circuit would be sufficient to bring up both relays 615 and 616. However, if the toll subscriber first operated his break key, it will be remembered that relay 515 first came up. This has the effect of including an additional resistance 517 in the ring circuit in series with conductor 514 and this would cause a current to flow through relays 615 and 616 insufficient in amount to bring up the relay 615. Thus it will be seen that the origination of a call from either a toll subscriber's station or a local subscriber's station has the same effect in the subscriber's line circuit.

The operation of the line relay 616 places a ground connection on the start lead 618 to the sequence circuit and this causes such sequence circuit to function and bid for the privilege of routing the call through the line concentration unit. As will be seen hereinafter, the sequence circuit returns a ground over the conductor 619, causing the lamp 620 to be steadily illuminated and the night alarm relay in the sequence circuit reached over conductor 605 to be energized until the sequence circuit obtains the privilege to route the call. The line circuit is held under control of the line relay 616 and in turn under the control of the power switch of the subscriber's station.

It has been mentioned above that the difference between a call originating in the normal manner, that is, when the subscriber intends to reach a trunk to his first choice office, and a call originated

in the other manner, that is, when the subscriber intends to reach his second choice office, is the difference between the non-operation and the operation of relay 617. If the marginal relay 615 is prevented from operating immediately by the operation of the subscriber's break key then relay 617 will become energized, but if the call is originated in the normal manner then relay 617 fails to energize. In either case then after the sequence circuit has obtained the privilege of routing a call through the line concentration unit it places battery on conductor 621 which leads to the left-hand armature of relay 617. Therefore, if the call is normal conductor 600 will be connected to battery, but if the call is for the second choice office then battery will be placed on conductor 601 instead. Conductors 600 and 601 lead to Fig. 16 where they connect respectively to conductors 1600 and 1601. The particular purpose of this will appear hereinafter. It will be noted that if the call has been originated in the normal manner so that relay 617 fails to operate, the ground returned from the sequence circuit on conductor 619 connecting to the back contact of the outer right-hand armature of relay 617 causes lamp 620 to light steadily. If the call has been originated in the other manner and relay 617 has become operated, then ground, through an interrupter 622 having an interval of sixty impulses per minute, will be connected through the front contact of the outer right-hand armature of relay 617 to cause lamp 620 to flash at the rate of sixty times per minute.

It will be noted that the leads from the back and front contacts of the left-hand armature of relay 617 are labeled "First choice" and "Second choice," respectively. Such leads may be connected in either manner to the common conductors 600 and 601 so that conductor 600 which may mean first choice for one line may be second choice for another. This is indicated by the manner in which the "first choice" and "second choice" leads coming from subscriber's line circuit "Station #90" are connected to conductors 601 and 600.

Connection to a trunk at the distant office

When the sequence circuit has obtained the privilege of routing a call through the concentration unit, a predetermined trunk to the master office is seized and the link circuit functions as will be hereinafter described. The operation of the magnet, such as 800, in the link circuit removes battery through the tip conductor and removes the line relay 616 and the marginal relay 615 from the ring conductor and connects the tip and the ring of the subscriber's line through the link circuit to the selected trunk. The subscriber's line supervision thereafter is handled by the supervisory relay in the trunk circuit.

Disconnect signal

When the subscriber disconnects, supervisory features of the trunk circuit function and in turn cause the hold magnet 800 of the link circuit to release, returning the circuit to normal.

All-trunks-busy condition

If all trunks leading from the line concentration unit are busy when a subscriber originates a call, the sequence circuit functions to seize the preference but the all-trunks-busy circuit places a ground on conductor 623 in a manner to be hereinafter described. This ground on conductor 623 causes the operation of relay 606 which locks under control of the line relay 616 in a circuit from ground, the armature and contact of relay 616, the armature and front contact of relay 615, the front contact and inner right-hand armature of relay 606 and the winding of this relay to battery. Relay 606 disconnects ground from conductor 618 which is the start lead of the sequence circuit and this causes the latter circuit to return to normal. Relay 606 also places a ground on conductor 603 at its front contact and outer right-hand armature. Conductor 603 leads to the circuit shown in Fig. 20 and there connects to conductor 2003. As will appear hereinafter, this ground permits a continuous output of "letters" or "K" signals. Relay 606 also maintains ground on conductor 619 over its outer left-hand armature and front contact in order to prevent the extinguishing of the lamp 620 after the sequence circuit has been dismissed. Relay 606 further transfers the tip conductor of the subscriber's line from negative 130-volt battery to the "K" lead conductor 602 leading to conductor 2002 of the all-trunks-busy circuit. Since all trunks are in use at this time the all-trunks-busy circuit sends "letters" characters at the rate of sixty per minute over lead 2002 to conductor 602 and thence through the inner left-hand armature of relay 606 to the subscriber. This "letters" signal consists of a short spacing pulse followed by a long marking pulse simulating the permutation code for "letters" and this causes a series of distinctive operations of the subscriber's teletypewriter which will appear as an audible signal. As soon as a trunk becomes idle the all-trunks-busy circuit sends "K" signals instead of "letters" over the "K" lead. These "K" signals consist of marking and spacing impulses arranged to simulate the regular permutation code for the character "K" and result in a series of "K's" being printed on the subscriber's teletypewriter. Meanwhile the relay 616 has remained operated during "letters" and "K" signals due to its slow-releasing characteristic, under control of the power switch at the subscriber's station. Upon receipt of the "K" signals, the subscriber is instructed to disconnect and originate a new call in order to seize the trunk which has become idle. The return of the power switch to normal releases relay 616 to normal. When the relay 606 releases, the output of "letters" or "K" signals in the all-trunks-busy circuit will be discontinued unless some other relay, such as 606 in the concentration unit, is operated.

Each subscriber's line circuit has an individual conductor leading to the director circuit. It will be noted that the subscriber's line circuit shown in full detail in Fig. 6 is marked "Station #44." It will be further noted that conductor 604 is labeled "To conductor 2104." Conductor 2104, it will be found, is that particular conductor in the director circuit which may be reached through the sending of figures 4—4. Similarly, conductor 690 leading to conductor 2190 from the upper subscriber's line circuit marked "Station #90" is that particular conductor in the director circuit which may be reached through the sending of the characters 9 and 0. The function of these conductors will appear hereinafter.

Link circuit

In Figs. 8 and 9 there is illustrated what is known as the link circuit. It is a diagrammatic representation of a cross-bar switch with the various connections leading on the one side to the subscriber's line circuit and on the other

side to the trunk circuits to the distant office.

For a full understanding of the cross-bar switch reference may be had to the following patents:

1,953,503, J. N. Reynolds, Apr. 3, 1934.
2,021,329, J. N. Reynolds, Nov. 19, 1935.
2,040,334, J. N. Reynolds, May 12, 1936.
2,039,630, J. A. Burrell, May 5, 1936.
2,039,644, D. H. Gleason et al., May 5, 1936.

It will be understood that with selecting magnet **801** and holding magnet **800** operated (with selecting magnet **801** then released) that the set of contacts **802** will be operated so as to extend the subscriber's line circuit shown in Fig. 6 to the trunk circuit indicated at the top of Figs. 11 and 13 leading to the circuit of Fig. 19. It will be understood also that with selecting magnet **900** operated and the holding magnet **800** operated (with selecting magnet **900** then released) that the set of contacts **901** will effectively connect the subscriber's line circuit of Fig. 6 to the trunk circuit shown in full in Figs. 11 and 13 and extending to the circuit of Fig. 15. Figs. 15 and 19 represent the termination of these trunks at distant offices.

Assuming that Fig. 15 represents an office in one locality and that Fig. 19 represents an office in another locality, the subscriber has, according to commercial arrangements made, selected one or another as his first choice office whereupon the other becomes the second choice office. Assuming Fig. 15 to represent the first choice office then if he initiates the call by the mere operation of his power switch the selecting magnet **801** or one of the other selecting magnets shown in Fig. 8 will cooperate with the holding magnet **800** to extend his line to the office of Fig. 15. It will be more fully explained hereinafter how, if all of the trunks leading from Fig. 8 are busy, the call will nevertheless be extended over one of the second choice trunks leading from Fig. 9. In case all of these are busy then the all-trunks-busy condition will be set up and the subscriber will have an appropriate signal displayed before him. In case the subscriber initiates the call in such a manner as to extend his call over one of the trunks of Fig. 9 to his second choice office then if all of the trunks indicated here are busy his call will nevertheless be extended over a trunk in Fig. 8 and in case that all of these are also busy an all-trunks-busy condition will be set up and he will be appropriately notified. The action of these circuits may be explained in another manner, that is to say that all of the available trunks in both the first and second choice offices are placed in a sequence circuit and when a call is initiated something akin to hunting for an idle trunk will take place, starting from a point determined in advance by the commercial arrangements made by the subscriber and continuing through the sequence until no idle trunk at all is found when the all-trunks-busy will become effective. If the subscriber changes the point of entrance into the sequence of these trunks by the operation of his break key in order to get a second choice trunk, then the action akin to hunting will begin with the second choice trunks but will nevertheless continue throughout all of the trunks in sequence until the all-trunks-busy condition is encountered.

In the idle condition of the link circuit or the cross-bar switch of Figs. 8 and 9 all magnets are released and the tip and ring sides of the subscriber lines are connected through the subscriber line circuit through the back contacts of the holding magnet, such as the holding magnet **800**. When a subscriber places a call the sequence circuit, as will be more fully explained hereinafter, will determine which trunk the subscriber shall use. The selecting magnet, such as **801**, which is associated with the trunk thus selected will be energized to position the selecting fingers of the cross-bar switches. The closure of the selector off-normal contacts will place a ground on conductor **902** which will extend to conductor **2302** and there operate relay **2300**. The operation of relay **2300**, as will be explained more fully hereinafter, will, through the operation of the sequence circuit, place a ground on conductor **628** which corresponds to conductors **828** and **928** and which will operate the holding relay **903** to close an energizing circuit for the holding magnet **800**. Operation of the holding magnet will cause the closure of the switch contacts at the intersection corresponding to the trunk to the calling subscriber line.

When a trunk is selected by the distant manual operator for the purposes of placing an inward call, the selecting magnet will be operated in advance of the completed selection of the desired subscriber line. If the selected subscriber is idle the closed condition of the selecting off-normal contacts through the operation of relay **2300** will extend the ground through the director circuit, which will eventually appear as a ground on conductor **628** and, as before, will cause the operation of relay **903** and thence the holding magnet **800**.

Two-way trunk circuit to master office—Figs. 11 and 13

The two-way trunk circuit to the master office shown in Figs. 11 and 13 is arranged to possess complete supervisory features and will operate in conjunction with the associated loop repeater which functions on a half-duplex transmission basis only in the transmitting condition. It is arranged to be the connecting link between the teletypewriter subscriber connected to it by a link circuit and a terminal repeater associated with the two-way trunk to the distant manual central office.

In Fig. 13 at the right are shown two broken-line rectangles. The circuit in rectangle **1327** represents a terminal repeater for the concentration unit end of the two-way trunk circuit and the rectangle **1328** represents a terminal repeater for the central office end of the two-way trunk circuit shown in detail in Fig. 15. A marking impulse transmitted over conductor **1301** operates the two relays **1330** and **1331** which reverse the battery connections to conductors **1332** and **1333** and eventually drives the armature of relay **1334** to its marking contact, thus placing a marking signal on conductor **1335** which will in turn affect relays **1505** and **1504**. A marking impulse from the central office end will come in over conductor **1329** and affect relays **1336** and **1337** which reverse battery on conductors **1338** and **1339**, eventually driving the armature of relay **1349** to its marking contact which in turn causes marking battery over conductor **1326** to affect relays **1303** and **1113**. Conductors **1350** and **1351** represent the trunk circuit between the concentration unit and the central office.

These terminal repeaters are well known in the art and therefore a detailed description is unnecessary. In the description hereafter, therefore, when a marking impulse is said to be transmitted from the circuit of Fig. 11 or from the armature of relay **1127** it will be understood that

such a marking impulse affects the terminal repeaters to transmit a marking impulse to relays **1505** and **1504**, and in the same way when hereafter it is said that a marking impulse is transmitted over conductor **1529** it will be understood that the terminal repeaters are affected to transmit a marking impulse to relays **1303** and **1113**.

The two-way trunk circuit to the master office shown in Figs. 11 and 13 will now be described. Before giving a detailed description of the circuits, the various functions of this circuit will be enumerated.

When this circuit is seized by a calling subscriber it is designed to send a mark signal to the distant manual office as the calling signal. In the case of an outward call this circuit is arranged to await an automatically sent ringing signal from the distant central office as a trunk conductor test before permitting the link to connect the calling subscriber to the trunk. In the case of an outward call this circuit is arranged to warn the miscellaneous alarm circuit that either the calling-in signal has not been registered at the distant central office or, in any event, that the automatically sent ringing signal from the central office has not been received at the line concentration unit. When the miscellaneous alarm circuit "times out," this circuit in conjunction with the sequence circuit takes the trunk in question out of service, making it busy to a local calling subscriber and sending a special signal originated in the sequence circuit to the operator at the distant end to indicate that the trunk is in trouble. In the case of an outward call, after the link has connected the calling subscriber to the trunk circuit and the sequence circuit has released but before the sequence circuit is made available for the routing of the new call, this trunk circuit is arranged in conjunction with the trunk sequence portion of the sequence circuit to make this particular trunk busy to all calling subscribers. This busy condition is locked in as long as the trunk is in service on a particular call. On a call originated by a subscriber this circuit remains in such a condition prior to being answered at the distant manual end that the local calling subscriber may manually flash the calling lamp at the distant manual end. Under this condition, if a subscriber disconnects before the operator answers, the calling mark signal is immediately discontinued and the signal lamp at the manual board is extinguished. After approximately three and seven-tenths seconds this circuit closes the bias winding of the loop supervisory relay, permitting it to detect the subscriber's release signal, upon detection of which this circuit orders the link circuit to release the calling subscriber's line from the selected trunk. As soon as the calling subscriber is disconnected from the selected trunk the busy condition is immediately removed and the trunk in question is made available to another calling subscriber. In the case of a call originated by a subscriber when a mark signal is sent from the central office to the line concentration unit, indicating that an operator has answered the subscriber being connected to the trunk circuit, the circuit is arranged to change to the half-duplex basis or the normal transmitting condition. After the circuit has been arranged to operate on a half-duplex basis in the case of a toll subscriber's line circuit, a ground is sent back over the sleeve lead, such as conductor **522**, to hold the toll subscriber's line circuit during transmission of pulses. During the half-duplex transmitting condition the circuit is arranged to distinguish between normal transmission of pulses and a transmission break caused either by the sending of a normal break from either end or by a subscriber disconnecting.

Upon the reception of a long space or break signal from the concentration unit this circuit sends a space signal to the distant end provided, of course, that a space signal is not already being received from the manual end. After three-fourths of a second continuous space the circuit closes the bias winding of the loop supervisory relay to permit it to detect the subscriber's disconnect signal. If the subscriber has not disconnected, this circuit continues to send ringing current to the manual end as long as the break persists. Upon the reception of a long space signal from the distant manual end this circuit immediately sends a space signal to the subscriber if the subscriber is not already originating a space signal. After one-half second this circuit continues and increases the loop spacing current to 10 milliamperes and arranges to make the loop supervisory relay more sensitive. The trunk circuit is also then arranged to detect the reception of ringing from the manual end, at the same time closing the bias winding of the loop supervisory relay to permit it to detect a subscriber's disconnect signal. The trunk circuit also removes ground from the sleeve lead to the toll subscriber's line circuit to permit such circuit to independently start timing the duration of the break, as heretofore described, and thereafter to enable the detection of the subscriber's disconnect signal, the results of which are sent to the trunk circuit over the ring lead, such as conductor **514**.

If the reception of a three-quarter second space signal from the manual end is followed by ringing from the manual end, indicating the reception of a break, the circuit remains in the condition above described for the duration of the ringing, provided the subscriber does not disconnect. Upon the conclusion of a break signal the circuit returns to its transmitting condition, sending a mark signal to the distant end if a subscriber's break was terminated or a mark signal to the subscriber if a break from the manual office was terminated. If the loop supervisory relay under the conditions above described detects a subscriber's disconnect signal, the trunk circuit sends a continuous space signal to the manual end as a disconnect signal. If the reception of a three-quarter second space signal from the manual end is not followed by ringing, the trunk circuit assumes the distant end has disconnected and as the subscriber has already disconnected, orders the link circuit to release the subscriber's line from the trunk. If the subscriber sends a recall signal during the reception of a mark signal from the central office the circuit sends a continuous space signal to the manual end as a disconnect signal and then sends a mark signal to the central office as soon as the subscriber's loop is closed again, thus erasing the disconnect signal. If a subscriber sends a recall signal after the registration of a break signal and during the reception of ringing from the manual end, the loop supervisory relay detects the opening of the subscriber's loop and sends a space signal to the manual end, changing it to a mark signal as soon as the subscriber's loop closes again. If a subscriber sends a recall signal during the reception of a space signal from the manual end no space signal is sent to the manual end until the loop super-

visory relay detects the open loop condition or a maximum delay of approximately one-half second as compared with the condition just described. When an operator at the manual end seizes a trunk to the line concentration unit this circuit receives a mark signal from the central office and upon the reception of such a signal of a definite length, the trunk circuit is arranged to make the trunk test busy to all calling subscribers and to enter the trunk portion of the sequence circuit for the privilege of seizing a director and routing the call to the calling subscriber. If an operator seizes a trunk at the central office at the same time that a subscriber makes an outward call calling for a routing over the same trunk, the operator receives the use of the operator's trunk and the subscriber's outward call is routed to the next idle trunk. If the operator selects a trunk after the calling-in signal appears, the calling subscriber will be connected to the calling operator. When the privilege to route the call through the office is received, the trunk circuit is connected to the director circuit to permit the latter circuit to send the "director ready" signal to the central office end and to receive from the central office the calling subscriber's number. The director decodes the information received from the central office end and proceeds to test the called subscriber line to determine whether it is idle, busy, out of order or unassigned. If it is idle it proceeds to connect the subscriber line to the trunk circuit. If the subscriber line is found in any of the other conditions a distinctive signal is immediately sent to the manual office. This distinctive signal has originated in the director circuit.

On a call originated by an operator when the called subscriber is connected to the trunk the sequence circuit is released, thus disconnecting the director circuit and the "director ready" signal from the particular trunk and making both the sequence circuit and director available to a new call.

The circuit is arranged to repeat ringing under control of the distant operator. In the case of a local subscriber line ringing is sent out over the tip conductor to the subscriber's premises, while in the case of a toll line terminating circuit ringing current is not sent to the subscriber line directly but a ground is sent over the sleeve lead, such as **522**, during the ringing period. It has been shown hereinbefore how relays **549** and **500** operate to send ringing current to the subscriber's line. When the subscriber answers the trunk supervisory relay operates, ringing is disconnected from the subscriber line and the trunk circuit is changed to a half-duplex operating basis.

If a call originated by the central office operator fails to get through due to conductor trunk failure, failure in the trunk circuit, the associated sequence circuit or the director circuit, the miscellaneous alarm circuit associated with this unit times out, returns the trunk circuit to normal and frees the director and sequence circuits. The trunk circuit is removed from service, being made busy to all calling subscribers and a distinctive signal originated in the sequence circuit is sent through to the distant central office to indicate to the operator that the trunk is in trouble. If the operator seizes a trunk at the central office but disconnects before the "director ready" signal is sent, the trunk circuit at the line concentration unit returns to normal immediately, releasing the sequence and director circuits if attached. If the operator disconnects after the "director ready" signal has been received but before completion of typing of the number, the trunk circuit, sequence circuit and director circuit return to normal, discontinuing the "director ready" signal. If under the above conditions the operator sends a break signal, the sequence and trunk circuits return to normal, disconnecting the "director ready" signal, but the trunk circuit is still under control of the operator and busy to calling subscribers. If the operator disconnects before the called subscriber answers but after his line has been connected to the trunk circuit, this circuit functions to release the link circuit and disconnect the subscriber's line from the trunk.

The details of the operation of this two-way trunk circuit to perform these functions will now be described.

Outward call originated by a subscriber

When a subscriber associated with a line concentration unit originates a call the functioning of his associated line and sequence circuit places a ground on the start lead **1100** of the preselected idle two-way trunk circuit shown in Figs. 11 and 13, the selection of the first idle trunk being a function of the sequence circuit. Ground on conductor **1100** causes the operation of the start relay **1101** which locks under control of a ground found on conductor **1102** at the back contact and inner upper armature of relay **1200**. Relay **1101** operates the off-normal relay **1103** from ground, outer lower armature and front contact of relay **1101**, winding of relay **1103**, conductor **1116**, back contact and inner lower armature of relay **1201** to battery. Relay **1101** also places a ground through the front contact and middle lower armature of relay **1101**, the back contact and upper outer armature of relay **1104** to conductor **1105**, which conductor is extended by conductor **1305** through the normal contacts of jack **1300** to conductor **1301** leading to the distant manual office. This causes the transmission of a marking signal to the distant manual end as a calling-in signal. Relay **1101** also extends ground from the outer lower armature and back contact of relay **1106** through the outer lower armature and back contact of relay **1107**, the outer upper armature and front contact of relay **1101** to conductor **1108** which connects in Fig. 23 to conductor **2308** and thence through the lower winding of relay **2301**. The connection of ground to the conductor **2308** and the operation of relay **2301** in the miscellaneous alarm circuit is utilized in such circuit as an indication that the trunk circuits have become off-normal and a calling signal has been sent to the distant manual end. The operation of the off-normal relay **1103** supplies ground to the winding of relay **1109** through the front contact and inner upper armature of relay **1103**, thence through the winding of relay **1109**, conductor **1110**, conductor **910** to the associated contacts of group **901** preparatory to extending this to conductor **928**, for the holding of relay **903** when the ground originally extended over conductor **828** is removed. The off-normal relay **1103** also furnishes battery potentials to the bias winding of the loop supervisory relay **1111** from battery, the lower armature and front contact of relay **1103**, resistance **1112**, the lower outer armature and back contact of relay **1104** and the lower winding of relay **1111** to ground. The off-normal relay **1103** also supplies battery potential to

the bias winding of the relay 1113 of the loop repeater over a circuit from battery, lower armature and front contact of relay 1103, resistance 1114, back contact and upper outer armature of relay 1302, lower winding of relay 1113 to ground.

At the distant manual end the reception of a mark signal is used to place busy condition on the multiple and advance the idle indicating lamp if one is used, light the calling-in signal lamp and at the same time send a continuous ringing signal to the line concentration unit. Reception of ringing in this circuit causes the relays 1303 and 1113 to operate and release rapidly. The rapid operation and release of relay 1303 has no effect upon relay 1304 but the relay 1113 of the line repeater connecting, as it does, negative battery and ground alternately to relay 1115, simulates an alternating current and relay 1115 responds. The operation of this relay causes the operation of relay 1107 from ground on the lower outer armature and front contact of relay 1101, armature and contact of relay 1115, winding of relay 1107, back contact and upper outer armature of relay 1106 to conductor 1116 leading, as before, through the back contact and lower armature of relay 1201 to battery. Relay 1107 removes ground from conductor 1108 and releases relay 2301 thus notifying the miscellaneous alarm circuit that the trunk is no longer off-normal since the proper reception of the calling mark signal at the distant manual office has resulted in the application of ringing current back toward the concentration unit. Relay 1107 also furnishes another operating path for the off-normal relay through its front contact and inner upper armature. In addition, relay 1107 causes the operation of relay 1117 from ground, the lower outer armature and back contact of relay 1106, the lower outer armature and front contact of relay 1107, winding of relay 1117, through the contact 1118 of jack 1119 to battery. Relay 1117 places battery on conductor 1120 which may be traced through conductor 920 to selector magnet 900, thus operating this selector magnet to prepare for the operation of the contacts 901. The operation of the selector magnet 900 causes ground to be extended over conductor 902 to conductor 2302 to operate relay 2300 in the miscellaneous alarm circuit. This results, as before described, in certain operations which return a ground over conductor 628 extending to conductor 828 and causing the operation of holding relay 903. The operation of the relay 903 causes the operation of the holding magnet 800, resulting in the extension of the subscriber's line circuit conductors through the contacts of set 901 and the release of the subscriber's line circuit (Fig. 6). As will be seen hereinafter, the operation of holding magnet 800 also releases the subscriber's subgroup sequence circuit, the subscriber's group sequence circuit, the sequence start circuit and finally results in the application of ground to conductor 1121 of the trunk circuit. Ground on the conductor 1121, the start relay 1101 being operated, is extended through the middle upper armature and front contact of relay 1101 to conductor 1122 which causes the operation of relays 1202 and 1200 in the sequence circuit, resulting in the release of relay 1101. However, before relay 1101 has had time to release, the operation of the hold magnet of the link circuit has connected battery through the hold relay 903, conductor 928, the corresponding contacts of the set 901, conductor 910, conductor 1110, to the sleeve relay 1109 to ground at the inner upper armature and front contact of relay 1106, and has connected the other leads from the subscriber's line circuit through to the trunk circuit.

If the calling subscriber is a local subscriber, battery connected to the tip conductor through his closed loop is extended over ring conductor 1123, the contacts of jack 1124, the upper winding of relay 1111, the back contact and upper outer armature of relay 1306 to ground, causing relay 1111 to operate. If the calling subscriber is a toll subscriber, such as one of those shown in Figs. 2 and 3, the toll line circuit connects battery potential to the ring conductor 514 which is extended through ring conductor 1123, normal contacts of jack 1124, the upper winding of relay 1111, back contact and upper outer armature of relay 1306 to ground, thus operating relay 1111. Relay 1111 through the movement of its armature connects ground through relay 1104 to conductor 1116 and thence to battery in the circuit heretofore traced through the back contact and lower armature of relay 1201. At the same time battery through the winding of holding relay 903 is extended back over conductor 1110 through the winding of relay 1109 and thence through the innermost upper armature and front contact of relay 1103 to ground, causing the operation of relay 1109 which results in the application of ground over the upper armature and front contact of relay 1109 to the winding of relay 1126 which, being polarized, will operate its armature in response to the movement of the armature of relay 1127 as will hereinafter appear. Relay 1109 also completes a connection from ground, front contact and lower armature of relay 1109, winding of relay 1106 to battery on conductor 1116, thus operating relay 1106. Relay 1106 supplies ground to conductor 1123 to keep the hold chain relays of the sequence circuit operated as will be more fully explained hereinafter. Relay 1106 causes the release of relay 1117 through removal of ground at the back contact of the lower outer armature of relay 1106, thus releasing the selector magnet 900 of the link circuit. Relay 1106 also places ground on the potentiometer in the associated loop repeater. This ground may be traced from the front contact and inner lower armature of relay 1106, through resistances 1129 and 1154 to a point between resistances 1130 and 1131. The purpose of this will appear shortly. Relay 1106 also lights the trunk busy lamp 1132 through a circuit from battery, lamp 1132, inner upper armature and front contact of relay 1106, outer upper armature and front contact of off-normal relay 1103 to ground. Relay 1106 further furnishes operating battery to relay 1133, the circuit for which may be traced from battery on conductor 1116 through the upper outer armature and front contact of relay 1106 to the winding of relay 1133 which is extended to the front contact of relay 1134 for purposes which will shortly appear.

The operation of relay 1104 provides an alternate operating path for the off-normal relay 1103 which may be traced from battery on conductor 1116, through the winding of relay 1103, the front contact and inner upper armature of relay 1104 to ground. Relay 1104 opens the circuit of relay 1115 through the movement of its inner lower armature, thus causing relay 1115 and relay 1107 to release. Relay 1104 opens the bias winding of the supervisory relay 1111 to help it remain operated. This last operation is caused by the opening of the connection between the back contact and lower outer armature of relay 1104. Re-

lay 1104 also closes a circuit from ground, its lower inner armature and front contact to conductor 1135 for the purpose of activating the vacuum tube 1136. Relay 1104 further replaces a marking signal toward the distant manual end created by the operated start relay 1101, by a marking signal on the armature of relay 1127 of the loop repeater which, incidentally, had operated at the same time as relay 1111 had operated. The release of relay 1107 removes ground from the conductor 1137 which may be traced through conductor 937 to conductor 804 through conductor 627 and conductor 522 for purposes hereinbefore described.

At this stage of the call, the calling-in signal having been registered, and having caused the illumination of the line lamp at the distant manual switchboard, the subscriber having been connected to the trunk, and the sequence circuit being released for use on a new call, the subscriber is awaiting the answer of the operator. Under this condition the subscriber can flash by operating and releasing the power switch associated with his set. The release of the power switch to the off position causes the reception of a space signal in this trunk circuit which results in the operation of the relay 1127 from the tip lead 1145, upper outer armature and back contact of relay 1142 to the operating winding of relay 1127 of the loop repeater. Relay 1127 moves to its spacing contact, in turn sending a spacing signal to the distant manual end where it results in the extinguishing of the calling line lamp. The operation of relay 1127 to its spacing contact causes the operation of polarized relay 1126 to its right-hand contact, permitting positive battery through resistance 1138 to slowly charge condensers 1139 and 1140. Condenser 1139 is charged in a circuit from positive battery, resistance 1141, resistance 1138, condenser 1139 and its associated resistance, conductor 1135 to ground on the front contact and inner, lower armature of relay 1104. Condenser 1140 is charged in a circuit from positive battery, resistance 1141, resistance 1138, the inner upper armature and back contact of relay 1142, condenser 1140, resistance 1143 to ground. The reoperation of the power switch to the on position causes the reception of a mark signal from the subscriber in this circuit, resulting in the operation of relay 1127 of the loop repeater to its marking contact, thus sending the marking signal to the distant manual end where it causes the reillumination of the calling lamp. Locally, in this circuit it causes the polarized relay 1126 to operate to its left contact to discharge the condensers 1139 and 1140. Tube 1136 and its associated apparatus has been designed to prevent sufficient plate current to flow to operate the relay 1134 until approximately three and three-quarters seconds have elapsed. If, therefore, the subscriber flashes at such a rate that at no time the spacing signal received from his set exceeds three and three-quarters seconds the operation and release of the power switch will only cause the flashing of the line lamp at the distant manual switchboard.

Should the space signal received from the subscriber's set exceed this amount the circuit will assume the subscriber has disconnected. The time having been exceeded, the relay 1134 will operate and cause in turn the operation of relay 1133 which connects potential to the bias winding of the supervisory relay 1111 in a circuit including the front contact and lower armature of relay 1133 and resistances 1153 and 1112 to battery on the lower armature of relay 1103. The placing of potential on the bias winding of the supervisory relay 1111 permits it to detect the subscriber's release signal. The subscriber having disconnected, the relay 1111 will release and in turn will release relay 1104. The release of relay 1104 causes the release of the off-normal relay 1103. The off-normal relay 1103 releasing will remove ground from the relay 1109, allowing relay 1109 and the associated hold relay 903 to release. The release of relay 1109 causes the release of relay 1106, thus returning the circuit to normal. Relay 1106 in releasing removes ground from the hold chain lead 1128, thus releasing the relay 1200 and 1202 of the sequence circuit and removing the busy condition making the trunk available to another calling subscriber.

If when start relay 1101 originally operated as the result of a subscriber call the calling signal sent to the distant manual end either failed to arrive due to an open outward conductor or failed to be registered at the distant end or at any rate if the ringing automatically sent from the distant end failed to be registered in this circuit, the relay 1115 and therefore the relay 1107 would not have operated and ground would continue to remain on the conductor 1108 leading to conductor 2308 of the miscellaneous alarm circuit. The operation of relay 2301 under this type of call will result in approximately two seconds in the application of ground to conductor 2325 as will be further explained hereinafter, which conductor will thereupon extend ground through conductor 1125, the front contact and inner lower armature of relay 1101 to conductor 1144, ultimately causing the operation of relay 1203 in the sequence circuit where the "busying out" apparatus will function (1) to advance the trunk chain portion of the sequence circuit thereby opening the conductors 1100 and 1102 causing the release of start relay 1101 and forcing the subscriber to the next idle trunk, and (2) to place a distinct signal on the conductor 1146 which would be transmitted to the associated terminal repeater and therefore to the distant end where if the registration of incoming signals is not faulty it would cause a distinctive flash of the calling-in signal or the supervisory lamp of the cord circuit as an indication of trunk trouble, and (3) would cause the trunk lamp associated with this circuit to flash as an indication of trouble.

Operator answers an incoming call

When the operator inserts a cord plug into the jack associated with the calling-in signal lamp the equipment at the distant end functions to (1) disconnect the ringing which has been continuously sent since the calling subscriber's mark signal reached the distant end, and (2) to transmit a marking signal to this trunk causing the continued operation of both relays 1303 and 1113 to their marking contacts. The operation of relay 1303 to its marking contact opens the secondary winding of relay 1304. Current in the secondary winding of relay 1304 continues to flow to charge condenser 1307 through resistances 1314, 1308 and 1147 to ground. After approximately a half second has elapsed the charging current has diminished to such a value that relay 1304 operates on its primary winding to its right-hand contact, causing the operation of relay 1309 and relay 1142. Relay 1309 is operated in a circuit from ground, the right-hand contact and armature of relay 1304, the normal contacts of the lower armature of relay 1310, winding of

relay 1309, conductor 1316, to battery on conductor 1116. Relay 1142 is operated in a circuit from ground, the right-hand contact and armature of relay 1304, conductor 1311, winding of relay 1142 to battery on conductor 1116.

Relay 1309 in operating definitely opens the secondary winding of relay 1304. Relay 1309 also removes ground from the conductor 1312 leading through conductor 1149 to the sequence circuit for purposes which will hereinafter be described. Relay 1309 places ground on conductor 1322 which is extended over conductor 1122 to the sequence circuit to operate the advance chain relays 1200 and 1202 in the sequence circuit. Relay 1309 also short-circuits resistance 1313 through its inner lower armature and front contact. Normally, approximately 5 milliamperes flows continuously along the following path from battery, resistance 1314, resistance 1315, filament of tube 1317, lower winding of relay 1304, resistance 1313 and the bias winding of relay 1303. The short circuit of resistance 1313 and the connection of resistance 1318 to ground cause this 5-milliampere current to be increased so that 60 milliamperes flow through the filament of the tube and the primary winding of relay 1304 and 30 milliamperes through the bias winding of the relay 1303.

The operation of relay 1142 furnishes an additional operating path for the off-normal relay 1103 through its front contact and lower outer armature and causes the operation of relay 1302 under control of relay 1111. The operating path for relay 1302 may be traced from ground on the armature and right-hand contact of relay 1111, through the lower inner armature of relay 1142, the winding of relay 1302 to battery on conductor 1116. Relay 1142 removes condenser 1140 from the grid of vacuum tube 1136 and completes the transmitting path from the loop repeater to the subscriber's line through its upper outer armature and front contact.

Vacuum tube 1317 and its associated apparatus is designed to monitor the marking contact of relay 1303 and will not permit sufficient current to flow in the plate circuit to operate relay 1319 until relay 1303 has registered a space signal in excess of a half second. The operation of relay 1302 in general arranges the loop repeater for half-duplex operation and furnishes a ground for the sleeve lead 1137 through the armature and right-hand contact of relay 1304. The circuit is now in the transmitting stage. Ordinary incoming telegraph signals are monitored on by relay 1303. The vacuum tube 1317 and its associated apparatus does not function on the telegraph signals. Outward signals from the subscriber's set are monitored on by relay 1126 and here also the vacuum tube 1136 and its associated apparatus does not function on telegraph signals. Telegraph communication is therefore possible until a space signal of over a half second is sent in either direction. During transmission the following relays are operated: 1309, 1142, 1109, 1106, 1103, 1104, 1302, 1111 to its right-hand contact and 1304 to its right-hand contact. Relays 1303, 1113, 1127 and 1126 follow the telegraph pulses.

Transmission of break signals in either direction

When the subscriber operates the break key at his station a space signal is received from him in this trunk circuit causing relay 1127 of the loop repeater to operate to its spacing contact and to transmit a space signal to the distant end. Locally relay 1126 will operate to its right-hand contact, thus removing ground from the grid of vacuum tube 1136. After approximately three-quarters of a second condenser 1139 will receive sufficient charge through resistance 1138 to permit a plate current to flow that will operate relay 1134. The operation of relay 1134 causes relay 1133 to operate, which terminates the space signal sent to the distant office and sends instead a 20-cycle ringing current from the source indicated by the current limiting resistance lamp 1150. Relay 1133 also applies potential to the bias winding of relay 1111 permitting this relay to detect the subscriber's disconnect signal. The net result of a subscriber's break, therefore, is the transmission of a three-quarter second space signal to the distant office followed by ringing for the remaining duration of the subscriber's break.

If a break is originated at the distant manual office or beyond, this circuit receives a space signal of three-quarters of a second in length followed by ringing for the duration of the break originated at the distant end. At the expiration of a one-half second space signal condenser 1320 obtains sufficient charge to permit a plate current to flow in vacuum tube 1317 of sufficient magnitude to operate relay 1319 which in turn causes the operation of relay 1321. Relay 1321 operating, again closes the secondary winding of relay 1304 to ground on the space contact of relay 1303. As soon as relay 1304 operates to its spacing contact ground is available for the operation of relay 1306. Relay 1306 in operating increases the subscriber's loop space current from 5 to 10 milliamperes to permit the relay 1111 to more definitely determine whether a subscriber has disconnected. The manner in which this is accomplished is through opening the connection from ground, the outermost upper armature and back contact of relay 1306 to a point between resistances 1324 and 1325. While relay 1306 is unoperated resistance 1324 is short-circuited and therefore when relay 1306 operates, resistance 1324 is placed in series with resistance 1325. The battery for supplying the loop spacing current is that connected to resistance 1131 and the path of the current may be traced through resistance 1131, resistance 1129, the biasing winding of relay 1127, the main winding of relay 1127 to the tip conductor 1145. The potential at the point where this connection enters the biasing winding of relay 1127 is reduced by connection through resistance 1154, the inner lower armature of relay 1106 to ground. The potential at the point between the biasing and the main windings of relay 1127 is further reduced by a connection through the outer upper armature and front contact of relay 1302, the armature and spacing contact of relay 1113 to resistances 1325 and 1324. If, therefore, the resistance 1324 is introduced into the circuit, the potential at the point between the biasing and main windings of relay 1127 is raised and therefore the current through the main winding rises from 5 to 10 milliamperes, as before stated. Relay 1306 by disconnecting ground at its middle upper armature and back contact from the upper winding of relay 1111 places the middle and upper windings of relay 1111 in series with the ring conductor 1123. Relay 1306 furnishes an additional operating path for relay 1304 through the front contact and innermost upper armature of relay 1306. Relay 1306 also locks under control of relay 1304 through its lower armature and front contact and through its additional contacts worked by this

lower armature it places a ground through the back contact and outer upper armature of relay 1323 to the grid of vacuum tube 1317, resulting in the release of relay 1319. Relay 1319 in releasing causes the release of relay 1321. Ground on the space contact of relay 1304 through the operated locking contact of relay 1306 and now normal back contact of relay 1321 causes relay 1323 to operate. Relay 1323 in operating removes ground from the grid of vacuum tube 1317 which has just been applied to cause this vacuum tube to go through another cycle of operations. Relay 1323 also connects potential to the bias winding of relay 1111 to permit it to detect a subscriber's release signal. This circuit may be traced from battery through the lower armature and front contact of relay 1103, resistances 1112, 1153 and 1151, the front contact and middle upper armature of relay 1323, to the lower winding of relay 1111 and thence to ground. Relay 1123 removes ground from the sleeve lead to the toll subscriber's line circuit to permit the latter circuit to determine for itself whether a subscriber has released. This ground is removed at the back contact and inner upper armature of relay 1323. Relay 1323 also short-circuits at its front contact and inner lower armature the line winding of relay 1113 of the loop repeater definitely continuing a space signal toward the subscriber. Relay 1323 finally prepares an operating path for relay 1310 from ground, the armature and front contact of relay 1319 when this relay again becomes operated, through the outer lower armature and front contact of relay 1323, the back contact and lower armature of relay 1302, the lower winding of relay 1310 to battery on conductor 1316.

After a space of three-quarters of a second has been received from the distant end, the distant end sends 20-cycle ringing current to the concentration unit. This causes the relay 1303 to operate and release at the rate of 20 cycles per second. Due to condenser 1307, relay 1304 will remain on its spacing contact provided the armature of relay 1303 does not stay on its marking contact for more than 0.45 second. Therefore, relay 1304 will remain on its space contact as long as the ringing is received. The net result, therefore, of the reception of a break from the distant end is to send the continuous space signal to the concentration unit subscriber and locally in this circuit to register the fact that a break has been received.

In the description above the performance of the circuit upon the reception of a break from either end depended upon the reception of a marking signal from the opposite end. Since the loop repeater associated with this circuit and also the loop repeater associated with the terminating circuit at the distant end are both arranged in the transmitting condition to operate on a half-duplex basis, the reception of a break signal from both directions will cause one break signal to nullify the other.

Resumption of transmission after a break signal

When the subscriber releases the break key at his station a mark signal is received from him in this circuit, causing the relay 1127 to operate to its marking contact and resulting in the operation of relay 1126 to its left-hand contact causing the application of ground to the grid of vacuum tube 1136 and in turn resulting in the release of relays 1134 and 1133. The release of relay 1133 not only removes the battery potential from the bias winding of relay 1111 but also disconnects the 20-cycle ringing current from the outward path and allows the marking polarity of the armature of relay 1127 of the loop repeater to be connected to the sending leg including conductors 1105, 1305 and 1301 of the terminal repeater. The circuit, therefore, has returned to the original transmitting condition. At the conclusion of the break originated at the distant manual end, ringing is removed from the circuit and a mark is received from the distant end. This causes the operation of relay 1303 to its marking contact and after approximately .045 second results in the operation of relay 1304 to its marking contact, resulting in the release of relays 1306 and 1323, thus returning the circuit to its original transmitting condition.

Subscriber disconnects

When a subscriber disconnects at his station while a mark signal is being received from the distant manual end the circuit functions as hereinbefore described. Relay 1111, however, detects the subscriber's release signal and causes the release of relays 1104 and 1302. The release of relay 1104 (1) definitely continues a space signal toward the distant manual end, (2) opens up one of the operating circuits of the off-normal relay 1103, (3) removes power from the vacuum tube 1136 and its associated apparatus, (4) effectively connects relay 1115 to the armature of relay 1113 of the loop repeater, and (5) increases the current to the bias winding of relay 1111 by short-circuiting the resistance 1153. The continued spacing signal sent to the distant manual end is an indication at that end of the subscriber's disconnect.

If a subscriber should disconnect while the spacing signal is being received from the distant manual end relay 1127 of the loop repeater will, of course, remain upon its marking contact and will continue to send a marking signal to the distant manual end. When the incoming space signal has been registered as heretofore described, the connection of potential to the bias winding of relay 1111 will permit it to detect the subscriber's release signal and, therefore, to operate to its left-hand contact and cause the release of relays 1104 and 1302. As indicated above, the release of relay 1111 will send a steady space signal toward the distant manual end where it will be registered as a subscriber's disconnect.

If a subscriber should disconnect while the ringing portion of the break signal is being received from the distant manual end, relay 1111 releases immediately causing the release of relays 1104 and 1302 and the immediate transmission of a space signal to the distant manual end.

Subscriber recalls

When the subscriber reoperates the power switch associated with his set to the mark position as a recall signal battery potential on the ring lead 1123 causes relay 1111 to reoperate to its right-hand contact, thus causing the reoperation of relays 1104 and 1302. The reoperation of these three relays returns the circuit to its regular transmitting condition, resulting in the transmission of a mark signal from the armature of relay 1127 of the loop repeater. The reception of a mark signal following a prolonged space signal at the distant end is an indication of a recall by a subscriber and is so registered. It should be noted that the reoperation of relay 1111 to its right-hand contact and the reoperation of relays 1104 and 1302 is entirely independent of

any signal or signals being received from the distant manual end provided, of course, a disconnect signal, indicating that the operator has taken down the cord, has not been received and registered in this circuit. When the operator wishes to rering a concentration unit subscriber who has just disconnected, she splits her cord circuit resulting in the reception in this circuit of a marking signal of sufficient duration to release relays 1306 and 1323 if they were operated. The operator then operates the ringing key, resulting in the reception of a 20-cycle ringing current at this office causing relays 1303 and 1113 to operate and release at the ringing rate. The operation and release of relay 1113 causes the operation of relay 1115 which in turn results in the operation of relay 1107. Relay 1107 in operating (1) places a supplementary operating path on the off-normal relay 1103, (2) connects 20-cycle ringing current to the tip lead 1145 to the subscriber's line circuit, and (3) connects ground to the sleeve lead 1137 to the toll subscriber's line circuit. In the case of a local subscriber, the application of ringing current to the tip lead of his line causes the bell at his station to sound. In the case of a toll subscriber line circuit, the ringing on the tip lead is not sent to the subscriber because the tip lead is open in the toll subscriber's line circuit but the application of ground on the sleeve lead causes the operation of a relay in the toll subscriber's line circuit which sends a fresh source of ringing out to the toll subscriber's premises as hereinbefore described.

Operator disconnects in answer to a subscriber's disconnect

When a line concentration unit subscriber disconnects, this circuit functions as heretofore described to cause a disconnect signal to appear at the manual board. When the operator removes the cord from the jack this circuit receives a space signal from the manual end. After one-half second a space signal is received provided a mark signal was being transmitted when the operator disconnected, the circuit acts as described hereinbefore causing the operation of relays 1306 and 1323. If these relays have already been operated, due to the transmission of a break signal, the circuit acts after the first one-half second space signal as will be described hereafter in the second half second. After the second half second space signal has been received the vacuum tube 1317 again causes the relay 1319 to operate and through its operation to cause the operation of relay 1310 which holds the relay 1304 on its spacing contact, locks under control of the sleeve relay 1109 until the subscriber's line is released from the trunk circuit and causes the release of relay 1309. Relay 1309 in releasing causes relays 1306, 1323 and 1142 to release and relay 1142 releases the off-normal relay, which causes the sleeve relay 1109 and the subscriber's hold relay 903 and therefore the hold magnet 800 to release, disconnecting the subscriber's line from the trunk. The release of the sleeve relay 1109 causes relays 1106 and 1310 to release, thus returning the circuit to normal. If a new inward call is originated immediately relay 1310 in holding relay 1304 operated will not permit it to receive attention until the formerly connected line is removed from the trunk.

Operator originates a call

The operator originates a call for a subscriber in a line concentration unit by observing the idle indicating lamp, if it is available, by the busy lamp, or by making the busy test. Upon plugging into an idle trunk the trunk circuit at the distant manual end transmits a marking signal to the concentration unit. As hereinbefore described, the reception of a mark signal of approximately one-half second causes relay 1304 to operate to its right-hand contact and this results in the operation of relays 1309 and 1142. The operation of relay 1304 to its right-hand contact also applies ground to conductor 1155 and thence through conductor 1155 to the sequence circuit where it connects through the winding of relay 1204 and thence back through the back contact and upper outer armature of relay 1106 to battery on conductor 1116 since relay 1106 is not operated at this time. As will be more fully described hereinafter, the sequence circuit as a result of this functions to permit this trunk to be connected to an idle director circuit whereupon the transmitting lead from the central office is connected to the director circuit over conductor 1150 and the transmitting lead from the director circuit is connected to conductor 1146 for purpose of transmitting the "director ready" signal over conductor 1105. The sequence circuit in functioning also applies ground to conductor 1157 to cause the operation of relay 1117 and therethrough to operate the selector magnet in the link circuit associated with this trunk.

Routing of an inward call

When the director circuit is ready to receive the typing of the subscriber's number it connects a ground to conductor 1146 of this circuit and, therefore, to the sending leg of the associated terminal repeater which in turn sends a marking signal to the distant manual end as a "director ready" signal. Upon the reception of this signal the operator at the distant end types the called subscriber's number. The director circuit attached to the trunk circuit at this end deciphers the information and makes appropriate tests of the called subscriber's line. If the line is idle it arranges to connect it to the trunk circuit or if it is busy, out of order or unassigned, sends appropriate signals originated in the director circuit over conductor 1146 to the terminal repeater and thus to the distant end. If the called subscriber's line is idle the director causes the hold relay and magnet associated with the called line to operate and to connect the tip and ring of the subscriber's line to this trunk circuit. At the same time battery through the hold relay causes the sleeve relay 1109 to operate and in turn to operate relay 1106. Relay 1109 in operating places ground on the winding and armature of relay 1126. Relay 1106 in operating lights the trunk busy lamp 1132, removes battery from the lead 1158 to the sequence circuit and causes the sequence circuit to return to normal to remove ground from the lead 1157 and to disconnect the associated director circuit resulting in the removal of the "director ready" signal and consequently in the transmission of a space signal to the distant manual end. Relay 1106 also connects battery to the winding of relay 1133, supplies ground for the potentiometer in the loop repeater and furnishes ground to the hold chain lead 1128 to the sequence circuit to hold the advanced chain portion of the sequence circuit operated. Removal of ground from lead 1157 causes the release of relay 1117 and the associated selector magnets in the link circuit.

Ringing the called subscriber

The reception of a space signal at the distant manual end transmitted as indicated hereinbefore causes the illumination of the cord lamp at the switchboard. The operator can then operate the ringing key, resulting in the reception in the circuit of ringing current causing the operation of relays **1303** and **1113**. Both of these relays vibrate their armatures in unison with the ringing current. The rapid operation of the armature of relay **1303** has no effect upon vacuum tube **1317** but the operation and release of relay **1113** causes the operation of relay **1115** and in turn relay **1107**. The operation of relay **1107** (1) connects a separate source of superimposed ringing current from lead **1159** to the tip conductor of the local subscriber's loop causing the ringing of the subscriber's bell at his station, (2) furnishes a supplementary operating path for the off-normal relay **1103**, and (3) places ground on the sleeve lead of the toll subscriber's line circuit where it operates a relay which connects a separate source of ringing to the toll subscriber's line conductor as hereinbefore described. In the case of either the local subscriber or the toll subscriber, the bell of the subscriber's set will be rung therefor in accordance with the ringing received from the distant manual end. In the case of local lines of maximum loop resistance some ringing current due to the mutual line capacity flows into the windings of the supervisory relay **1111** but because of the condenser **1160** and the high bias current flowing in the bias winding of relay **1111** since relay **1104** is normal at this time, the supervisory relay remains on its left-hand contact.

Called subscriber answers

The called subscriber answers by operating his power switch to the "on" position or, in the case of an unattended subscriber's line, an equivalent action will take place. This causes the toll subscriber's line circuit to function in the case of the toll subscriber's line and to apply battery potential to the ring lead **1123**. In the case of a local line the throwing of the power switch to the "on" position closes the subscriber's loop. In either case, therefore, relay **1111** operates to its right-hand contact causing the operation of relay **1104**. Since relay **1127** is operated at this time relay **1111** also causes the operation of relay **1302**. The operation of relay **1104** (1) causes the release of relays **1115** and **1107**, (2) furnishes a supplementary holding path for the off-normal relay **1103**, (3) places power on vacuum tube **1136** and associated apparatus, (4) removes bias current from the supervisory relay **1111** to enable it to remain operated on its right-hand contact, and (5) connects the armature of relay **1127** of the loop repeater to the sending leg of the terminal repeater. The operation of relay **1302** arranges the loop repeater to function on a half-duplex basis and furnishes a ground on the sleeve lead **1137** to the toll subscriber's line circuit. The release of relay **1107** removes ringing current from the called subscriber's line and completes the transmission path from the loop repeater to the calling subscriber. The circuit is now in the transmitting stage and will continue to function as described hereinbefore.

Failure to complete the routing of an inward call

When the operator at the distant manual end originates a call the circuit functions as hereinbefore described. As soon as the privilege to route the call through the office is received from the sequence circuit, the miscellaneous alarm circuit starts timing the interval required for such routing. If due to the failure of any of the associated apparatus or the failure of the trunk conductors or due to unnecessary delay on the operator's part in typing the called subscriber's number and the time required for such routing exceeds ten seconds, the miscellaneous alarm circuit "times out." In timing out, the miscellaneous alarm circuit, when necessary, gives appropriate alarms and indications of the circuits possibly in trouble; causes the sequence circuit to remove the particular trunk from the advanced chain circuit thus making it busy to a calling subscriber; and at the same time places a characteristic signal on conductor **1146** which the terminal repeater transmits to the distant manual office. If the path to the central office is satisfactory and the operator's teletypewriter is still "in circuit" this characteristic signal will arrive on the teletypewriter. If the trunk path to the distant manual office is in good condition but the operator has already withdrawn the teletypewriter from the circuit this signal, which actually partakes of the nature of a disconnect signal followed by a recall signal, will cause the operator's cord lamp to flash. Upon reconnecting the teletypewriter into the circuit this distinctive signal will appear on the teletypewriter as an indication that the trunk is in trouble and that the call failed to get through.

Operator disconnects before subscriber answers

If the operator disconnects after originating an inward call before the "director ready" signal is sent back to the distant manual end, the prolonged space signal received in this trunk circuit from the distant manual end causes the vacuum tube **1317** and its associated apparatus consisting of relays **1319**, **1321**, **1304**, **1306**, **1323** and **1310** to operate as described hereinbefore. This results in the release of relays **1309** and **1142** and the removal of ground from lead **1355**, thus returning the circuit to normal. If the operator disconnects upon originating an outward call after the "director ready" signal has been sent and registered at the distant end the vacuum tube **1317** and its associated apparatus function because of a break signal received from the distant end. This break signal operating as it does relay **1323** as hereinbefore described causes the removal of ground from conductor **1355**, returning the sequence circuit and the director circuit to normal. The return of the director circuit to normal releases the sequence circuit and discontinues the "director ready" marking signal to the distant manual end and after a delay approximately five seconds the break signal is replaced by a disconnect signal causing the circuit to function as hereinbefore described to return to normal. If instead of disconnecting, the operator had sent a break signal this would, by operating relay **1323**, have released the sequence and director circuits but the trunk would remain under the operator's control. If the operator disconnects from an outward call before the called subscriber answers but after the called subscriber's line has been obtained, the reception of the disconnect signal from the distant manual end causes vacuum tube **1317** and its associated apparatus to function, returning the circuit to normal after approximately one second.

Simultaneous selection of the two-way trunk by a calling subscriber and the distant manual operator

If an operator seizes a trunk at the central office at the same time that a subscriber originates an outward call calling for the routing to the distant office over the trunk selected by the operator the trunk sends a marking signal to this end, causing relay **1304** to release and relays **1309** and **1142** to operate. The insertion of the plug at the manual switchboard also prevents ringing from being received at this end while ringing will ordinarily have been used to permit the connection of a subscriber's line to the trunk circuit. The operation of relay **1309** causes ground to be placed on the lead **1322** connecting through conductor **1122** to the sequence circuit operating the advance chain portion of this circuit and forcing a subscriber to use the next idle trunk. On the assumption that a subscriber originates a call simultaneously, the sequence circuit being assumed available at the same time, the subscriber will have seized the privilege of routing the call through the concentration unit. The operation in the advance chain, therefore, will connect ground to the start lead of the next idle trunk. After the routing of the subscriber's call to the distant manual office the sequence circuit is again free to route the operator's inward call. In simultaneous operation, therefore, the operator receives preference in the use of the trunk, the subscriber being forced to use the next idle trunk, but the routing of the subscriber's call will take place before the routing of the operator's inward call. If the operator plugs into a trunk circuit selected by an outward subscriber before the calling-in lamp is illuminated but after the trunk is busy, the subscriber may be forced to use another trunk as indicated above. This is due to the fact that ringing might have been received in this circuit for too short a time, not allowing time for the subscriber to have been connected by means of the link circuit to the trunk circuit. If the operator plugs into a trunk circuit the lamp of which has been illuminated, the calling subscriber and operator will be connected together, a fact of which the calling operator will soon become aware.

Two-Way Trunk Circuit Between Line Concentration Unit and Central Office

Central office termination

The circuit shown in Fig. 15 is the central office end of the two-way trunk circuit shown in Figs. 11 and 13. While many of the functions of this circuit have been mentioned and described in general terms in connection with the operation of the circuit of Figs. 11 and 13, a detailed description will now be given.

The functions of this circuit may be listed as follows: The circuit upon receiving a "calling-in" mark signal from the line concentration unit is arranged, after a brief delay, to light the busy lamp **1500** associated with the trunk multiple, to place a busy condition on the jack sleeve of all multiple appearances of the trunk and at the same time to send a steady ringing signal to the concentration unit as a preliminary trunk conductor test and as a means of connecting the calling subscriber to the selected trunk at the distant end.

Approximately three-quarters of a second after the trunk is made busy, the circuit lights the line lamp **1501** and actuates the night alarm circuit here indicated by an alarm **1502**, as a calling-in signal. The circuit is arranged to manually flash the line lamp under control of the subscriber's power switch at the distant end while waiting for the operator to answer. This circuit is also arranged not to register a disconnect signal from the line concentration unit when the cord is not in the trunk jack until a space signal of approximately five seconds duration has been received. If, while waiting for the operator to answer, the distant subscriber disconnects, this circuit removes the busy condition from the sleeve and extinguishes the busy lamps **1500** associated with the trunk. The circuit is arranged to prevent the illumination of the answering cord lamp when the operator plugs into a jack to answer an outward call.

Immediately after the operator plugs into jack **1503** to answer a calling signal, this circuit is arranged to extinguish the calling-in signal and to discontinue the ringing sent to the line concentration unit and place itself in a condition to detect space signals of a greater duration than occur in ordinary transmission of telegraph characters. Upon the reception of a long space signal from the concentration unit, this circuit immediately sends a space signal to the cord circuit provided a space signal is not being received from the cord circuit at that time. After the space signal has continued for one-half second, this circuit short-circuits the line winding of the receiving relay **1504** of the loop repeater, definitely continuing a space signal to the cord circuit, and arranges itself to detect the reception of ringing from the line concentration unit. If the reception of the three-quarter second space signal from the concentration unit is followed by ringing, indicating the reception of a break signal, the circuit remains in the condition just above described until the reception of ringing ceases, when the circuit returns to the transmitting condition. If the reception of the three-quarter second space signal from the concentration unit is not followed by ringing, indicating the reception of a disconnect signal from the concentration unit, this circuit continues to send a space signal to the cord circuit and after a one second space signal has been received, lights the cord circuit lamp as a disconnect signal. If this condition is followed by the reception of a mark signal from the concentration unit, this circuit causes the cord circuit lamp to flash as a recall signal and returns to the transmitting condition. Upon the reception of a space signal from the cord circuit this circuit immediately sends a space signal to the concentration unit provided a space or break signal is not being received from the unit at this time. After three-quarters of a second this circuit sends ringing instead of the space signal as long as the space signal from the cord circuit continues. When the cord circuit sends a mark signal, this circuit discontinues the ringing and sends a mark signal to the line concentration unit, returning to the transmission stage.

If a break signal (space followed by ringing) is received from the concentration unit while the cord circuit is transmitting a space signal, this circuit continues to send a mark signal to the cord circuit as long as the space signal from the cord is being received, changing it to a space signal when the cord circuit goes to a mark signal. If a continuous space signal is received from the concentration unit while a space signal is being received from the cord, this circuit after one second causes the cord lamp to light as a

disconnect signal, sending a mark signal to the cord until the disconnect signal is registered and then a space signal.

If the operator pulls a cord out falsely, this circuit sends a space signal followed by ringing toward the concentration unit until a disconnect is registered from the concentration end, meanwhile the line lamp **1501** is illuminated. Under this condition, the disconnect signal from the concentration end is not registered in this circuit until a space of approximately five seconds has been received from the concentration unit. Also under this condition if the subscriber at the concentration unit flashes, this circuit will cause the line lamp to flash in accordance with the subscriber's flashes.

When the operator removes the cord from the jack in answer to a disconnect signal from the concentration unit, the circuit returns to normal, sending a space signal to the concentration unit. This circuit is also arranged to permit rering of the subscriber's line after the reception of the disconnect signal from the concentration unit. The recall of the subscriber to the line, under the condition above described, causes this circuit to return to the transmitting condition and to extinguish the cord lamp as an indication that the subscriber has reanswered.

When the operator plugs into a jack to call a line concentration unit subscriber this circuit is arranged to light the cord lamp and to transmit a mark signal originated in the cord to the unit as a calling-in signal. After the reception of a "director ready" signal from the unit to indicate the readiness of the distant end to receive the called subscriber's number, this circuit is arranged to flash the cord lamp and assume the transmitting circuit condition. This circuit during the "director ready" signal is arranged to transmit to the cord circuit any information concerning the condition of the line sent to it from the unit and to similarly treat a special trouble signal. In the case of a trouble signal, only the cord lamp will light and then start flashing. If the operator disconnects after receiving information concerning the called subscriber's line, this circuit sends a three-quarter second space signal followed by ringing to the concentration unit. Under these conditions, after the reception of approximately five seconds space from the unit, this circuit returns to normal and sends a space signal to the unit.

If the operator sends a break signal to the unit instead of disconnecting, this circuit sends a break signal to the distant unit. Under this condition this circuit after reception of a one-second space signal from the concentration unit, lights the cord lamp. Under these conditions, when the operator discontinues the break signal, the circuit acts to send a mark signal to the concentration unit as a new calling signal.

The circuit is arranged to retransmit ringing from the cord circuit to the unit following the sending of the called subscriber's number. The reception of a mark signal from the unit, indicative of the answering of the call by the subscriber, causes this circuit to extinguish the cord lamp and to transmit any telegraph information received from the subscriber to the cord circuit.

Operation of the Termination Two-Way Trunk Circuit

Idle condition of the circuit

This circuit is designed to function with its associated loop repeater into an ordinary full-duplex terminal repeater connected to two paths to the distant line concentration unit. It is arranged to terminate these paths to the distant line concentration unit on switchboards having cord circuits such as that described in Patent 2,143,000 issued on January 10, 1939, to W. W. Cramer and K. E. Fitch.

During the normal idle condition, the polarized relay **1505** is held operated to its spacing contact by its local biasing winding which is included in a circuit from ground, resistance **1506**, the biasing winding of relay **1505**, resistance **1507**, the primary winding of relay **1508**, the filament of the vacuum tube **1509**, resistance **1510** to battery. Relay **1505** on its spacing contact completes a circuit from ground through the upper outer armature and back contact of relay **1511**, resistance **1512**, lower winding of relay **1508**, resistance **1513**, resistance **1510** to battery, holding relay **1508** to its left-hand contact. All other relays in this circuit in the idle condition are non-operated.

The inward path to the line concentration unit during the normal condition does not reach the loop repeater. Both inward and outward paths to the line concentration unit are normally in the spacing zero-current condition.

Reception of an outward call from the distant concentration unit

When a subscriber of the line concentration unit originates an outward call the distant trunk circuit transmits a marking signal to this office. The reception of the marking signal in this trunk circuit causes relays **1505** and **1504** to operate to their marking contacts. The operation of relay **1505** to its marking contact opens the lower winding of relay **1508** but current continues to flow through this winding to charge condenser **1514** through resistance **1512**. After approximately three-tenths of a second the charging current has diminished to such value that relay **1508** operates to its right-hand contact under the influence of its biasing winding. Relay **1508**, in operating, causes the operation of relay **1511** in a circuit from ground, the right-hand contact and armature of relay **1508**, the alternate contacts of the lower armature of relay **1515** and the winding of relay **1511** to battery. Relay **1511**, in operating, (1) opens the lower winding of relay **1508**, (2) opens the ring spring of jack **1503** at the back contact and inner upper armature of this relay, (3) locks under control of relay **1515** at its front contact and inner upper armature, (4) operates the off-normal relay **1516** through its front contact and innermost lower armature and by the same act places battery potential through resistance **1517** on the sleeve of jack **1503** to denote a busy condition, and (5) short-circuits resistance **1507**, causing the value of current flowing in the filament of vacuum tube **1509** to change. Normally, approximately 5 milliamperes flow continuously along the following path: From battery, resistance **1510** through the filament of vacum tube **1509**, upper winding of relay **1508**, resistance **1507**, upper winding of relay **1505**, resistance **1506** to ground. With the short-circuiting of resistance **1507** and the connection of resistance **1517** to ground, about 60 milliamperes of current will flow through the filament of the vacuum tube and the primary winding of relay **1508**, while a 30-milliampere bias current will exist in the upper winding of relay **1505**.

The operation of the off-normal relay **1516** (1)

connects the apex of the sending relay 1518 of the loop repeater from the outermost upper armature and front contact of relay 1516 to the front contact of the inner lower armature of relay 1521, (2) connects the bias winding of relay 1504 to marking potential through the front contact and middle upper armature of relay 1516, the outer upper armature and back contact of relay 1521, to the marking contact of send relay 1513, (3) lights the busy lamp at the various multiple appearances of this trunk from a source of alternating current 1522 through the front contact and innermost upper armature of relay 1516, (4) places ground on the winding of relay 1523 through its innermost lower armature and front contact, (5) connects power to vacuum tube 1524 through its middle lower armature and front contact, and (6) closes through an operating path for relay 1525 at its outermost lower armature and front contact. Relay 1525 is operated in a circuit from ground, armature and marking contact of relay 1505, the outer upper armature and back contact of relay 1520, winding of relay 1525, outermost lower armature and front contact of relay 1516, resistance 1526, resistance 1510 to battery. Relay 1525, in operating, transmits ringing current to the concentration unit in a circuit from a source of ringing current indicated by the current limiting resistance lamp 1527, the inner, upper armature and front contact of relay 1525, the outer lower armature and back contact of relay 1521, the back contact and inner lower armature of relay 1520, the back contact and upper armature of relay 1528 to the sending leg 1529. Relay 1525 also connects ground to the grid of vacuum tube 1509, keeping this grid negative with respect to the filament.

Meanwhile relay 1518 of the loop repeater remains on its spacing contact and relay 1523, which has operated to its right-hand contact, removes ground from the grid of vacuum tube 1524. After approximately three-quarters of a second, condenser 1530 having received a positive charge through the resistance 1531, the relation of the grid and the filament potentials of the vacuum tube 1524 is such as to cause a plate current to flow of sufficient magnitude to operate relay 1532. The operation of this relay causes the operation of relay 1528 and relay 1528 continues to send ringing current to the distant concentration unit directly from its front contact and upper armature. Through its front contact and inner lower armature, relay 1528 extends a ground connection through the inner lower armature and front contact of relay 1525 to the night alarm circuit and through its lower armature relay 1528 connects battery through the innermost lower armature and front contact of relay 1511, the front contact and outer lower armature of relay 1528, the outer upper armature and front contact of relay 1525 to line lamp 1501, causing the illumination of this lamp as a calling-in signal. The reception of ringing at the distant concentration unit is utilized to connect the calling subscriber to his preselected trunk.

Subscriber flashes prior to the operator's answer of an outward call

The subscriber is instructed to operate and release the power switch associated with his set if he wishes to flash the operator. At the distant line concentration unit the circuit is arranged to send mark or space pulses in accordance with the subscriber's power switch operation. The reception of a space signal in this circuit causes relay 1505 and relay 1504 to operate to their spacing contacts. The operation of relay 1505 to its spacing contact causes the release of relay 1525, resulting in the extinguishing of the line lamp 1501 and the silencing of the night alarm circuit represented by 1502. When the following mark signal is received, relay 1505 operates to its marking contact again, causes relay 1525 to reoperate and relight the lamp, and causes the reoperation of the night alarm circuit. The release of relay 1525 removes ground from the grid of vacuum tube 1509 but since under the flashing condition relay 1525 is never released for a time in excess of approximately five seconds, vacuum tube 1509 does not cause the operation of relay 1533. Operation and release of the subscriber's power switch, therefore, merely flashes the calling-in signal at the manual switchboard.

Disconnect of a calling subscriber prior to the operator's answer

If a calling subscriber at the line concentration unit should disconnect before the operator answers, the circuit at the distant end causes the termination of a mark signal and the transmission of a space signal. The reception of a continued space signal in this circuit causes it to function as just described. This time, however, relay 1525 being released for a period in excess of approximately five seconds, sufficient potential has accumulated on condensers 1534 and 1535 to change the potential of the grid with respect to the filament so that a plate current of sufficient magnitude flows to permit relay 1533 to operate. Relay 1533, in operating, causes the operation of relay 1536 over a circuit extending from ground, the armature and front contact of relay 1533, the inner, lower armature and back contact of relay 1537, winding of relay 1536 to battery. Relay 1536 closes the lower winding of relay 1508 to ground on the spacing contact of relay 1505. Relay 1508, therefore, operates to its spacing contact, resulting in the operation of relay 1538 over a circuit from ground, the front contact and inner upper armature of relay 1511, armature and spacing contact of relay 1508, front contact and lower armature of relay 1536, winding of relay 1538 through resistance 1539 to battery. Relay 1538 operates in this circuit and (1) closes an alternate path for the lower winding of relay 1508, (2) locks under control of relay 1508, and (3) connects ground through resistance 1540 to the grid of vacuum tube 1509. This connection to ground discharges condensers 1534 and 1535, causing the release of relay 1533. Relay 1533, in releasing, causes the release of relay 1536. Ground on the armature of relay 1511 through the spacing contact of relay 1508, the operated locking contact of relay 1538 and the now normal back contact of relay 1536 is extended to the winding of relay 1537 which now becomes operated. Relay 1537, in operating, (1) disconnects condenser 1535 from the grid of vacuum tube 1509, (2) short-circuits the line winding of relay 1504 of the loop repeater, (3) prepares an operating path for relay 1515, and (4) removes the ground from the grid of vacuum tube 1509 so that this vacuum tube may again go through its cycle of operation. One-half second after the removal of this ground, condenser 1534 will have received sufficient charge through the charging resistance 1541 to affect the grid and thus cause plate current to flow of sufficient magnitude to again operate relay 1533. Relay 1533, in operating, now causes the operation of relay 1515 which locks to ground

at the front contact and inner upper armature of relay 1511 and opens up the holding path of relay 1511, causing its release, and at the same time definitely holding relay 1508 to its spacing contact by the application of a ground at the upper armature and front contact of relay 1505 independent of the spacing contact of relay 1505. Relay 1511, in releasing, recloses the normal path of the lower winding of relay 1508, and returns ground to the ring spring of the jack from ground on the upper inner armature and back contact of relay 1511. The release of relay 1511 also causes the release of the off-normal relay 1516, removes battery from the sleeve multiple, returns the filament of vacuum tube 1509 and the bias windings of relays 1508 and 1505 to their idle condition and then causes the release of relays 1538, 1537, 1525 and in turn 1515.

Release of the off-normal relay 1516 extinguishes the busy lamps at the multiple appearances, removes power from vacuum tube 1524 and its associated apparatus and returns the loop repeater to its idle condition. The return of the 5-milliampere condition in the filament of vacuum tube 1509 causes the release of relay 1533. The removal of power from vacuum tube 1524 and its associated apparatus causes the release of relays 1532 and 1528, discontinuing the sending of ringing to the distant line concentration unit and effectively returns this trunk circuit to normal.

Operator answers an outward call

The operator in plugging the answering cord into a jack associated with a lighted line lamp causes the operation of the sleeve relay 1519 which in turn causes the operation of relay 1520 and furnishes additional battery for holding the off-normal relay 1516 operated. The plugging of the answering cord into this jack also keeps a busy potential on the sleeve of the jack. The operation of relay 1520 (1) disconnects condenser 1535 from the grid of vacuum tube 1509, (2) furnishes an operating battery for relay 1521, (3) removes the winding of relay 1525 from the marking contact of relay 1505, causing relay 1525 to release and connects the marking contact of relay 1505 to the grid of vacuum tube 1509, and (4) connects the armature of the sending relay 1518 of the loop repeater to the inward path to the line concentration unit. The release of relay 1525 (1) extinguishes the line lamps, (2) silences the night alarm circuit, and (3) removes supplemental ground from the grid of vacuum tube 1509. The marking potential in the cord circuit causes the operation of relay 1518 of the loop repeater to its marking contact, resulting in the operation of relay 1523 to its left-hand contact whereby ground from the middle lower armature of relay 1516 is connected to the grid of vacuum tube 1524. This causes the release of relay 1532 and in turn relay 1528 which discontinues the transmission of ringing current to the distant line concentration unit and completes the inward path to the line concentration unit. Meanwhile the operation of relay 1520 will cause the operation of relay 1521 which (1) locks under control of the ground at relay 1511, (2) definitely removes the possibility of sending ringing current to the line concentration unit should relay 1520 release on a false disconnect, and (3) changes the connection to the loop repeater to permit its operation on a half-duplex basis. Release of relay 1528 permits a marking signal from the armature of the sending relay 1518 from the loop repeater to be sent to the distant line concentration unit where it is utilized and is an indication that the operator has answered. The circuit is in its transmitting condition.

Transmission of telegraph signals will proceed uninterruptedly. This is possible because outgoing signals from the line concentration unit are monitored upon by relay 1505 and because vacuum tube 1509 and its associated apparatus have been designed not to function unless a space signal in excess of one-half second is received and similarly since inward signals to the line concentration unit are monitored upon by relay 1523 and vacuum tube 1524 and its associated apparatus which have been designed not to function unless an outward space signal in excess of three-quarters of a second has been transmitted. In the transmitting condition the following relays are operated: 1511, 1516, 1519, 1520, 1521 and relay 1508 to its marking (right-hand) contact. In this condition, relays 1523, 1505, 1504 and 1518 follow telegraph signals.

Transmission of break signals in either direction

When a subscriber operates his break key, the trunk circuit at the distant line concentration unit sends a three-quarter second space signal followed by ringing, provided, of course, that a marking signal is being received at the distant end at the same time. The reception of the space signal in this circuit causes relays 1504 and 1505 to operate to their spacing contacts. The operation of relay 1504 sends a space signal to the cord circuit. The operation of relay 1505 removes ground from the grid of vacuum tube 1509. After approximately one-half second has elapsed, condenser 1534 has received sufficient charge through charging resistance 1541 to affect the grid of vacuum tube 1509 and permit a plate current of sufficient magnitude to flow to operate relay 1533. As hereinbefore described, this results in the operation of relay 1536 and relay 1538, the release of relays 1533 and 1536 and the operation of relay 1539. After three-quarters of a second has elapsed the reception of ringing causes the relay 1505 to operate and release at the same rate as the ringing current. Relay 1537, being operated, has short-circuited the line winding of relay 1504 and, therefore, relay 1504 continues to send a space to the cord circuit. The rapid operation and release of relay 1505 prevents vacuum tube 1509 and its associated apparatus from again operating relay 1533 and at the same time permits relay 1508 to remain on its spacing contact. Relay 1508 and its associated apparatus under this condition are arranged to remain on the spacing contact provided a marking signal of no greater than .045 second is received from the line concentration unit. The circuit remains in this condition, continuing to send space current to the cord circuit as long as ringing is being received from the distant concentration unit.

When a break signal originated in the cord or in circuits beyond the cord is received in this trunk circuit the sending relay 1518 of the loop repeater operates to its spacing contact provided, of course, the marking signal is being received from the concentration unit. The operation of relay 1518 of the loop repeater to its spacing contact causes relay 1523 to operate to its right-hand contact. After three-quarters of a second has elapsed condenser 1530 has received sufficient charge through the charging resistance 1531 to affect the grid of vacuum tube 1524 to permit sufficient current to operate relay 1532. The op-

eration of relay 1532 causes the operation of relay 1528 which results in the sending of ringing current to the distant line concentration unit. Three-quarters of a second break followed by ringing is an indication of a break signal in the line concentration unit. The circuit remains in this condition, sending ringing current continuously to the line concentration unit as long as a break is being received from the cord circuit end.

The operation of this circuit as just described under the condition of a break signal from either end presupposes the reception of a marking signal from the opposite direction. Since during the transmitting condition the associated loop repeater of this circuit and also of the trunk circuit at the distant line concentration unit are operating on a half-duplex transmission basis, the reception of a space or break signal from both ends simultaneously is effectively prevented. The reception of a space signal from the line concentration unit, while this circuit is sending a spacing signal to the line concentration unit, is prevented by the loop repeater in the distant office and the sending of a space signal to the line concentration unit while this circuit is receiving a space signal from the line concentration unit is prevented by the loop repeater associated with the trunk circuit of this end. At the conclusion of the blocking space signal the break signal that was blocked will cause this circuit to function as described above, depending upon the direction from which the break was transmitted.

Resumption of transmission after a break signal

When the subscriber in the line concentration unit releases the break key associated with his set, the distant line concentration trunk discontinues the ringing and sends a mark signal to the circuit. Reception of a marking signal of greater than .045 second in this circuit causes relay 1503 to operate to its marking contact, resulting in the release of relays 1538 and 1539. Relay 1538, in releasing, opens the lower winding of relay 1503 and relay 1539, in releasing, removes the short circuit from the line winding of relay 1504 of the loop repeater, thus returning the circuit to its transmitting condition. The termination of the break signal received from the cord circuit causes a mark signal to be received from the cord, resulting in the operation of relay 1518 of the loop repeater to its marking contact. This causes relay 1523 to operate to its left-hand contact, reapplying ground to the grid of vacuum tube 1524 and causing the release of relays 1532 and 1528. The release of relay 1528 discontinues the ringing continuously sent to the distant line concentration unit and permits a mark signal originated at the armature of relay 1518 of the loop repeater to be sent to the distant line concentration unit. The circuit, therefore, similarly returns to the transmitting condition.

Line concentration unit subscriber disconnects

When the line concentration unit subscriber disconnects, the circuit at the distant end transmits a continuous space signal. The reception of a continuous space signal in the unit causes relay 1505 and relay 1504 to operate to their spacing contacts. After one-half second has elapsed, the circuit functions as hereinbefore described. Relay 1503 continues to remain on its spacing contact because relay 1505 remains on its spacing contact. After an additional half-second has expired, the condenser 1534 has again received sufficient charge to affect the grid circuit of vacuum tube 1509 to permit relay 1533 to operate. The operation of this relay, since relay 1537 is now operated, causes the operation of relay 1515 which locks under control of relay 1511 and places a ground on the lower winding of relay 1503 to permit it to hold on its spacing contact and then causes the release of relay 1511. Relay 1511, in releasing, (1) closes the normal holding circuit for relay 1503, (2) places ground on the ring spring of the jack to the cord circuit where it is instrumental in lighting the cord lamp as a disconnect signal, (3) removes one battery connection to the off-normal relay 1516, (4) reinserts resistance 1507 in the path of the filament of vacuum tube 1509, reducing the filament current to approximately 5 milliamperes, and (5) causes the release of relays 1538, 1537, 1515 and 1521. Relay 1521, in releasing, returns the associated loop repeater to its idle condition.

The reception of a disconnect signal from the line concentration unit subscriber while a marking signal is being received from the cord has therefore caused the cord lamp to light as a disconnect signal and to return to idle condition the following relays: 1504, 1505 and 1503 to their spacing contacts, 1511, 1538, 1537, 1515, 1533, 1536 and 1521 to their normal unoperated conditions.

If the subscriber's disconnect signal was received in this circuit while a space signal was being sent to the distant line concentration unit, the circuit would perform exactly as described except that the relay 1504 of the associated loop repeater would remain on its marking contact and therefore send a marking signal to the cord circuit as long as the break signal from the cord circuit persisted or at least until relay 1521 released; thereafter this circuit would transmit a space signal to the cord circuit.

Line concentration unit subscriber recalls

To send a recall signal, the line concentration unit subscriber is instructed to release his power switch for approximately one second and then reoperate it to its "on" position. This results in the reception of at least a one-second space followed by a mark signal from the concentration unit. During the one-second space signal the circuit functions exactly as described hereinbefore, causing the cord circuit lamp to light as a disconnect signal. Upon the reception of the mark signal from the distant line concentration unit relays 1505, 1504, 1503 and 1511 operate exactly as described above, causing in addition the reoperation of relay 1521 and thus returning the circuit to its transmitting condition. Removal of ground from the ring lead, however, causes the associated cord lamp to flash as a recall signal. The net result of a recall, therefore, is to return the circuit to the transmitting condition and to cause the associated cord circuit lamp to flash as a recall signal.

Rering of line concentration unit subscriber

If the operator wishes to rering a subscriber who has disconnected, as evidenced by the steady cord lamp, she depresses the ringing key of the cord circuit, causing the reception of ringing current in this trunk circuit and resulting in the rapid operation of loop repeater relay 1513. This results in the sending of marking and spacing pulses at ringing frequency to the distant line concentration unit. Reception of these marking and spacing pulses at the distant end, the subscriber's disconnect signal having been registered,

causes the ringing of the bell at the subscriber's station.

Operator disconnects in answer to a disconnect signal from a line concentration unit subscriber

The reception of a disconnect signal from a line concentration unit subscriber results in the steady illumination of the cord circuit lamp. Removal of a cord from the trunk jack in answer to the subscriber's disconnect signal results in the release of relay **1519** which causes the release of relays **1520** and **1516** and the operation of relay **1518** of the loop repeater to its spacing contact. Release of the off-normal relay **1516**, removing as it does power from vacuum tube **1524** and its associated apparatus, prevents the operation of relay **1523** and therefore sends a spacing signal to the distant line concentration unit as evidence of the fact that the operator has disconnected from the trunk. If the operator had disconnected while a space signal was being received from the cord, any ringing which might have been sent as a result of the operation of relay **1528** is discontinued with the removal of power from vacuum tube **1524** and its associated apparatus and replaced by a spacing signal to the distant line concentration unit. A prolonged space followed by a ringing signal is also an indication in the distant line concentration unit of an operator disconnecting from a trunk.

Operator originates an inward call

The operator originates a call for the line concentration unit by selecting an idle trunk as indicated by the absence of a lighted busy lamp or the busy potential on the sleeves of the jacks. Upon plugging into an idle trunk the cord circuit causes relay **1519** to operate. The operation of this relay results in the operation of relay **1520** and the off-normal relay **1516**. Through the connection of the plug to jack **1503** busy potential is placed on the multiples of the sleeve of this jack for giving a busy test to operators at other positions. The relay **1520**, in operating, (1) disconnects condenser **1535** from the grid of vacuum tube **1509**, (2) prepares an operating path for relay **1521**, (3) connects the marking contact of relay **1505** to the grid of vacuum tube **1509** and opens the circuit of relay **1525**, and (4) closes the inward path to the line concentration unit to the armature of the sending relay **1518**, which, having operated to its marking contact from the mark potential in the cord circuit, sends a marking signal to the line concentration unit for a calling-in signal. The operation of the off-normal relay **1516** (1) lights the busy lamps at the various multiple appearance of the trunk, (2) connects power to vacuum tube **1524** and its associated apparatus, (3) places ground on relay **1523** to enable it to monitor on the inward path to the line concentration unit, (4) connects marking potential to the apex of the sending relay **1518** of the loop repeater, and (5) connects marking potential to the bias winding of relay **1504** of the loop repeater.

Reception of the director signal

When the equipment at the distant end is available and ready to receive the called subscriber's number to be transmitted by the operator, the distant end transmits a continuous marking signal to this circuit. Reception of the marking signal causes relays **1504** and **1505** to operate to their marking contacts and, as described hereinbefore, results in the operation of relay **1521**, thus bringing the circuit to its transmitting condition. Ground is also removed from the ring spring of jack **1503**, causing the associated cord lamp to flash as a "director ready" signal.

Transmitting the called subscriber's number to the concentration unit

The operator after receiving the flashing "director ready" signal in her circuit extinguishes the flashing lamp and types the called subscriber's number on her teletypewriter. The permutation code signals are received in this circuit from the cord circuit and transmitted to the director in the concentration unit where they are decoded. In the director circuit a conductor individual to the called line is selected, whereupon this line is tested and if it is found idle the line is ordered by the director circuit to be connected to the calling trunk. If the director circuit discovers the called subscriber's line to be busy, out-of-order or unassigned, certain predetermined character codes are sent back to this end and result immediately in the typing of certain predetermined characters on the operator's teletypewriter. Similarly, if the distant end discovers trouble in the circuits in use, a special trouble out-of-order signal will be originated and sent to this end. In this case, however, in addition to affecting the operator's teletypewriter the signal being of such a nature, causes the registration of a disconnect and recall in this circuit, possibly resulting first in lighting the cord lamp and then causing it to flash. If the called line at the distant end is connected to the selected terminal the dismissal of the sequence circuit and the director at that end discontinues the transmission of the marking signal and its discontinuance in this circuit causes the registration of the disconnect, resulting in the steady lighting of the associated cord lamp.

Operator disconnects before the called subscriber answers

If the operator disconnects after receiving information concerning the called subscriber's line, such as busy, out-of-order, unassigned or in trouble, relays **1519** and **1520** will be released and a space signal will be received from the direction of the cord resulting in the sending of a break signal to the concentration unit. At the distant end reception of the break signal will order the release of the sequence circuit and the director circuit, terminating the sending of the permutation codes for the predetermined characters mentioned. Five seconds after a prolonged space has been received in this office, this circuit registers the disconnect signal and returns this trunk circuit to its normal idle condition. If, instead of disconnecting from the trunk upon the arrival of such predetermined character signals, the operator sent a break signal to the distant line concentration unit by means of the teletypewriter, this circuit would, of course, transmit a break signal to the distant end where it would result eventually in the transmission of a space signal to this circuit. After a one-second space signal had been transmitted this circuit would register a disconnect signal and the resulting release of relay **1511** would cause the associated cord lamp to light as a disconnect signal. When the break key of the operator's teletypewriter releases, this circuit would send a mark signal to the distant line concentration unit as a new calling-in signal.

If the operator disconnects after the called subscriber's line is connected to the trunk but before the called subscriber answers the ringing of

his line, the withdrawal of the cord from the trunk jack will send a spacing signal to the distant line concentration unit and at the same time the trunk circuit at this end returns to its normal idle condition.

Ringing the called subscriber

The illumination of the cord circuit supervisory lamp is an indication that the called subscriber's line has been connected to the trunk. The operator then depresses the ringing key which transmits ringing to this circuit and this circuit, as hereinbefore described, retransmits twenty-cycle mark and space pulses to the distant line concentration unit where it is utilized as a signal to connect ringing to the called subscriber's line.

Called subscriber answers

When the distant line concentration unit subscriber answers the ringing of the bell, the distant line concentration unit sends a permanent mark signal to this office. The reception of the mark signal causes relays **1505** and **1504** to operate to their marking contacts. The operation of relay **1505** to its marking contact, as hereinbefore described, results in the operation of relays **1511** and **1521** bringing the circuit into the transmitting condition and extinguishing the cord lamp of the associated cord circuit. The circuit now continues to function as hereinbefore described.

False disconnection

If the operator should falsely remove the plug of the cord circuit from a trunk, relays **1519** and **1520** will release and the sending relay **1518** will be operated to its spacing contact, provided, of course, a space signal was not being received from the distant line concentration unit. The operation of relay **1518** to its spacing contact causes relay **1523** to operate to its right-hand contact and permits vacuum tube **1524** and its associated apparatus to function. After three-quarters of a second this results in the operation of relays **1532** and **1528**, whereupon ringing current is transmitted to the distant line concentration unit. From a transmission standpoint, therefore, the false disconnect results in the sending of a break signal to the distant line concentration unit. Meanwhile, with relay **1520** released and relay **1505** presumably on its marking contact, a circuit is available for the operation of relay **1525**. Not until relay **1528** operates or three-quarters of a second after the cord has been removed from the jack has elapsed does the line lamp associated with the trunk and the night alarm circuit function. During this condition, if the subscriber in the line concentration unit flashes the operator, the line lamp and the night alarm circuit will follow the flashing of his power switch. If the operator plugs a cord into the jack from which the cord has been falsely removed the transmission of a marking signal from the cord circuit will immediately cause relays **1518** and **1523** to operate to their marking contacts, resulting in the release of relays **1532** and **1528** and the transmission of a marking signal to the distant line concentration unit. The circuit, therefore, has returned to the transmitting condition.

Connection established to another central office

Let us assume that the subscriber at the station shown in Fig. 4 establishes a connection. As shown on Fig. 6 this is station No. 90 which is indicated by a rectangle in the upper part of the drawing. It will be noted, in this case, that the conductors corresponding to those leading from the front and back contacts of relay **617** connect to the common conductors **600** and **601** in a different manner than those of the circuit for station No. 44. Thus the upper or first choice conductor connected to the back contact of the relay connects in this case to conductor **601** so that the first choice office for this station will be that reached over the trunks of Fig. 19 and the second choice office will be that reached over the trunks of Fig. 15. Should the subscriber at the station in Fig. 4 initiate his call by first operating his break key one of the trunks in Fig. 9 will be selected whereas if he initiates his call in the regular manner one of the trunks in Fig. 8 will be selected.

Let us assume that the subscriber initiates his call in the regular manner and that in due course the selecting magnet **801** will become energized followed thereafter by the operation of holding magnet **803** and then the release of selecting magnet **801** whereby the set of contacts **805** is operated to effectively connect this subscriber to the trunk indicated by the rectangle **1161** in the upper part of Fig. 11 and **1361** in the upper part of Fig. 13. This trunk is similar in all respects to the trunk shown in detail in Figs. 11 and 13. Also the repeaters **1362** and **1363** correspond to the repeaters **1327** and **1328**. The trunk thereafter extends to Fig. 19 which will be found to be essentially identical with the trunk shown in Fig. 15. For this reason no detailed description of the operation of the trunk termination in Fig. 19 will be given but the different pieces of apparatus will be numbered to correspond exactly to the same pieces of apparatus in Fig. 15.

An exception is first the fact that the transmission conductor connected to the jack **1903** is on the ring instead of on the tip as in Fig. 15. Two additional relays are shown in Fig. 19, these being the relay **1950** in series with the tip conductor leading to the back contact of the inner upper armature of relay **1911**. In the case of Fig. 15 the ring conductor corresponding to this connection leads directly to the back contact of the inner upper armature of relay **1511**. Relay **1950** is provided for unattended subscriber's station calling. With the cord circuit used in connection with Fig. 15 when an unattended station is called the operator must depress her ringing key and hold it manually for a period of at least six seconds. In the cord circuit shown in Figs. 25 and 26 cooperating with the trunk termination of Fig. 19 the operator may press a key for only a very short interval and then attend to other business. The depression of such a key will cause the operation of relay **1950** and this in turn will cause the operation of relay **1951** which locks through its lower winding and causes the operation of the ringing relay **1928** by its upper armature. With the short description of this feature the trunk termination circuit of Fig. 19 will be left and the cord circuit cooperating therewith will be described.

Universal cord circuit

The circuit shown in Figs. 25 and 26 is a universal cord circuit provided for connecting the operator's position circuit with various types of lines and trunks and for interconnecting these lines and trunks; for receiving and sending supervisory signals; for repeating teletypewriter communications from one connected circuit to

another or to a group of circuits and to provide a busy test and an operator's lock-out feature.

The features of this cord circuit may be listed as follows:

1. One side of the cord circuit is arranged for answering calling subscribers or trunk circuits.

2. Answering cord is arranged for operator lock-out when two or more operators answer the same call.

3. The operators not getting the line in the case of a multiple plug-in receive an indication by the illumination of their busy lamps.

4. Both cords are equipped with automatic flashing recalls.

5. Both cords are arranged for steady disconnect signals.

6. Operator may send a trunk disconnect or recall signal over both cords.

7. Both sides of the cord circuit are arranged for calling subscribers or toll operators.

8. Operator may ring over the calling cord using the machine ringing. Operator may manually ring over the answering cord only.

9. A guard lamp is used on the calling cord to indicate when ringing.

10. Guard lamp is extinguished when subscriber answers.

11. An unattended subscriber's station may be started from either cord.

12. The toll disconnect signal may be sent over both cords.

13. Busy test can be made with the calling cord before entering a line jack, differentiation being provided between a regular busy and an out-of-order busy.

14. Each cord circuit is equipped with a single line repeater for repetition of telegraph signals.

15. Each cord circuit is equipped with means of indicating when a cut-off takes place at that cord.

16. A splitting key is provided for communication in either direction independent of the other side.

17. When either plug is inserted in a line circuit the opposite side of the cord circuit is closed automatically so that "conversation" can take place.

18. A teletypewriter key is provided for connecting the operator's set into the cord circuit.

Operation answering a call: operator lock-out feature

A call is answered by inserting the answering plug **2500** into a calling line jack such as **1903** and by operating teletypewriter key **2600**. Ground is present on sleeve of this jack **1903** through the upper winding of relay **1919**. When the plug is in, a circuit is completed through the sleeve of the plug and jack, the lower winding of relay **2501**, the winding of relay **2502**, to a potentiometer made up of resistances **2503** and **2504**. If this cord is the first to complete the sleeve circuit, the mid-point of the potentiometer will be negative with respect to the sleeve and relays **2502** and **2501** will operate and apply ground to the winding of relay **2505**. Relay **2505** becomes operated and establishes a connection from battery, the winding of relay **2506**, the front contact and middle upper armature of relay **2505** through the upper winding of relay **2501** to the sleeve of the plug **2500** and thence through the sleeve of the jack circuit in Fig. 19. This path will constitute a locking circuit for relay **2501** and an operating circuit for relay **2506**.

If another answering cord has preceded this cord into the multiple of the line, the sleeve will be negative with respect to the mid-point of the potentiometer and the polar relay **2501** will not operate. Relay **2502** will operate closing a connection from ground, the armature and right-hand contact of relay **2501**, the inner upper armature front contact of relay **2502**, the winding of relay **2507** to battery causing the operation of relay **2507**. Relay **2507** connects positive battery through resistance **2508**, the contact and armature of relay **2507** to the ring of the plug **2500** and thence over the line multiple to the ring of the preceding cord. This positive battery connection extending over the line multiple will be traced through the ring of the other cord, the alternate contacts of the inner lower armature of relay **2505**, the normal contacts of the lower armature of relay **2524**, the normal contacts of relay **2527**, the front contact and outer upper armature of relay **2614** which has been operated through the operation of key **2600**, the tip of jack **2616**, the tip of plug **2617**, the transmitting contacts **2615**, the break contacts **2618**, the tip of plug **2619**, the tip of jack **2620**, the upper winding of relay **2613**, the lower outer armature and front contact of relay **2614**, the back contact and inner lower armature of relay **2517** and in multiple therewith the upper outer armature of relay **2517** and its back contact, the upper winding of the repeater relay **2528**, through the armature of repeater relay **2532** to positive battery. Thus, the relay **2613** in the first cord circuit will be shunted and will, consequently, move its armature to its right-hand or spacing contact. This will connect positive battery directly to the winding of relay **2633**, causing this relay to release. It will be noted at this time that relay **2624** in the original operator's position is energized in a circuit which may be traced from battery, the winding of relay **2624**, the inner lower armature and front contact of relay **2614**, the lower armature and front contact of relay **2608**, the front contact and lower outer armature of relay **2509**. Relay **2509** is energized in parallel with relay **2505**.

Relay **2633** in releasing closes a circuit from positive battery through the alternate contacts of relay **2633**, the armature and front contact of relay **2624**, resistance **2635**, sleeve of jack **2616**, sleeve of plug **2617**, printer magnet **2621**, sleeve of plug **2619**, sleeve of jack **2620**, resistance **2622** to negative battery, whereby the printer circuit of the operator set is locked so as to form an indication to the first operator that another operator has tried to make connection to the same calling line. As soon as the interfering operator disconnects, the first operator's set circuit restores to its normal operating condition by the operation of relay **2613** and the operation of relay **2633** which allows the printer magnet **2621** to properly follow the movement of the line relay **2613**.

In the second position, the line relay **2613** moves to its spacing contact because in this case the failure of relay **2505** to operate holds the transmission circuit open. Here again relay **2633** releases but this time without effect since relay **2624** in the interfering operator's position does not become energized. However, a circuit is established from positive battery through the winding of relay **2634**, the normal contacts of relay **2624**, resistance **2635**, through the printer magnet, resistance **2622**, to negative battery. Thus, in the second operator's position the printer is also locked and, in addition, relay **2634** is

operated. The operation of this relay energizes the busy lamp **2627** so that the interfering operator is given an indication that she has trespassed upon a busy circuit. She thereupon disconnects her answering cord from the jack of the calling line.

In the circuit of the first operator to plug in on a calling line the operation of relay **2509** applies ground through its front contact and upper armature to the balancing networks of the repeater. Relay **2509** will operate when either or both calling or answering cords are inserted.

After the operator inserts the answering plug in the line jack the teletypewriter key **2600** is operated to connect the operator's teletypewriter in series with the answering side of the single line repeater. As the calling side of the repeater is closed the operator can transmit into and receive from the line to which the answering cord is connected.

Completing call to trunk circuit

After the operator has received the number of the desired station the calling cord **2510** will be inserted into a trunk jack indicated as idle in any well-known manner. When the plug is in the jack a circuit is completed from ground which is present on the sleeve of the jack through the sleeve of the plug **2510**, resistance **2511**, and the winding of relay **2512** to battery. Relay **2512** will thus be operated and in turn will operate relay **2513**. Relay **2513** will connect the ring of the cord to the calling side of the repeater through the contacts of relays **2514** and **2515**. Relay **2513** will also transfer the tip of the cord from the busy test circuit leading to relays **2625** and **2626** to the calling supervisory relay **2603**. The operator will call by operating the ringing key **2516** which in turn will cause the operation of relay **2515**. This will open the trunk but the calling side of the repeater will be connected to negative battery through resistance **2601** in order to hold the calling station and the operator's teletypewriter closed.

Completing the call to a station line

After the operator has received the number of the desired station the calling cord **2510** is inserted in the jack of that station's line. When the calling plug is inserted in a station line, ground present on the tip will close a circuit through the tip of jack and plug, the inner lower armature and front contact of relay **2513**, the outer lower armature and back contact of relay **2517**, the lower armature and back contact of relay **2518**, the back contact and upper outer armature of relay **2514**, conductor **2604**, the upper outer armature and back contact of relay **2602**, the winding of calling supervisory relay **2603** to battery. Relay **2603** operates in this circuit and in turn will cause the operation of relay **2602** through its upper winding. The operating circuit of relay **2603** was traced from a ground which was finally extended over conductor **2604**. This ground is now extended over the front contact and inner lower armature of relay **2603** to the upper winding of relay **2602**. The upper armature of relay **2602** acts to open this circuit but the ground on conductor **2604** is now connected to the outer lower armature of relay **2603** and thence through the energizing circuit for the upper winding of relay **2602**. The operation of relays **2602** and **2603** will light the calling cord lamp in a circuit from ground, the front contact and outer upper armature of relay **2603** calling cord lamp **2519** through the winding of relay **2520** to battery. Relay **2520** is known as the auxiliary signal relay and operates to cause the illumination of pilot lamp **2521**. Relay **2603** through its front contact and inner upper armature also connects the calling side of the repeater to battery through resistance **2601**, in order to keep the typing circuit closed.

The operator will then operate the ringing key **2516** operating relay **2515** as before. The operation of relay **2515** applies ground from the tip of the cord to relay **2514** causing it to operate. Relay **2514** becoming operated locks to ground on the tip and opens the holding circuit for relays **2602** and **2603**. This will release and extinguish the calling lamp **2519** and the pilot lamp **2521**. Relay **2514** also closes the calling side of the repeater and connects battery to the ringing guard lamp **2522**. Battery is also connected through the inner upper armature of relay **2514** and its second front contact to the winding of relay **2605**. The other side of the winding of relay **2605** is connected to a source of signal supply, that is a connection to ground which is periodically interrupted by some well-known means. In this circuit relay **2605** will be repeatedly operated for two seconds and released for four seconds. When relay **2514** is operated and relay **2605** is released, positive battery is connected through the back contact of relay **2605** to the station line, through the lower outer armature and front contact of relay **2514**, the alternate contacts of the upper outer armature of relay **2513** to the ring of plug **2510**. When relay **2605** is operated then ringing current is connected to this circuit over the front contact of relay **2605**. This alternate battery and ringing current will continue to be applied to the line until the station operator answers. When the station operator answers ground will be removed from the tip circuit. Relay **2514** will release. The ringing guard lamp **2522** will be extinguished and relay **2605** will remain released. The ringing circuit is therefore restored to normal and transmission may take place.

Disconnect from station

When a station disconnects the tip of the jack and plug is connected to ground. In the case of an answering cord the ground on the tip will complete a circuit to the winding of answering supervisory relay **2606**. This circuit may be traced from ground on the tip of plug **2500** through the outer lower armature and front contact of relay **2505**, the inner upper armature and back contact of relay **2517**, the inner upper armature and back contact of relay **2507** to the winding of relay **2606**. Relay **2606** will operate and close an operating circuit for relay **2607** through the front contact and inner lower armature of relay **2606**. Since relay **2607** operates to open its original energizing circuit, relay **2606** is maintained operated through its outer lower armature and front contact. Relay **2606** will close the answering side of the repeater and will light the answering cord lamp **2523**. The circuit may be traced from ground, the front contact and inner upper armature of relay **2606**, lamp **2523** and thence to supervisory relay **2520**. When the cord is disconnected from the jack these relays will release and the lamp will be extinguished.

In the case of a calling cord relays **2603** and **2602** will be operated in the same manner.

Flashing recall from station

A station recalls the operator by operating a recall key which will cause ground to be applied to the tip of the jack circuit. Relay **2606** will operate from ground supplied through a normally closed contact of relay **2607**. When operated, relay **2606** prepares its own locking circuit and closes the operating circuit of relay **2607** as hereinbefore described. Relay **2606** will apply battery to hold the answering side of the repeater closed and will light the answering lamp **2503**. Relay **2607** will also close a locking circuit through its lower winding which may be traced through the back contact and inner upper armature of relay **2524**, the front contact and outer lower armature of relay **2506**, the upper armature and back contact of relay **2608**, back contact and inner upper armature of relay **2609** to ground. When the station operator releases the recall key ground will be removed from the tip of the jack and plug. Relay **2606** will release and will transfer the answering line from ground at the front contact of its inner upper armature to an interrupting ground found on the back contact of its inner upper armature extending from an interruptor **2610** through the outer lower armature and the front contact of relay **2607**. Interrupter **2610** will cause lamp **2523** to flash. As relay **2606** will open its own locking circuit when released subsequent operations of the station recall key will not cause this relay to reoperate. The answering lamp will flash under control of the interrupted ground until the locking circuit of relay **2607** is opened by the operator operating the teletypewriter key **2600** associated with this particular cord. The disconnect and recall signal from a trunk circuit such as that shown in Fig. 19 operates in exactly the same manner as above described. In this last case, the ground applied to the tip is supplied by the inner upper armature of relay **1911** in response to the operation of the recall key at the distant subscriber's station.

Ringing on the answering cord

When it is desired to ring on the answering cord the ringing key **2525** is operated causing in turn the operation of relay **2524**. This opens the ring circuit of the plug **2500** through the movement of the lower armature of relay **2524**. If the jack to which the cord is plugged is connected to a trunk circuit this opening will constitute the call. If the cord is plugged into an idle station line battery will be present on one side of the winding of relay **2526** and ground will be applied to the other side through the upper outer armature and front contact of relay **2524**, the front contact and outer lower armature of relay **2505** through the tip of the plug **2500**. Relay **2526** will operate and apply ringing current to the line from the source represented by current limiting lamp **2611**. Ringing current from this source is connected to the ring of the plug and will cause the operation of the polarized relay **1918** in the trunk circuit with the result hereinbefore described. Relay **2524** applies battery to hold the answering side of the repeater. This circuit may be traced from battery, the lower armature and front contact of relay **2524**, the normal contacts of relay **2527**, the back contact and upper outer armature of relay **2609**, the back contact and inner lower armature of relay **2517** to the upper winding of polarized relay **2528** forming part of the repeater.

It will be noted that the calling signal to a trunk is under manual control of the ringing key when either cord is used. Ringing on the calling cord on a station line is always controlled mechanically and on the answering cord on a station line is always controlled manually.

Teletypewriter key and relays

The teletypewriter keys and relays are so arranged that the operator's teletypewriter may be connected to any cord in the immediate position. In Fig. 26 it will be noted that the lower part of the circuit diagram is connected to the upper part with five conductors, one of which leads from the alternate contact of the teletypewriter key **2600**. To the right of the key **2600** there are indicated two other keys and a multiple of five conductors whereby the common teletypewriter apparatus may be alternately connected to the various cord circuits. The circuit from the answering side of the repeater to the ring of the answering cord may be traced from the upper winding of relay **2528** through the inner, lower armature and back contact of relay **2517** and in multiple therewith through the back contact and outer, upper armature of this same relay, through resistance **2612**, the outer, upper armature and back contact of relay **2609**, the normal contacts of the relay **2527**, the normal contacts of the lower armature of relay **2524**, alternate contacts of the inner, lower armature of relay **2505** to the ring of plug **2500**. When the teletypewriter key **2600** is operated ground is supplied through the lower winding of relay **2613**, through the operated contacts of key **2600**, the normal contacts of the lower armature of relay **2609** to the winding of relay **2614**. In the case of other cord circuits, this ground is extended through the normal contacts of the preceding teletypewriter keys. When relay **2614** operates, this same ground will be connected through the front contact and inner, upper armature of relay **2614** to the winding of relay **2609**, whereupon relay **2609** operates and provides a local ground connection for maintaining relay **2614** energized. With relays **2609** and **2614** now operated a circuit is established for the transmitting contacts **2615** as follows: From the ring of the plug **2500** through the alternate contacts of the inner lower armature of relay **2505** through the normal contacts of the lower armature of relay **2524**, the normal contacts of the relay **2527**, the front contact and upper outer armature of relay **2614**, the tip of jack **2616**, the tip of plug **2617**, the transmitting contacts **2615**, the break key **2618**, the tip of plug **2619**, the tip of jack **2620**, the upper winding of relay **2613**, the lower outer armature and front contact of relay **2614**, the back contact and inner lower armature of relay **2517**, and in multiple therewith, the upper outer armature and back contact of relay **2517** to the upper winding of repeater relay **2528**. It should be noted that during the operation of relays **2614** and **2609**, that the transmitting contacts **2615** and the receiving relay **2613** are shunted by the resistance **2612** so that the circuit from the trunk to the repeater relay **2528** will not be even momentarily opened during this operation. The relay **2613** responds to impulses from the trunk and the transmitting contacts **2615** are used to transmit impulses to the trunk.

The selecting magnet **2621** is under control of the receiving relay **2613** in a circuit extending from positive battery, the armature of relay **2613**, its left-hand or marking contact, sleeve of jack

2616, sleeve of plug 2617, magnet 2621, sleeve of plug 2619, sleeve of jack 2620, resistance 2622 to negative battery. In this circuit the selecting magnet 2621 is energized. When the relay 2613 moves its armature to its spacing contact this circuit is broken and the selecting magnet 2621 releases.

When the teletypewriter key 2600 is restored to normal the relay 2609 will release before relay 2614 and thus resistance 2612 will be replaced in the circuit between the answering plug and the answering side of the repeater before the operator's teletypewriter is removed. This is done to insure that transmission through the repeater will not be interrupted by the introduction or removal of the operator's set. When the teletypewriter key is operated the ground circuit from the operator's set is disconnected from all succeeding cords thus preventing the interruption of transmission in the cord in case the teletypewriter keys of more than one cord are operated.

The line relay 2613 of the operator's teletypewriter is normally held closed by a local circuit from ground through its lower winding, resistance 2623 to battery and the teletypewriter magnet 2621 is held operated by another local circuit described just above. The current for operating relay 2614 and later holding operated relay 2609 is applied to the biasing or lower winding of the operator's set line relay 2613 in the opposite direction to the local holding current. This current is greater than the local current and will therefore act as the biasing current for the operation of the line relay. When the teletypewriter key is operated the operation of the relays 2614 and 2609 as hereinbefore described might cause a sufficiently large current through the biasing winding of line relay 2613 to overpower not only the local holding current but the line current as well. If the teletypewriter magnets were under control of the line relay at this time false characteristics might be recorded on the operator's set. This condition is prevented by the fact that a second local circuit through the winding of relay 2634 in the operator's circuit holds the line magnet 2621 of the teletypewriter closed until relay 2608 operates. Relay 2608 operates upon the operation of relay 2609 and will then supply ground over its front contact and lower armature, the front contact and inner lower armature of relay 2614, the winding of relay 2624, to battery which last relay in operating will open the second holding circuit for the magnet 2621. When the teletypewriter key is restored to normal the biasing circuit for the operator's line relay will be opened and the local holding current will be established before the line circuit is opened.

While the teletypewriter key 2600 is normal ground is supplied from the inner upper armature and back contact of relay 2609 and through the back contact and upper armature of relay 2608, for the locking windings of relays 2607 and 2602. The circuit for the locking winding of relay 2607 is effective when the answering plug 2500 is in a line jack and relay 2506 is operated. The circuit for the locking winding of relay 2602 is effective when relay 2513 is operated due to the insertion of plug 2510 in a line jack. When relay 2609 is operated ground will be removed from relays 2607 and 2603 until relay 2608 operates. When relay 2609 is released ground will again be removed from the locking windings of relays 2607 and 2602, during the releasing time of relay 2608. The releasing and operating times of relay 2608 are sufficiently long to cause relays 2607 and 2602 to release whenever the teletypewriter key is operated or restored.

Unattended key and relay

When the unattended key 2529 is operated ground will be applied to operate relay 2518. When this relay operates the negative battery which is normally supplied to the calling cord tip by the calling supervisory relays will be replaced by positive battery. Normally the tip of the answering plug is connected through the outer lower armature and front contact of relay 2505, the inner upper armature and back contact of relay 2517, the inner upper armature and back contact of relay 2507 through the winding of relay 2606 to negative battery. Similarly the tip of plug 2510 is connected through the lower inner armature and front contact of relay 2513, the lower outer armature and back contact of relay 2517, the lower armature and back contact of relay 2518, the normal contact of the upper outer armature of relay 2514, the upper outer armature and back contact of relay 2602, the winding of relay 2603 to negative battery. The operation of relay 2518 in response to the operation of key 2529 replaces these negative battery connections with a positive battery connected to the front contacts of the armatures of the relay 2518. When plug 2500 is connected to jack 1903 this causes the operation of the polarized relay 1950 as hereinbefore described.

Split key and relays

The two keys 2530 and 2531 are known as the split keys. When key 2530 is operated relay 2527 responds and opens the answering side of the cord circuit. The operator's set will be connected to negative battery and the ring of the answering cord will be connected to positive battery. When this is done the operator will receive from and transmit to the calling cord ending in plug 2510.

When the split key 2531 is operated then relay 2517 makes the split between the answering side of the repeater and the operator's set. In this case, the operator will receive from and transmit to the answering cord ending in plug 2500 only.

When the split key 2531 is operated the functions described above under the heading "Unattended key and relay" will be transferred from the calling cord to the answering cord.

Repeater

When both sides of the cord circuit are closed, both the repeater relays 2528 and 2532 will be operated to their marking contacts by the line currents flowing in their upper windings. The currents in the lower windings are in the opposite direction and tend to operate the relays to their spacing contacts. But these currents are approximately one-half the line currents. Assume the line circuit connected to the answering side of the cord is open, the relay 2528 will be operated to its spacing contact under the influence of the biasing current in its lower winding. While the relay 2528 is traveling from its marking to its spacing contact no battery is supplied to the junction point between the upper and lower windings of relay 2532. During this period relay 2532 will be held closed by current flowing from the negative battery at the distant end of the line through the two windings in series aiding, through the artificial line resistances 2533 and 2534 to ground at the front contact and inner lower armature

of relay **2509**. When the relay **2528** closes on its spacing contact negative battery will oppose the negative battery at the distant end of the calling line with the result that no current will flow in the upper winding of relay **2532**. Relay **2532** will be held closed by the reversed current in its lower winding. When the answering line is again closed relay **2528** will be operated to its marking contacts and the original conditions will be reestablished.

When the calling line is opened relay **2532** will be operated to its spacing contact and relay **2528** will be held against its marking contact by the reversed current in its upper winding.

Cut-off indicator

When a cord circuit is connected to two jacks and the supervisory relays **2607**, **2606**, **2602** and **2603** are not energized a circuit may be traced from ground, the inner upper armature and back contact of relay **2609**, the inner lower armature and front contact of relay **2506**, front contact and outer lower armature of relay **2613**, back contact and upper outer armature of relay **2607**, inner upper armature and back contact of relay **2602**, the lower winding of relay **2535** to battery. Relay **2535** will be energized in this circuit only when both cords are connected to jacks and the supervisory relays are in their normal positions. If a cord is removed from a jack while relay **2535** is operated either the relay **2505** or relay **2513** will release and open the circuit through the lower winding of relay **2535** but will close a circuit from battery through the associated supervisory lamp through the other winding of relay **2535**, the armature and front contact of this relay to conductor **2536** leading to the winding of cut-off alarm relay **2537** to ground. When this is done the cut-off alarm **2538** will be energized and the supervisory lamp **2522** or **2523** will be lighted until the cord is either replaced in the jack from which it was removed or plugged into a special jack which is provided for clearing out the alarm. If both cords are removed when the relay **2535** is operated both supervisory lamps will be lighted.

The cut-off alarm feature is disabled when the teletypewriter key **2600** is operated, for the ground for the operation of relay **2535**, is furnished from the armature of relay **2609**.

If a disconnect or recall signal has been received on either or both cords prior to the removal of either or both cords the cut-off alarm will not be energized, thus the relay **2535** will have had sufficient time to release and open its primary locking circuit.

In order to insure that the cut-off alarm will not be given after a normal disconnect or recall signal the circuit including the upper contacts of relay **2608** and the back contact of the upper inner armature of relay **2609** has been designed to supply ground to the locking circuits of relays **2607** and **2602** continuously except during a short interval immediately after operating or restoring the teletypewriter key. When disconnecting, the locking circuits of these relays are opened eventually at the contacts of the associated relays **2505** and **2513** in order that once a supervisory relay is operated it will not release to close the secondary winding of relay **2535** until after that circuit has been opened at other contacts of relays **2506**, **2505** or **2513**.

Busy test

Polar relays **2625** and **2626** are associated with the tips of all of the cord circuits in the position through the back contacts of the sleeve relays **2505** in one instance and **2513** in the other. When a line is busy and the tip of the plug **2509** is touched to the sleeve of the jack of such an engaged line negative battery from that sleeve closes a circuit through relay **2625** to ground to operate that relay. Relay **2626** does not respond, both of these relays being polarized. Upon the movement of relay **2625** to its left-hand contact, ground is connected to lamp **2627** which operates as an indication that the line being tested is busy.

When the tip of a cord is touched to a sleeve of a line in which an out-of-order cord is plugged positive battery will be impressed on the sleeve of the multiple of this line so that a circuit is completed now for the operation of relay **2626**. This relay closes ground through relay **2628** and lamp **2627** in series. Relay **2628** operates a buzzer **2629** so that with the busy indicating lamp **2627** glowing and the buzzer **2629** operating an out-of-order condition is indicated.

Monitoring

Jack **2630** is provided so that a supervisor's circuit may be connected to this operator's set. Relay **2631** will be operated in a local circuit and will connect the supervisor's teletypewriter circuit in parallel with the magnet **2621** in the operator's teletypewriter. The return circuit from the supervisor's circuit is completed through resistance **2632**. Relay **2624** is operated in a circuit hereinbefore described and as the energization of the magnet now depends only on the path through the armature of relay **2613** the supervisor's teletypewriter as well as the operator's teletypewriter will follow the transmission signals in relay **2613**. Relay **2613** follows signals sent from the operator's keyboard represented by the transmitting contacts **2615** as well as incoming signals.

Sequence circuit

This circuit is designed as a subscriber and trunk sequence circuit so arranged as to permit the routing of only one call in any direction through the line concentration unit at any one time. The circuit is shown in Figs. 10, 12, 14 and 16. Fig. 10 indicates the subscriber line sequence arrangements. There are indicated three groups of subscribers' lines, that controlled by relays **1000** and **1001**, that controlled by relays **1002** and **1003**, and that controlled by relays **1004** and **1005**. Each group has a pair of relays, such as **1006** and **1007**, for each line of the group. Thus, the drawing shows the group relays for the first, an intermediate and the last group of subscribers' lines and the individual relays for the first, an intermediate and the last subscriber's line in the first group.

Fig. 12 is a trunk sequence arrangement for the group of trunks terminating in Fig. 15 and Fig. 14 is a sequence circuit arrangement for the group of trunks terminating in Fig. 19. In both these figures there is a set of seven relays per trunk and here again the first, an intermediate and the last trunk of the group is illustrated. Fig. 16 shows some general circuit arrangements for controlling the sequence circuit arrangements of Figs. 10, 12 and 14.

The functions of the sequence circuit as a whole may be listed as follows:

1. This circuit is arranged to permit only one subscriber at any one time the privilege of routing and establishment of a call through the line concentration unit, provided a call is not being

received from the distant office over one of the trunks of Figs. 15 and 19, hereinafter referred to shortly as the distant TWX office.

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

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

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

5. This circuit is arranged to allot in a predetermined order idle trunks to subscribers calling the distant manual TWX office regardless of whether the trunks are in one or more trunk groups to one or more distant central offices. When more than one trunk group exists in an office, the circuit is arranged to pick an idle trunk in the particular trunk group to which the subscriber is predeterminedly connected before proceeding to select any trunk in the other subgroup or to hunt through both subgroups of trunks before connecting to the all-trunks-busy circuit.

6. When the subscriber's line is arranged for key selection of outlets, this circuit, in conjunction with the subscriber's line circuit, is arranged to select an idle trunk in the trunk group selected by the subscriber before proceeding to select an idle trunk in the other trunk group.

7. This circuit causes the call lamp associated with the subscriber's line to light when a subscriber originates an outward call and during the time the particular call is being routed through the unit.

8. When the subscriber's line is arranged for key selection of outlets, this circuit, in conjunction with the subscriber's line circuit, is arranged to steadily light the call lamp during the routing of the outward call when the subscriber selects his first choice outlet and to flash the call lamp during the same period if the subscriber selects his second choice outlet.

9. This circuit is arranged to cause the selected trunk to repeat a calling signal to the manual TWX office when seized by the calling subscriber.

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

11. In case a subscriber places an outward call when all trunks of both groups are busy, this circuit is arranged to connect the subscriber to the all-trunks-busy circuit which thereupon transmits an all-trunks-busy signal to the subscriber station.

12. This circuit is arranged to advance the trunk chain of Fig. 12 or Fig. 14 to the next idle trunk immediately after each subscriber calling the TWX office has obtained a routing through the line concentration unit and before the sequence circuit is permitted to handle the next call in either direction.

13. This circuit is arranged to prevent the release of any link equipment set up for an established call during the interval the link circuit is actually being used to establish a routing through the line concentration unit in either direction.

14. This circuit is arranged to keep the trunk chain of Figs. 12 and 14 in a fixed condition during the entire period that the sequence circuit is attempting to route an outward call through the unit.

15. This circuit is arranged to permit the miscellaneous alarm circuit to function to time the duration required for routing an inward call through the line concentration unit.

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

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

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

19. This circuit is arranged to operate on a manual basis outward to the central office if the outward central office key **1602** is operated and if an idle trunk is selected by means of its associated call key, such as key **1205**.

20. This circuit is arranged to operate on a manual basis for inward calls from central office if the inward central office key **1603** is operated. A local attendant's station is connected to the trunk by means of the call key, such as **1205**, and busy-test circuit to obtain information concerning the inward call after which the local attendant's station is released and the called station is connected by the same means.

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

Description of Operation

General

Each subscriber line terminating equipment is equipped with a pair of relays **1006** and **1007** and

each subgroup of subscribers is equipped with a set of four relays 1000, 1001, 1008 and 1009. All these relays are used in routing through an outward call except the last, 1009, which is used to remove the subgroup from outward service. In general, subscribers of a subgroup seek the privilege of the use of its subgroup sequence circuit. The subscriber obtaining the privilege has permission to use the subscriber subgroup sequence circuit and, if permission by the latter circuit and the trunk sequence circuit is given, to route the call through the line concentration unit. Each trunk to the distant central office is provided with a group of relays, such as 1200, 1202, 1204, 1206, 1207, 1201 and 1203 and a contact on a relay such as 1604 of Fig. 16, which holds the trunks and link circuits in a "fixed" condition while a call is being routed through the unit. In general, the trunk circuit receives normal preference in the sequence circuit chain. When a trunk call obtains permission to be routed through the line concentration unit, the trunk circuit is connected to a director circuit which translates the pulses received from the distant TWX operator into the number of the desired line. As common office equipment, this circuit provides the equipment shown in the broken line rectangle generally designated 1606 which is the originating source of the characteristic trunk trouble signal. In addition, the equipment provided consists of a pair of relays 1607 and 1608 as a common start circuit for the group of trunks, such as that terminating in Fig. 15. Relays 1609, 1610 and 1611 are supplied for the other trunk group, such as that having trunks terminating in Fig. 19. The transfer relay 1611 is designed to change the order of the trunk chain and advance circuit in such a manner that all trunks in the selected group are tested for busy before a trunk is selected in the other group existing in the office and all trunks of both groups are made available to a calling subscriber.

Routing of a call originated by a subscriber

When a subscriber originates a call, the start lead from his circuit is grounded. As hereinbefore described, conductor 618 is grounded and since this conductor is traced to the winding of relay 1006 it causes this start relay to operate. Relay 1006, in operating, steadily lights the call lamp associated with the subscriber's circuit. Ground is extended over the front contact and inner upper armature of relay 1006, conductor 619, the back contact and outer right-hand armature of relay 617, call lamp 620, conductor 605, conductor 1605, the winding of relay 1612 to battery. If the subscriber has selected his second choice outlet, the relay 617 will be energized and the call lamp 620 will be flashed intermittently in a local circuit from the interrupter 622.

With the start relay 1006 operated, the chain ground coming from the inner lower armature and back contact of relay 1008 is disconnected from all the higher numbered start relays. That is, the circuit connected to the inner lower armature and upper outer armature of relay 1006 is interrupted so that this ground will not extend to the corresponding armatures of relay 1010. If relay 1008 is normal and no other start relay preceding relay 1006, such as relay 1011, is operated, then this ground will be extended to the winding of relay 1007 and this relay operates from battery, providing no other corresponding relay, such as 1013, is operated. Relay 1007 locks under control of its associated relay 1006, the circuit extending from ground, front contact and outer lower armature of relay 1006, the inner upper armature and front contact of relay 1607 and thence to its winding. The operation of relay 1007 removes the chain battery from all lower numbered corresponding relays, such as 1012. Thus, when relays 1006 and 1007 associated with the calling subscriber's line are operated, ground and battery chain circuits of the subgroup sequence circuit have been broken, preventing the operation of any other relay, such as 1007, in that group. Relay 1007 operated, in addition to locking under control of its associated start relay 1006, connects battery to the start lead of the associated subgroup and causes the operation of relay 1009, providing this particular subgroup has not been removed from service by the operation of relay 1009. Relay 1007 also connects certain common leads through to the subscriber's line circuit through its upper middle and outer armatures and its lower outer armature. Here also, if no other relay, such as 1000, 1002 or 1004, is operated or if the particular relay 1000 is in a preferential position and if no relay, such as 1001, 1003, 1005, in either this subscriber group sequence circuit or the trunk sequence circuit is in an operated position, the associated relays 1000 and 1001 will function in a manner similar to that described for the corresponding relays 1006 and 1607 of the subscriber line set. The relays, such as 1000, 1002, 1004, control a chain ground extending from the back contacts of a relay 2305 in the miscellaneous alarm circuit and extending in a chain through the lower armatures and back contacts of the various trunk relays first in Fig. 14 and then in Fig. 12, such as relays 1204, thence to the lower and upper outer armatures of relay 1004 and, in order, the corresponding points on relays 1002 and 1000. The relays, such as 1001, 1003, 1005, control a chain starting from battery on the back contact of relay 2303 in the miscellaneous alarm circuit, thence to the winding and upper armature of relay 1001, the back contact of this upper armature to the winding and upper armature of relay 1003, the back contact of this armature and thence to the winding and upper armature of relay 1005. From here the chain circuit extends through certain relay contacts, in the miscellaneous alarm circuit, Fig. 16, and thence goes on through the armatures of the relays, such as 1206, finally ending in the winding of relay 2304 in the miscellaneous alarm circuit.

When the relays 1000 and 1001 of the particular subgroup associated with the calling subscriber's line have operated, permission to route the outward call through the line concentration unit has been received. The relay 1001 operated causes the operation of relay 1008 and places battery from the chain circuit through its upper armature and front contact, thence through the lower outer armature and front contact of relay 1007 to conductor 621. This battery will then be extended through the left-hand armature and either the back or front contact of relay 617. Let us assume that relay 617 is not energized. Therefore, the battery on conductor 621 will be extended to conductor 600, thence over conductor 1600 to the winding of relay 1607. Relay 1607 is energized in this circuit.

The operation of relay 1008 removes ground from the ground chain of the particular subscriber's subgroup sequence circuit and connects the lead 1014, known as the busy out lead, to the winding of relay 1009 for purposes which will

be hereinafter described. Relay 1608 also connects leads 1015 and 1016 to leads 1017 and 1018, respectively, which in turn are connected through two armatures of relay 1607 to conductors 628 and 623, respectively. Conductor 1015 now connected through conductors 1017 and 628 completes a circuit from the front contacts of relay 2300 in a miscellaneous alarm circuit to conductor 928 and thence through the winding of holding relay 903 so that when the relay 2300 operates, as will be hereinafter described, the holding relay 903 will be operated. The conductor 1016 now connected through conductors 1018 and 623 establishes a connection from the front contacts of relay 2000 to the winding of relay 606 so that if the relay 2000 becomes operated, as will be hereinafter described, the busy back relay 606 will be operated.

Meanwhile the battery furnished by relay 1001 connected through the lower outer armature and front contact of relay 1007 to the winding of relay 1007, as hereinbefore described, causes the operation of relay 1607. This relay places ground on conductor 1615 to cause the operation of relays 1604, 1613 and 1614. These relays, in turn, place individual grounds on the trunk chain and advance circuits composed of relays 1200 and 1202, for instance, of Fig. 12 holding such circuits in a fixed condition during the entire interval that an outward call is being routed through the unit. This anti-release feature is necessary to prevent snagging of two sets of cross-bar fingers. As is fully explained in the prior art hereinbefore set forth, the operation of the cross-bar switches shown in Figs. 8 and 9 consists first in the energization of a selecting magnet such as 801 which moves a selecting finger in place so that when the magnet such as 803 is operated, the selecting finger will be instrumental in closing the contacts of the set 805. There is one finger for each of the sets 805, 802, etc., in a horizontal row and it is necessary, due to the resiliency of such fingers, that the operation be completed before another operation takes place. Hence the "hold chain" circuit is provided through the contacts of such relays as 1604, 1613 and 1614.

In addition, where relay 1609 is associated with a second trunk group in the concentration unit the operation of this relay will cause the operation of an associated transfer relay 1611. The transfer relay is designed to alter the chain circuit to permit the selection of trunks first in the second trunk group and to seek selection of trunks in the first group only if all trunks in the second group are busy. Therefore, not only is the trunk chain circuit placed in a fixed condition by the operation of relay 1604, but if the order of selection was to have been changed relay 1611 had accomplished this function before the start lead to the trunk chain and advance circuits was called into use.

The operation of relay 1604 permits the operation of relay 1608 through a circuit extending from ground, the front contact and inner right-hand armature of relay 1604, outer right-hand armature and front contact of relay 1607, winding of relay 1608 to battery. Relay 1608 extends this ground through its front contact and inner left-hand armature to conductor 1616 which may be traced through Figs. 14 and 12 to the lower armature of relay 1202. Assuming this relay to be non-operated, denoting that the trunk of Fig. 11 is idle, then this ground would be extended over conductor 1100 to the winding of start relay 1101. If the particular trunk shown in Fig. 11 were busy, then both relays 1200 and 1202 would be operated and the ground on the lower armature of relay 1202 would now be extended over the lower armature and front contact of relay 1200 to the lower armature of relay 1208 of the next trunk corresponding to relay 1202. If all trunks in this group were busy then such ground would be extended to conductor 1209 and from there through the right-hand armature and back contact of relay 1611 to conductor 1617 which leads to the lower armature of relay 1402 of the first trunk in the other group. It should be noted further that if all trunks in this group are busy then the ground is extended to conductor 1400 and from there through the left-hand armature of relay 1611 and its back contact leading to the all-trunks-busy circuit.

The operation of relay 1608 places battery on conductor 1618 which may be traced to the winding of start relay 2306 and since this relay has the other side of its winding grounded, it will become operated. Relay 2306 through its upper inner armature and front contact places a ground on common start relay 2305 and causes its operation. Relay 1608 through its outer left-hand armature and front contact places ground on the inner left-hand armature of relay 1604 to provide a locking circuit for this relay to be sure to keep the trunk chain and advance circuits in fixed condition until the routing of the call has been completed. The common start relay 2305 removes the main chain ground from both the trunk sequence and subscriber's sequence circuits.

Establishing connections of a subscriber originated call

The operation of relay 1608, as described, places ground on the start lead of the trunk at such a place in this trunk chain as to permit selection of the first idle trunk in the trunk group desired. This ground will be connected by means of the back contact of the first relay such as 1202 to the associated idle trunk circuit, causing this circuit to function. A signal will be sent to the TWX office and an automatic signal will be returned from the TWX office to make a preliminary test for conductor failure. Thereafter the trunk circuit will function in conjunction with the link circuit and miscellaneous alarm circuit. When selecting magnet 900 has been energized as hereinbefore described, ground will be placed on conductor 902 which will be extended to conductor 2302 and thence to the winding of relay 2300. Relay 2300 through its inner lower armature and front contact and in parallel therewith through its middle upper armature and front contact places a ground on the winding of relay 2307, thence through normal contacts of relay 2310 and in parallel therewith through resistance 2311 to the hold lead 2312. This lead may be traced to conductor 1015, thence to conductor 1017, through conductor 628, conductor 928 to the winding of relay 903, causing this latter relay to operate. This relay in turn causes the operation of holding magnet 800. Upon the operation of magnet 800 the subscriber's line terminating circuit of Fig. 6 will be disconnected. This opens the start lead 618 which results in the release of relays 1006 and 1007 and this in turn results in the release of relays 1000 and 1001 and the extinguishing of the call lamp 620. The release of relay 1007 causes the release of relay 1607 and the release of relay 1008. The release of relay 1008 disconnects the holding and busy-back leads from

the common circuits, while the release of relay 1607 causes the release of the associated transfer relay 1611, if used, returning the trunk chain to its originally predetermined order, at the same time closing the chain circuit on its back contact to place ground on the advance lead 1619 to all of the trunk circuits. In only one of these trunk circuits is this ground effective and that is the trunk circuit which has just been selected by the calling subscriber. Ground on this lead in this trunk circuit causes the operation of relay 1202 and in turn the operation of relay 1200. This circuit may be traced from ground, the left-hand armature and back contact of relay 1607, the left-hand armature and back contact and in parallel therewith the inner right-hand armature and back contact of relay 1608, conductor 1619, conductor 1121, the middle upper armature and front contact of the start relay 1101, conductor 1122, the winding of relay 1202 to battery and ground. Relay 1202 is operated in this circuit and through the additional contact of the upper armature of relay 1202 extends the ground for operating relay 1202 to the winding of relay 1200. Relay 1200 now extends the chain circuit from the lower armature of relay 1202 through the lower armature of relay 1200 to the lower armature of the next relay 1208. Relays 1200 and 1202 are thereafter held energized over conductor 1128 by ground on the lower outer armature of relay 1106. As hereinbefore described, these relays are held temporarily by such relays as 1604 to prevent the release of such advance chain relays during another operation. The operation of relay 1200 through the movement of its inner upper armature removes ground from conductor 1102 which was used as a locking ground for the start relay 1101. Relay 1200 also closes a ground to conductor 1210 which starts the establishment of a circuit which will be completed when all of the relays in a group corresponding to relay 1200 are energized. If this chain is completely closed, ground is connected to the all-trunks-busy circuit, causing the latter circuit to time the interval that such condition persists.

The operation of relay 1202 removes the holding ground from relay 1608 supplied over conductor 1616 in the sequence circuit, causing this relay to release. Relay 1608, releasing, allows relays such as 1604 to return to normal. The release of relay 1604 and its companion relays removes the individual holding grounds to the relays such as 1202 of all trunk circuits, thus permitting any relay such as 1202 that was in a position to do so to release, removing the "fixed" condition of the trunk chain circuit which had been in force throughout the entire routing of the call. The release of relay 1607 also causes the release of the common start relay 2305 of the miscellaneous alarm circuit which in turn replaces ground on the entire office chain. The trunk sequence and subscriber sequence circuits have thus been returned to normal and to a condition that will permit the routing of another call in either direction. Upon the completion of the thus established call, the locking ground that holds the relays 1200 and 1202 operated will be removed, permitting their release provided an auxiliary path is not being temporarily furnished by relay 1604. Upon the removal of any such temporary holding path, relays 1200 and 1202 release, returning the entire circuit to normal.

In case the relays 1200 and 1202 of all the trunks in the office are operated, ground connected by relay 1607 is connected by means of the trunk chain circuit to the all-trunks-busy lead 1620. This conductor extends to the all-trunks-busy circuit and causes such circuit to function to produce a special telegraph character and to arrange to connect to the line circuit of the particular subscriber calling, transmitting this character to the teletypewriter at his station. The line circuit meanwhile operates to disconnect ground from the start lead leading to relay 1006, causing the release of the subgroup sequence circuit, the group sequence circuit and all other relays that were operated as a result of this call, but the line circuit continues to keep the call lamp in service. The all-trunks-busy circuit meanwhile continues to produce and continues to be connected to the subscriber's line circuit until the subscriber releases.

Routing of a call originated at a distant TWX office

When a trunk is seized at the distant TWX office, the associated trunk in the line concentration unit functions as hereinbefore described (*a*) to place a ground on the start lead 1155, causing the operation of relay 1204, and (*b*) places a ground on conductor 1122, causing the operation of relays 1202 and 1200 in the manner described. The trunk chain circuit is, therefore, immediately advanced and if this causes the completion of the chain circuit leading from the upper outer armature of relay 1200, ground is sent to the all-trunks-busy circuit and causes it to time the interval that this condition persists. The operation of the relay 1204 places a ground on the lead 1219 connected to the front contact of the middle upper armature of relay 1204 leading to the director circuit which is used to keep in speed the distributor motor associated with the director distributor circuit, lights the call lamp 1213 associated with the selected trunk through its outer upper armature, and if no other corresponding relay of the sequence circuit is operated or if the particular relay 1204 associated with this trunk circuit is in preferential position, ground on the lower armature of relay 1204 coming from the back contact of the common start relay 2305 in the miscellaneous alarm circuit will permit the operation of relay 1206, provided also that no other relay corresponding to relay 1206 is in an operated position. If these conditions are not met, the particular relay 1206 will be delayed in operating until it has received a preference accorded it by the sequence circuit. When relay 1206 is operated its locks under control of its associated relay 1204 through a circuit extending from ground, the inner upper armature and front contact of relay 1204, the inner upper armature and front contact of relay 1206, the winding of relay 1206 to battery at the back contact of relay 2303 in the miscellaneous alarm circuit. Relay 1206 causes the operation of relay 1207 by extending a battery connection through its lower armature and front contact to the winding of relay 1207. Relay 1206, in operating, extends the battery also through its upper outer armature and front contact to conductor 1211 which extends to the winding of relay 2306 in the miscellaneous alarm circuit. This relay becomes energized and through its inner upper armature and front contact causes the operation of the common start relay 2305. The operation of relay 1207 places ground on conductor 1212 which extends through the contacts of director transfer

relay 1701 to the winding of relay 1800 in the director circuit, as a start signal for the director. Relay 1207 also (1) extends a connection from conductor 1105, conductor 1146, to conductor 1214 leading through the contacts of director transfer relay 1701 to the left-hand winding of relay 1801, (2) extends a connection from the armature of relay 1113, conductor 1156 to conductor 1215 leading through the contacts of director transfer relay 1702 to the lower winding of relay 1802, (3) grounds conductor 1216, causing the energization of relay 1117 and in turn selecting magnet 900 of the cross-bar switch, (4) connects relay 1201 to conductor 1217, leading to the miscellaneous alarm circuit, and (5) connects relay 1203 to conductor 1218, also leading to the miscellaneous alarm circuit. The operation of the common start relay 2305 following the operation of relay 2306 by the application of battery to conductor 1211 removes ground from the ground chain passing through the lower armatures of all relays corresponding to relay 1204 in the entire office sequence circuit chain.

Establishing connections for a call originated at the distant TWX office

After the conductor 1212 leading to relay 1800 in the director circuit has been grounded by the operation of relay 1207 the associated director circuit functions, sends a "director ready" signal to the distant TWX office which is followed by the reception from the operator of the desired called subscriber's number. The director circuit proceeds to translate this number and designate the particular desired line, causing the link circuit to function and to connect the subscriber line terminating circuit of the called subscriber to the trunk selected at the distant office. Immediately after the first digit is received by the director circuit, conductor 1803 in the director circuit, connecting with conductor 1615, is grounded, causing the operation of relays 1604, 1613 and 1614 which, as described previously, fixes the conditions preventing the release of the link circuit used in an established call. The fixation of the trunk chain circuit has no useful function at this time. After the link circuit has functioned, the trunk circuit removes battery from relay 1204, causing the release of this relay, relay 1206 and relay 1207, and extinguishing the call lamp 1213. The release of relay 1204 removes ground from conductor 1219, heretofore described as extending to the director circuit and used for the purpose of keeping the motor in speed, whereby the director circuit is returned to its non-operating condition providing no other relay corresponding to 1204 is placing a ground on this conductor. The release of relay 1207 (*a*) removes ground from conductor 1212 to the director circuit, permitting the director circuit to return to normal, (*b*) opens the two transmission conductors 1214 and 1215, disconnecting the trunk circuit from the director circuit, and (*c*) removes relays 1201 and 1203 from the leads 1217 and 1218. The release of relay 1206 removes battery from conductor 1211, leading to the miscellaneous alarm circuit. The common start relay 2305 of the alarm circuit does not release until the director circuit has returned to normal and upon its release, reconnects ground to the chain ground circuit connected, as before described, to the lower armature of relay 1202 thus enabling the sequence circuit to handle a new call. The director in returning to normal removes ground from the lead 1803, permitting the release of relays 1604, 1613 and 1614, which in turn permits any other link equipment on an established call in a position to release to return to normal. Upon the completion of a call the trunk circuit functions to permit the release of relays 1200 and 1202 which, if relays such as 1604 are not operated, release and return to normal. If the chain is held in a fixed condition by the operated relay 1604 the particular relay pair 1200 and 1202 will remain operated until the fixed condition is removed and then return this circuit to normal.

Removal of equipment because of trouble detected in routing a call through the office

As described hereinbefore during the routing of a call established by the subscriber or one established by the distant TWX, a relay is operated in the miscellaneous alarm circuit. The interval used in routing the call is timed to see that it does not exceed a certain specified limit and thus prevent the permanent disabling of the trunk and the subscriber's group circuit. In case of an outward call, the miscellaneous alarm circuit times out in two seconds and a ground is placed on conductor 1014 if the indication is that the trunk is not in trouble. Since relay 1008 associated with the particular subscriber subgroup containing the calling subscriber line is operated, ground on conductor 1014 will cause the operation of relay 1009 which, in turn, will lock under control of its associated key 1019. The operation of relay 1009 will cause the release of the associated relays 1000 and 1008 and light lamp 1020, indicating which particular subscriber's subgroup is in trouble. The operation of relay 1009 prevents any subscriber of that particular subgroup from entering the subscriber's subgroup sequence circuit, thus removing that particular subgroup of subscribers from outward service. The release of relay 1000 permits the release of the associated relay 1001. Relay 1001 released causes the relays 1607 or 1609, as the case may be, to release so that ground is removed from the trunk advance chain and the companion relay 1610 or 1608, as the case may be, is released. If the trunk has not been connected to the calling line, the "advance" is not locked up. The release of relay 1608 causes the release of relays 1604, 1613 and 1614, as described before. The common start relay 2305 of the miscellaneous alarm circuit is meanwhile held operated for approximately one second longer to permit all this action to take place and, upon release, connects ground to the entire office ground chain. This reconnection of ground permits all of the outward calls, except those originated by the subscriber in the group out of service, to be routed through the unit. An appropriate alarm is sounded by the miscellaneous alarm circuit and, together with the lamp indicating the subgroup in trouble, gives an indication to the attendant of the existing type of trouble. The subgroup subscribers remain out of service until the attendant has remedied the trouble and then operated the release key 1019 associated with the illuminated lamp 1020. The operation of this key causes the release of relay 1009 returning the busying-out feature to normal, extinguishing the trouble indicating lamp and permitting the particular subscriber subgroup access to the subscriber sequence circuit and, in turn, to calling service.

If the miscellaneous alarm circuit times out in two seconds on an outward call and the indications are that the trunk conductors or some part of the trunk relay equipment is at fault, ground

is not placed on lead 1014 or 1217 but connected rather to conductor 1125 leading to all the trunk circuits. The particular trunk circuit preselected at the time by the outward call is the only trunk circuit that is in position to utilize this ground. This trunk circuit, therefore, transmits the same ground through the front contact and lower outer armature of relay 1207 to conductor 1218 associated with the particular trunk and causes the operation of relay 1203. Relay 1203 operated locks under control of the associated trunk release key 1221, causing, in turn, the operation of relay 1201. Relay 1201, in operating, (1) places ground on the chain lead 1122, causing the operation of relay 1202 and, in turn, relay 1200, (2) connects conductor 1146 to conductor 1222, (3) connects battery to conductor 1223 which extends to the circuit in rectangle 1606 and causes it to function, (4) removes battery from conductor 1116 where it is instrumental in bringing the trunk to normal and (5) locks under control of any mark signal from the distant manual office. The operation of relay 1203 also causes the associated lamp 1220 to flash under control of interrupter 1403 as an indication that the trunk is in trouble. The operation of the chain advance relays 1200 and 1202 removes the possibility of using the particular trunk on a particular outward call but permits this outward call to be connected to the next idle trunk. Under this condition, therefore, the subscriber will receive service even though the connection to the distant manual operator is delayed shortly.

The operation of relay 1622 on first closure of the 60 IPM interrupter connects ground to conductor 1222 through the left-hand armature and back contact of relay 1621 and at the same time causes the operation of relay 1624. On the first following open period of interrupter 1623, relay 1622 releases and relay 1625 then operates. Relays 1624 and 1625 operated permit relay 1626 to operate. On the second closure of the interrupter 1623, relay 1622 again operates, connecting ground to conductor 1222 of the trunk, but this time it causes the release of relay 1624. Relay 1624, in releasing, permits relay 1627 to operate. On the second open period relay 1622 again releases, removing ground from lead 1222 and permitting relay 1625 to release. On the third closure of interrupter 1623, relay 1622 again operates, connecting ground to lead 1222 and causing relay 1624 to operate. Relay 1628 being operated, the operation of relay 1624 causes relay 1621 to operate which, in turn, removes ground from conductor 1222. On the third open period of the interrupter 1623, relay 1625 operates and, together with relay 1624, causes the release of relay 1626. On the fourth closure of the interrupter 1623, relay 1624 again operates but relay 1621 being locked to relay 1625 prevents connection of ground to lead 1222. Relay 1624, however, is released, causing the release of relay 1627. On the fourth open period, relays 1622, 1625 and 1621 release, and on the fifth closure of the interrupter 1623, the four-second cycle starts all over again.

Ground on the lead 1222 to the trunk circuit causes the latter circuit to send a mark signal to the central office end. The apparatus generally denoted 1606, therefore, causes the production of the following signal: one-half second mark; one-half second space; one-half second mark; one-half second space; approximately fifty mil second mark at the beginning of the next half second followed by space approximately 1.950 seconds. This characteristic signal is sent to the distant office as a trunk trouble indicator. If the operator has not answered the calling-in signal, the characteristic signal will cause a lamp to flash in a peculiar way. If the operator had, however, already answered the call lamp, this characteristic signal will appear on her teletypewriter. If the path to the distant manual office is in trouble, obviously no signal can be sent to it and trouble of such a nature will become apparent when the distant operator selects the trunk to originate an inward call. The miscellaneous alarm has, therefore, effectively removed the trunk from service and has given a trouble indication to the operator at the distant manual office. When the trouble is cleared by the attendant, the trunk may be put back into service by momentarily operating the key, such as 1221, associated with the flashing lamp 1220. This causes the release of relay 1203 which removes ground from the secondary winding of relay 1201 and at the same time changes the flashing lamp to a steady lamp. Relay 1201 will, however, remain operated under control of a mark signal that might be received from the distant manual office. After connection of this mark signal, relay 1201 releases and thereby causes (*a*) the release of the trunk advance relays 1200 and 1202 so as to readmit the trunk to the trunk advance chain making it available to the subscriber originating outward calls and (*b*) the removal of the characteristic trouble signal from the trunk which removes the trouble indication at the distant central office, thus returning the circuit to normal.

On an inward call, the miscellaneous alarm circuit permits three separate timing intervals, two seconds being allowed to place the director circuit in an off-normal condition, a total of four seconds being allowed for the director circuit to prove itself in a position to receive the telegraph characters typed by the distant manual operator and ten seconds in which to completely fulfill its functions. When the miscellaneous alarm circuit times out at the conclusion of the two-four-ten second interval, it places ground on the conductors 1217 and 1218, if it has been determined that the trouble causing the failure of the inward call to be routed through the office might possibly exist in the trunk sequence or trunk circuits, but grounds only conductor 1217 if it has been determined that a trouble does not exist in either of these two circuits. If both conductors 1217 and 1218 are grounded, relays 1201 and 1203 operate and become locked under control of both the release key 1221 and any mark signal that may be received from the distant manual office causing the associated trunk lamp 1220 to flash and connecting the output of circuit 1606 to lead 1222 and placing a ground on the trunk advance relays 1200 and 1202, causing the operation of both. In addition, the operation of relay 1201 removes battery from conductor 1116 to the two-way trunk circuit, returning the trunk to normal and causing the release of relays 1204 and 1207. The release of relay 1204 removes ground from conductor 1219 to the director circuit and causes the release of relay 1206 which, in turn, releases relay 1207. The release of relay 1207 opens the operating winding of relays 1201 and 1203, disconnects the trunk circuit from the director circuit, removes the starting ground from the conductor 1212 to the director circuit and removes ground from conductor 1216 to the trunk circuit. The release of relay 1206 removes battery from

conductor 1211 leading to the start relay 2306 of the miscellaneous alarm circuit, permitting that relay to release, if it is not held operated from some other source, and reconnects ground to the main chain ground of the sequence circuit, thus permitting the sequence circuit to handle a new call in either direction. The operation of the chain advance relays 1200 and 1202 removes the trunk circuit from the trunk chain as far as an outward call is concerned. The apparatus, generally designated 1606, operates as hereinbefore described and the characteristic trouble signal is connected to conductor 1222 and thence to conductor 1146 of the trunk taken out of service and, if the path to the distant central office is complete, this signal appears at the distant manual operator's position as a trouble indication. In this case, after the trouble has been remedied, the attendant restores the trunk to service by momentarily operating the key 1221 associated with the flashing lamp 1220 and, as indicated heretofore, relay 1201 will still remain operated until any mark signal that might be received at the distant manual end is terminated. At the conclusion of any such mark, the trunk circuit is restored to service. If, however, it has been determined that neither the trunk sequence circuit nor the trunk circuit is in any way responsible for the routing of the inward call, then conductor 1217 alone is grounded, causing the operation of relay 1201 which, as described before, takes the trunk out of service temporarily as long as a mark signal is received from the distant manual end. At the conclusion of such a mark signal, the trunk is restored to service.

Emergency manual service for outward calls

In case of an emergency, such as the failure of the sequence circuit, in which the automatic features of the unit are in trouble, the outward calls are routed to the central office by the following semiautomatic method of operation. A call lamp, such as 620, associated with the subscriber line will, of course, indicate a calling subscriber. Failure of the sequence circuit would call for the operation of the inward key 1603 and outward key 1602, the former making the trunk sequence portion of the sequence so ineffective that a director can not be attached to a trunk, while the latter prevents the subscriber portion of the sequence circuit from completing its task of automatically selecting an idle, satisfactory trunk and connecting the subscriber to it. The operation of either or both of these keys or, incidentally, the insertion of a double plug into the jacks 1628 and 1629 of the busy test circuit causes the red manual service lamp 1630 to flash. The operation of either of these keys safeguards the battery and ground chain of the sequence circuit, making it possible for manual operation to proceed in one direction while calls are handled automatically in the other direction.

The attendant renders service on an outward call by depressing a call key, such as 1205, associated with an idle trunk which does not have a call lamp, such as 1213, a trunk lamp, such as 1220, or a busy lamp, such as 1132, illuminated. If the line is arranged for key selection, the attendant tries to select an idle trunk to the outlet desired by the subscriber. This action places ground obtained from conductor 1312 through the upper contacts of key 1205 to conductor 1100 in the trunk circuit, causing the trunk to send out a calling-in signal and receive back ringing, which positions a selector magnet, such as magnet 900, of the link circuit and, in turn, results in the illumination of lamp 2315 in the miscellaneous alarm circuit. If lamp 2315 does not light, it is possible that the idle trunk was in trouble and another trunk should be selected. Should the second trunk fail to light the lamp 2315, the attendant proceeds to handle the call on a full manual basis unless he discovers the trouble in the lamp itself. At the illumination of lamp 2315, the attendant patches between jacks 1628 and 1629 of the busy test circuit and jacks 609 and 612 of the calling line. This causes the hold magnet of the link to function and connect the subscriber to the selected trunk, lighting the busy lamp 1132. The attendant then releases the call key 1205 and pulls out the patch at the line circuit jacks 609 and 612. The call does not require any further attention. In case the busy lamp 1132 fails to light, the trouble may be in the link circuit and the attendant proceeds as indicated hereinafter. The double plug patching cord is patched between the jacks 1119 and 1124 of the idle trunk and the jacks 609 and 612 of the calling line. This last resort will, of course, require a manual disconnect of the patching cord at the completion of the call.

Emergency manual service for inward calls

The inward calls can be handled manually if the inward key 1603 is operated. If outward calls are also to be handled manually, the outward key 1602 is also operated. The inward call appears as a lighted call lamp 1213 associated with the trunk. The attendant patches a double plug patching cord into the busy test circuit jacks 1628 and 1629, next operates the attendant's answering and teletypewriter keys of the test set (not shown) and then holds the calling key 1205 associated with the lighted lamp depressed while he observes that the lamp 2315 of the miscellaneous alarm circuit lights, and then plugs the other end of the patching cord into the jacks of that line circuit which is used for the attendant's set. The operation of the key 1205 causes the selector magnets of the link to be positioned, the double plug in the busy test circuit secures the sequence preference and plugging into the jacks, such as 609 and 612, of the attendant's line causes the hold magnet to operate and to associate the attendant's line with the calling trunk. The call key 1205 is released as soon as the busy lamp 1132 is lighted and then the plug is removed from the line jacks 609 and 612.

If outward calls are being handled on an automatic basis, the plug is also removed from the busy test circuit to permit outward calls to be routed through, otherwise it may remain in the busy test jacks 1628 and 1629. The operator under this condition receives a permanent mark signal, the first portion of which is used as a "director ready" signal. Her typing, however, appears on the attendant's typewriter. The attendant again plugs into the busy test circuit jacks to capture the busy test sequence if he has removed the plug, then makes a busy test of the called subscriber's line by patching into the jacks 609 and 612 of the called line. If the line is busy, the red lamp 1631 of the busy test circuit lights. The attendant then manually sends "K" signals on the attendant's teletypewriter. If the line is idle, the attendant momentarily operates an attendant's line release key associated with the hold magnet of his line. This releases the

attendant's line from the trunk, extinguishing the green busy lamp **1132**. The attendant waits for the trunk call lamp **1213** to light again and then connects the called line to the trunk by means of the call key **1205** and a patching cord between the busy test circuit jacks **1628** and **1629** and the line circuit jacks **609** and **612** of the called line just as he connected the attendant's line to the trunk. The busy lamp **1132** of the trunk again lights when the called subscriber's line is attached to the trunk. Should the link circuit fail to attach either the attendant's line or the called line to the trunk, manual patching must be resorted to and, of course, a manual disconnect of the patching must take place at the conclusion of the call.

Night alarm circuit

During manual or semiautomatic operation, the night alarm cut-off key **1632** is released if it is desired to receive an audible, as well as a visual, indication of the reception of inward and outward calls. The ground placed on any subscriber's or trunk call lamp **620** or **1213** also causes the operation of relay **1612** which, in turn, causes the operation of relay **1633**, causing the buzzer **1634** to sound as an audible indication of a call requiring attention and giving a night alarm lamp signal through the illumination of lamp **1635**.

Director circuit

The circuit shown in Figs. 17, 18, 21 and 22 is designed to receive the telegraph pulses sent by the distant operator's teletypewriter and to decipher these pulses, thereby causing the selection of the called subscriber's line. The functions of this circuit may be summarized as follows:

(1) Upon the receipt of an inward call from the manual central office, the sequence circuit will connect the director circuit to the trunk circuit on which the call is waiting. The distributor motor is then started and after it has attained proper speed a "director ready" signal will be transmitted to the distant end to indicate to the manual operator that the call may be routed through the line concentration unit.

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

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

(4) A "figures" teletypewriter character received from the distant manual office will indicate that the operator has recognized the "director ready" signal and will cause the director to accept the next two characters transmitted from the distant end as the called subscriber's number.

(5) The next two teletypewriter characters received from the distant office are separated into dot elements by the receiving distributor, causing the proper selection relays to be operated.

(6) Upon receipt of the first digit of the call directing teletypewriter pulses, the director circuit will select the group of ten lines which contain the desired subscriber's line.

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

(8) If the called subscriber's line has been made out of order, a series of "Q" teletypewriter signals will be transmitted as an indication of this condition to the distant manual operator.

(9) If the called subscriber's line is busy because of a previously established call or because of busy condition placed on it by the test circuit, a series of "K" signals will be transmitted to the distant manual operator.

(10) If the manual operator has transmitted first and second digits for which no subscriber line is assigned, or has transmitted an impossible combination of digits, a series of "I" signals will be returned to the manual operator.

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

(12) The miscellaneous alarm circuit is arranged to allow two seconds for the director to become off-normal, four seconds to complete a self-imposed preliminary test and give satisfactory evidence to the alarm circuit, and a total of ten seconds for the director to complete its task in any event.

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

(14) If the director becomes off-normal but the distributor motor fails to get up to speed in four seconds, the director is removed from service and the trunk is taken out temporarily. A signal lamp of the distributor circuit lights and a minor alarm is sounded.

(15) If the "director ready" signal fails to reach the associated loop repeater or a mark signal from the trunk circuit is not registered in the director circuit, both director and trunk circuits are removed from service. In this case a minor alarm is sounded and appropriate telltale lamps are lighted.

(16) In a line concentration unit containing two director circuits, in the case of the condition described in the two previous paragraphs, the miscellaneous alarm circuit, after freeing the distributor circuit in trouble from the sequence circuit, causes the transfer portion of the director circuit to function, removing the director circuit placed in the stuck condition from service and replacing it by a spare available director circuit.

Origination of "director ready" signal

When an operator seizes the trunk to the line concentration unit at the distant manual board, the associated trunk at the line concentration unit functions to cause the sequence circuit to attempt connection to the director circuit in use. When the two-way trunk at the line concentration unit receives permission to route the call through the office, the sequence circuit connects this director circuit to the particular trunk. The inward transmission path from the two-way trunk circuit is in a marking condition and is connected to the lead to the lower winding of relay **1302** while the transmission lead to the two-way trunk is connected to the lead passing through the left-hand winding of relay **1301**. The sequence circuit also upon seizing a director circuit places ground on the lead connected to

the winding of relay 1800. The operation of relay 1800 (1) operates relay 1804, (2) extends a ground from the right-hand outer armature of relay 1805 through its outer left-hand armature to cause the operation of relay 1806, (3) applies ground through its right-hand armature (a) through the back contact of relay 1807 over conductor 1808 and conductor 2208 to the receiving contacts 2200 and causes the operation of start magnet 2201 which permits rapid acceleration of the motor by eliminating clutch drag, (b) extends ground to the upper winding of the receiving relay 1802 which biases this relay to spacing, (c) extends ground over conductor 1809 to the stop pulse contact of the distributor 2202, (d) extends ground to the left-hand winding of relay 1810, causing this relay to operate providing the receiving relay is on its right-hand contact due to a marking signal being received from the loop repeater over the lead connected to the lower winding of relay 1802, (e) extends ground over conductor 1809 to the potentiometer formed by resistances 2203 and 2204, which potentiometer is later used in operating the polar relays 2205, 2206, 2207, 2209 and 2210, (f) extends ground to the upper winding of relay 2211 which biases this relay to spacing (as shown), and (g) extends ground to the front contact of the outer left-hand armature of relay 1805 which is later used to start the "director ready" signal.

Relay 1804 places battery on conductor 1811 and starts the distributor motor 2212, the return circuit being through current limiting resistance 2213 and the governor contacts which are closed while the motor is coming up to speed. Relay 1804 locks to ground on the conductor leading from the relays, such as 1204 and designated in Fig. 12 as conductor 1219. Therefore, the motor is kept running under control of the sequence circuit as long as an incoming call is awaiting completion. Relay 1804 also supplies ground to the armatures of the polar relays 2205 to 2210 over its outer right armature and front contact and this ground connection permits these relays to lock in either direction until they may be operated. While the motor is attaining speed, the distributor cams are successively operating, causing brief closures of each receiving contact in turn. The polar relays will, therefore, operate and lock in the spacing direction due to these closures of ground.

The spacing locking paths of the polar relays 2205, 2206, 2209 and 2210 are through such resistances as 2214 and the winding of relay 2215. Polar relay 2207 has a spacing locking path independent of the winding of relay 2215 for a purpose which will be hereinafter described. Therefore, relay 2215 will operate as soon as any one of relays 2205, 2206, 2209 or 2210 operates to spacing. The operation of relay 2215 opens the operating path of relay 1812 to prevent its premature operation.

Meanwhile, relay 1806, in operating, has in effect placed a sensitive relay 1813 across the governor contacts and has prepared in advance a path for operating the fast operating relay 1807. The operation of relay 1806 has also resulted in the operation of relay 1814 in a circuit from the outer left-hand armature of relay 1806. Relay 1814, in operating, prepares a path for sending the director ready signal out over lead 1815, operates relay 1816 and prepares a path for lighting lamp 1817 in case the director is timed out in this condition. Relay 1816, in operating, grounds leads 1818 and 1819 leading to the miscellaneous alarm circuit as an indication that the director has been moved off normal. Lead 1818 furnishes the miscellaneous alarm circuit with information about the apparent health of the associated trunk circuit. Relay 1816 also prepares to lock to ground at the contacts of relay 1805, prepares a path toward lamps 1820, 1821 and 1822 and provides a locking circuit for relay 1810.

Relay 1810, being operated at this time, prepares to ground leads 1855 and 1856 as soon as the director ready signal has operated relay 1801. Relay 1810 also prepares to light lamp 1822, in case of trouble, to indicate that the incoming marking signal has been registered.

While the motor 2212 is accelerating, relays 1800, 1804, 1806, 1814 and 1816 are operated. When full speed is reached, the governor contacts open momentarily, removing the short circuit from resistance 2216 and allowing relay 1813 to operate through resistances 1825 and 2217. Relay 1813 is slow-releasing and, with the help of condenser 1826, holds over during momentary governor contact closures operating relay 1807 as soon as the stop pulse contacts 2202 close.

Relay 1807, in operating, removes ground from the receiving contacts and start magnet 2201, latching the clutch and preventing further operation of the contacts. Relay 1807 locks through the winding of and operates relay 1805 which, in operating, applies ground to start the director ready signal out over lead 1815 to the loop repeater. The director ready signal consists of the connection from ground, right-hand armature and front contact of relay 1800, inner left-hand armature and front contact of relay 1805, front contact and outer left-hand armature of relay 1814, and left-hand winding of relay 1801 to conductor 1815. This operates relay 1801 through its left-hand winding, provided the lead 1815 is not in trouble. Relay 1805, in operating, also (1) transfers the armature of relay 1802 from the left-hand winding of relay 1810 to a circuit extending through the back contact and right-hand armature of relay 1827 to conductor 1808 leading to the start magnet 2201 and the contact 2200 preparatory to receiving pulses from the loop repeater, (2) releases relay 1806 and (3) provides off-normal ground on conductor 1828 to a large part of the director circuit, including locking ground for relay 1816 and ground on the armature of relay 2211 through the back contact and right-hand armature of relay 1829. Relay 1801, in operating, (1) closes a path to light lamp 1821 instead of lamp 1820, in case of trouble, to indicate that the director ready signal has been sent, (2) locks to ground on conductor 1828 and (3) connects ground to conductors 1855 and 1856 to the miscellaneous alarm circuit to indicate that, in case of trouble, the director should not be taken out of service. Relay 1806, in releasing, disconnects relay 1813 from the governor contacts, releases relay 1814 and transfers the stop pulse contacts 2202 from relay 1807 to the operating winding of relay 2211 preparatory to receiving pulses from the loop repeater. Relay 1814, in releasing, (1) disconnects the director ready signal and prepares a path to contacts of relays 1830 and 1831 for sending signals to indicate busy, out-of-order or unassigned lines, (2) opens the operating path of relay 1816 which nevertheless remains locked through its left-hand winding and (3) transfers ground from the path to light lamp 1817 to a path to light lamps 1821 and 1822. The director ready signal is, therefore, sent during the releas-

ing times of slow-releasing relays **1806** and **1814**. After the director ready signal is sent, the following relays are held operated: **1800**, **1804**, **1810**, **1816**, **1807**, **1805**, **1801**, **1802**, (on its marking contact) **2215**, and the polar relays **2211**, **2205**, **2206**, **2207**, **2209** and **2210** (all on their spacing contacts). The circuit is now prepared to receive pulses from the distant TWX office.

Reception of figures character

Telegraph pulses over the inward path are repeated by relay **1802** which is normally held to its marking contact. The distributor motor is running but the receiving contacts of the distributor are not operating because the start magnet **2201** is released, latching the clutch. As soon as a character is received, the start pulse of the character sends relay **1802** to spacing, which operates magnet **2201**, allowing the cams to successively operate the receiving contacts. The motor speed and receiving contacts are adjusted so that, at the time the first selecting pulse of the character is received, the secondary winding of relay **2210** is momentarily connected to the armature of relay **1802**. If the first pulse is marking, relay **2210** will operate and lock to its marking contact. Similarly, the other polarized relays **2209**, **2207**, **2206** and **2205** will, in turn, be left either spacing or marking, depending on the character of the following pulses. The reception of the figures character then proceeds as follows:

Dot elements	Relay 1802	Register relays	Fan relays operated
1	Marking	2210 marking	2222 and 2224.
2	do	2209 marking	2221 and 2223.
3	Spacing	2207 spacing	
4	Marking	2206 marking	2219.
5	do	2205 marking	2218.

With the polarized register relays operated as above, it will be noted that none of the locking paths of these relays pass through the winding of relay **2215**. If any one is operated in the reversed direction, relay **2215** will be energized. Relay **2215** will, therefore, release only when a figures character is received. The succeeding stop pulse is marking which causes magnet **2201** to release. With relay **2215** released, a momentary closure of ground by the stop pulse distributor contacts causes relay **2211** to operate to its marking contact, overcoming the effect of its bias to its spacing contact. The timing condenser **2225** causes relay **2211** to remain on its marking contact for .030 second after the stop pulse distributor contacts open. This allows time for the operation of relay **1812**, which thereupon locks to ground on conductor **1828** and prepares a path for operating relay **1832** when relay **2211** returns to its spacing contact. In this way relay **1832** operates and locks to ground on conductor **1828** and transfers the marking contact of relay **2211** along to succeeding counting relays in preparation for the registration of the next two digits. The reception of "figures" has, therefore, set up a combination of register relays locking direct to battery instead of through the winding of relay **2215**, thereby unlocking relay **2215** and allowing the next two characters to be registered. Hits or short interruptions like the spacing signals on the line are harmless until the operator has sent preliminary "figures." After the "figures" character has been received, the following relays are operated: **1800**, **1804**, **1810**, **1816**, **1807**, **1805**, **1801**, **2218**, **2219**, **2221**, **2222**, **2223**, **2224**, **1812**, **1832**, **1802** (to marking), **2210** (to marking), **2209** (to marking), **2207** (to spacing), **2206** (to marking), **2205** (to marking) and **2211** (to spacing). The operation of relays **2218**, **2219**, **2221**, **2222**, **2223** and **2224** performs no useful function at this time since the path from conductor **2226** is not closed to any of the 0 to 9 conductors.

Reception and deciphering of the first digit

The first digit of the subscriber's number will be repeated by relay **1802**, broken up pulse by pulse by the distributor contacts and recorded by the register relays in much the same way as the "figures" character was received. The polarized register relays will be operated in accordance with the position of relay **1802** during the reception of the corresponding pulses. In each case, the operating winding of such polarized relays can quickly overcome the holding winding but otherwise the relays hold in whichever direction they are operated under control of the outer right-hand armature of relay **1804**. The following table indicates the condition of the register relay resulting from the transmission of numerical characters. "M" indicates marking, "S," spacing.

Character		Relay condition				
Lower case	Upper case	R2210	R2209	R2207	R2206	R2205
Figures	Figures	M	M	S	M	M
P	0	S	M	M	S	M
Q	1	M	M	M	S	M
W	2	M	M	S	S	M
E	3	M	S	S	S	S
R	4	S	M	S	M	S
T	5	S	S	S	S	M
Y	6	M	S	M	S	M
U	7	M	M	M	S	S
I	8	S	M	M	S	S
O	9	S	S	S	M	M

It will be noted that when relay **2205** is on its marking contact that fanning relays **2222** and **2224** are operated. Similarly, the other fanning relays are operated when their associated register relays are on their marking contacts. Also, relay **2215** will be operated during the reception of the first digit but performs no useful function after the "figures" character has been received. At the conclusion of the dot elements of the particular character sent, relay **2211** again operates to marking and is again held to an additional period of .030 second.

Let it be assumed that the call is being extended to the subscriber's station shown in Fig. 4, known as station No. 90. The first digit, therefore, will be the digit 9 having three successive spacing signals followed by two successive marking signals. This will result in the operation of relays **2210**, **2209**, **2207** to their spacing contacts and relays **2206** and **2205** to their marking contacts. As a result, relay **2218** is operated by relay **2205** and relay **2219** is operated by relay **2206**. Therefore, a connection can be traced from conductor **2226** through the left-hand armature and front contact of relay **2218**, the right-hand armature and front contact of relay **2219**, the inner left-hand armature and back contact of relay **2220**, the outer left-hand armature and back contact of relay **2223**, the outer right-hand armature and back contact of relay **2224** to conductor **2227**. This latter conductor can be traced through the back contact and inner left-hand armature of relay **1705**, thence through the back contact and outer right-hand armature of relay **2100**, the left-hand wind-

ing of relay 2101, the back contact and left-hand armature of relay 2102 to battery. In the other direction this battery connection will be extended over conductor 2226 through the back contact and inner left-hand armature of relay 1833, the outer left-hand armature and back contact of relay 1829, the left-hand armature and back contact of relay 1834, the back contact and right-hand armature of relay 1835, the front contact and right-hand armature of relay 1832 to the marking contact of relay 2211. When the stop contact 2202 is closed with relay 2211 on its marking contact, ground from the front contact and right-hand armature of relay 1800 extending over conductor 1809 and eventually over the right-hand armature and front contact of relay 1832, causes the operation of relays 1836 and 2101. Relay 2101, which corresponds to the tens group of the particular called subscriber's line, in operating locks in series with relay 2102 to a ground which may be traced from the winding of relay 2102 over the back contact and outer right-hand armature of transfer relay 1705 to ground on conductor 1828. Relay 2102, in operating, (1) removes battery from the operating windings of all other relays corresponding to relay 2101, preventing the operation of another such relay on this call (2) causes the operation of relay 2100 and its companion relay 2103 which definitely remove any one of the relays, such as relay 2101, from their associated 0 to 9 fanning-out leads and (3) closes a connection to conductor 2114 which later supplies ground to operate the hold magnet of the link circuit in case the line is idle. Relay 1836, in operating, prepares a path for the operation of relay 1835. When the polarized relay 2211 returns to its spacing contact after .030 second, relay 1835 will operate and ground will be supplied to a contact on relay 2101, in a circuit from the ground supplied for the operation of relay 1835 over the back contact and inner right-hand armature of relay 1705, front contact and left-hand armature of relay 2101 to the windings of relays 2105 and 2106 associated with the particular tens group of the called subscriber's line. Relays 2105 and 2106, in operating, connect the fanning-out leads 0 to 9 to the 0 to 9 leads of the particular tens groups of subscribers' lines. The relay 1835, in operating (1) locks to ground on conductor 1828, (2) opens the operating paths of relays 1836 and 2101 and prepares a path for the operation of relay 1837, (3) connects ground to lead 1803 to the sequence circuit where it is instrumental in fixing the trunk advance chain and preventing the release of any link circuit in use on an established call. After the first digit has been received, the following relays are operated: 1800, 1804, 1810, 1816, 1807, 1805, 1801, 1812, 1832, 1836, 1835, 2101, 2102, 2100, 2103, 2105 and 2106. Relay 1802 is marking, relay 2211 is spacing and, in the particular case described, relays 2210, 2209, and 2207 are spacing and relays 2206 and 2205 are marking and relays 2218 and 2219 are operated.

Reception and deciphering of the second digit

The second digit of the called subscriber's number is received, registered and made to operate the fanning-out relays in the same way as the first digit. In this particular case, we are assuming that the second digit is 0. Therefore, relay 2210 will be spacing, relays 2209 and 2207 will be marking, relay 2206 will be spacing and relay 2205 will be marking. With the register relays so effected, fanning-out relays 2218, 2220, 2221 and 2223 will be operated. Therefore, a connection can be traced from conductor 2226 through the left-hand armature and front contact of relay 2218, the back contact and right-hand armature of relay 2219, the outer right-hand armature and front contact of relay 2220, the right-hand armature and front contact of relay 2221, the outer left-hand armature and back contact of relay 2222 to conductor 2228. This conductor may be traced through the outer left-hand armature and back contact of relay 1703 and thence to the outer left-hand armature of relay 2105.

Relay 2211 operates to its marking contact while the stop segment is grounded and thereby causes the operation of relay 1837. Relay 1837, in operating, (1) establishes a connection from ground, the lower winding of relay 1802, the front contact and outer left-hand armature of relay 1837, resistance 1838, resistance 2229 to battery to prevent any additional incoming impulses from being registered, (2) locks to ground on conductor 1828 and (3) opens the original operating paths of relays 1835, 2105 and 2106 and prepares a path for the operation of relay 1834.

When the polarized relay 2211 after .030 second returns to its spacing contact, it causes the operation of relay 1834. This relay, in operating, (1) connects battery through the windings of relays 1839 and 1840 in series, thence through the front contact and left-hand armature of relay 1834, the back contact and outer left-hand armature of relay 1829, the inner left-hand armature and back contact of relay 1833 to conductor 2226 which may be traced to conductor 2190 and thence to conductor 690 individual to the called subscriber's line and (2) causes the operation of the slow-acting relay 1841. It will be noted that, as usual, the polarized registration relays remain locked in the direction in which they were last operated.

Testing subscriber's line

The connection of battery through the relays 1839 and 1840 to the particular called subscriber's line enables these two relays to determine if the individual lead 690 to the subscriber's line is terminated in a direct ground which causes the operation of both relays 1839 and 1840 or a high resistance ground which results in the operation of relay 1839 only and denotes an out-of-order condition. In case no ground is available, neither relay 1839 nor 1840 operates. This test takes place during the slow-operating time of relay 1841 which begins to operate when relay 1834 operates. As soon as relay 1841 operates, off-normal ground on conductor 1828 is connected to the armature of relay 1839.

Assuming the subscriber's line idle, in which case ground is not connected to the lead passing through relays 1839 and 1840, neither of these relays will be operated and ground connected to the armature of relay 1841 will cause the operation of relay 1829. Relay 1829, in operating, (1) removes relays 1839 and 1840 from connection to the subscriber line lead, in this case conductor 690, and replaces such relays by relay 1842, (2) causes the release of relay 1834, by removing ground from the armature of polarized relay 2211, (3) prepares a path for the operation of relay 1830, and (4) locks to ground on conductor 1828. The release of relay 1834 allows relay 1841 to release, but since this latter relay is slow in releasing there will be a short interval during which relay 1834 is released and relay 1841 is operated, giving relay 1842 an opportunity to determine which of relays 1843 and 1830 shall be operated. During this time ground is connected

through the winding of relay 2307 in the miscellaneous alarm circuit, through conductor 2312, conductor 2114, the front contact and right-hand armature of relay 2102, the inner left-hand armature and back contact of relay 1702, winding of relay 1842, the front contact and outer left-hand armature of relay 1829, the inner left-hand armature and back contact of relay 1833 and thus over a path previously traced to the subscriber's individual lead 690. Under the assumed condition of the subscriber's line being idle, battery on the winding of relay 903 of the cross-bar switch permits relay 1842 to operate, but due to the high resistance of the circuit relay 903 remains unoperated. Relay 1842, in operating, opens the operating path of relay 1830 and closes a path to operate relay 1843. When relay 1841 releases, ground supplied over conductor 1828 is connected to the armature of relay 1842 through the back contact of relay 1841 so that now the circuit for the operation of relay 1843 is completed and this relay operates. Relay 1843, in operating, (1) locks to ground on conductor 1828, (2) short-circuits the winding of relay 1842, and (3) holds open the operating path of relay 1830. With the winding of relay 1842 short-circuited, ground supplied by the miscellaneous alarm circuit connected through the fanning-out relays of the director circuit and thence over conductor 690 will cause the operation in the link circuit of relay 903. The subscriber will, therefore, be connected to the trunk circuit which will function to release the sequence circuit. The sequence circuit in turn will function to remove the ground on the conductor leading to relay 1800. Relay 1800 therefore releases, (1) removing off-normal ground from various parts of the circuit including relays 1807 and 1805, and (2) releasing relay 1804 unless conductor 1219 leading to the inner right-hand armature of relay 1804 is held grounded, indicating that another inward call is awaiting completion. Relay 1805, in releasing, removes off-normal locking ground from a considerable part of the circuit. If relay 1804 releases, the motor 2212 will be stopped and all remaining parts of the circuit will be deenergized. If, however, relay 1804 is held operated, the motor is kept running and the polar relays 2205, 2206, 2207, 2209 and 2210 and the associated fanning-out relays 2218 to 2224 are locked in the condition in which they were operated by the last digit. When the next call comes in the operation will be as previously described except as follows: Relay 1813 now operates immediately, since the motor is running at full speed, and relays 1807 and 1805 follow at once upon receiving the closure of the stop pulse contacts 2202. Before this stop pulse is reached, the polar relays may be operated to spacing through the back contacts of the relay 1807, but in any case the circuit waits to receive "figures" before proceeding with the call. The operation then continues as hereinbefore described.

Inward call to busy or out-of-order line

The operation on this type of call is exactly the same as set forth above up to the point where the operation of relay 1834 connects relays 1839 and 1840 to the individual lead 690 of the subscriber's line circuit. Now, however, this lead terminates in direct ground or a high resistance ground (out-of-order busy). In either case relay 1839 quickly operates but relay 1840 is marginal and only operates on direct ground. Relay 1839, in operating, prevents relay 1829 from operating and therefore relay 1834 remains operated, keeping relays 1839 and 1840 connected to the lead 690. Relay 1839 therefore remains operated along with relays 1837, 1834 and 1841 and causes the operation of relay 1831. Relay 1831 (1) applies the ground to start the production of "K" or "Q" characters by polarized relays 1844 and 1845, and (2) connects the contact of relay 1844 to the outward transmission path which may be traced from the right-hand contact of relay 1844 through the outer left-hand armature and front contact of relay 1831, the back contact and outer left-hand armature of relay 1814, the left-hand winding of relay 1801 to conductor 1815.

Relays 1844 and 1845 operate in condenser-timed circuits to generate "K" and "Q" signals as follows: When the ground is applied to one end of the potentiometer formed by resistances 1846 and 1847, relay 1845 will operate to its left-hand contact due to current in its lower winding, supplied through resistance 1848. When such left-hand contact is closed the current in this lower winding is reversed but the discharging of condenser 1849 through the upper winding holds relay 1845 to its left-hand contact until the discharge current is so reduced that the lower winding regains control and sends the armature to its right-hand contact. Here the process is repeated, the lower winding tending to make the armature return to its left-hand contact while the condenser in charging holds it to the right-hand contact until its effect is overcome. The condenser and potentiometer resistances are so proportioned that relay 1845 will pulse at about 9 cycles per second if resistance 1850 is in circuit or 11 cycles per second if resistance 1850 is short-circuited. As will be seen later, if the line is busy the relay 1840 being operated and therefore including resistance 1850 in circuit, will cause relay 1845 to pulse at about 9 cycles per second. If, on the other hand, relay 1840 is not energized resistance 1850 will not be included in the circuit and relay 1845 will pulse at about 11 cycles per second.

When ground is connected by relay 1831, relay 1844 will operate to its right-hand contact due to current in the lower winding. This sends a marking signal over the outward transmission lead 1815. However, when relay 1845 reaches its right-hand contact condenser 1851 will discharge through the upper winding and resistance 1852 and cause the relay to leave its right-hand contact for one pulse length (approximately .022 second). Relay 1844 then returns to its right-hand contact and after relay 1845 opens its right-hand contact condenser 1851 is recharged through resistances 1853 and 1854. Since relay 1844 is pulsing continuously, relay 1844 will send out a spacing pulse of .022 second each time relay 1845 closes its right-hand contact. In this way relay 1845 drives relay 1844 at either 9 or 11 cycles per second, sending "K" signals if the line is busy and "Q" signals if the line is out of order. These characters are transmitted over the line and printed on the distant operator's teletypewriter.

Connection to unassigned or impossible number

If an unassigned number or non-numerical code is received and registered the circuit functions as hereinbefore described. When, however, the relay 1842 is applied to the individual lead of the called subscriber's line, as indicated heretofore, battery is not available on such lead and relay 1842 fails to operate. When, therefore, relay 1841 releases, off-normal ground will be

connected to relay **1830**, causing it to operate instead of relay **1843** as heretofore. With relay **1830** operated, ground is placed on relays **1844** and **1845** and their associated apparatus and relay **1830** transfers the right-hand contact of relay **1845** from resistance **1852** directly to the transmission conductor **1815** through the left-hand winding of relay **1801**. Under these conditions, relay **1845** pulses at approximately 11 cycles per second, since relay **1840** is unoperated and the resistance **1850** is short-circuited. Resistances **1846** and **1847** are so proportioned that the right-hand contact of relay **1845** will be successively closed and opened at intervals of approximately .044 second. This causes an "I" signal to be sent to the distant operator as an indication that an unassigned or impossible number has been selected. The operator, upon receiving the unassigned signal, disconnects the calling cord plug from the trunk jack at the distant manual end. This causes the associated two-way trunk at the line concentration unit to function to return to normal and release the sequence circuit which in turn removes ground from the conductor leading to the winding of relay **1800**. The circuit is then restored to normal as hereinbefore described.

Failure of the director circuit—General

When a trunk circuit on an inward call obtains the permission from the sequence circuit to route the call, the miscellaneous alarm circuit begins counting time. Ordinarily the alarm circuit will time out in two seconds but if the director circuit has grounded conductor **1819** indicating that it has moved off normal, the miscellaneous alarm circuit extends the timing out to four seconds. Then if the director ready signal is sent, as hereinbefore described, relay **1801** in operating grounds conductor **1855** causing the miscellaneous alarm circuit to extend the time allowed for handling the call to ten seconds.

Conductors **1818** and **1856** are used to indicate to the miscellaneous alarm circuit whether or not the trunk should be locked up in case of trouble. Ground on either of these leads prevents the removal of the trunk circuit from service.

Failure to move a director off normal

If after two seconds relay **1816** has not grounded conductor **1819**, indicating that the trunk circuit has failed to start a director off normal, the alarm circuit removes the trunk from service. The removal of the trunk of course removes any connection from the director to that trunk permitting the director to continue to handle calls.

Failure of the director motor to attain speed

In this case it is assumed that relay **1816** has operated and grounded conductor **1819** causing the miscellaneous alarm circuit to permit an elapsed time of four seconds but that relay **1805** has failed to operate either because the motor failed to attain speed or the relay arrangement designed to detect the speed failed to function. Relay **1814** in operating caused relay **1816** to operate and place a ground on conductor **1818**. In this case the alarm circuit after four seconds places a ground on the conductor leading to relay **1833** thereby causing this relay to operate. Relay **1833** in operating (1) locks under control of the release key **1857**, (2) operates relay **1827**, (3) grounds lead **1858** to indicate to the miscellaneous alarm circuit that the director is locked, (4) connects ground to relay **1800** to hold the director in timed-out condition and (5) opens the fanning out common lead **2226** to reley **2218**.

Relay **1827** in operating (1) opens conductor **1819**, (2) connects battery to lamps **1817**, **1820**, **1821** and **1822** which in this case causes lamp **1817** to light indicating the type of trouble and (3) places battery potential on magnet **2201** of the distributor to prevent the distributor from running open. Meanwhile, since conductor **1818** is grounded, the miscellaneous alarm circuit places the trunk back into service after removing it temporarily, disconnects the trunk from the director which of course has no effect on the stuck director and then if the sequence circuit has returned to normal places a ground on the transfer lead **1706** thereby operating transfer relays **1700** to **1705**, inclusive, and thus rendering director No. 2, indicated by rectangle **2314**, effective in place of the director shown in detail in Figs. 17, 18, and 22. If director No. 2 was the director that was sent into the stuck condition the transfer lead **1706** would have already been grounded and in this case the alarm circuit removes the ground on the transfer lead placing director No. 1 into service. New inward calls are serviced by the newly connected director.

Failure of the director ready signal to reach associated loop repeater or failure of registration of mark signal sent by trunk circuit to distributor circuit

In this case it is assumed that the distributor has attained speed and that relay **1805** has operated but the circuit by which the director ready signal was to be sent was opened somewhere before reaching the associated loop repeater or in any case the relay **1801** had failed to operate or if the incoming transmission lead to the distributor is open it is obvious that directing of the inward call by the connection will be impossible. Such condition would prevent relay **1810** from operating. These two troubles could occur on the same call. In any case, after four seconds the miscellaneous alarm operates relay **1832** and in turn relay **1827**, as hereinbefore described, except that since neither conductor **1818** nor **1856** is grounded the alarm circuit proceeds to lock the trunk as well as the director out of service. Relay **1827** in operating causes telltale lamps to light as follows: Lamps **1820** and **1822** lighted indicates director ready signal failure, lamp **1821** lighted indicates failure to register the incoming mark and lamp **1820** alone lighted indicates a combination of both types of trouble. The alarm circuit meanwhile proceeds to place the other director into service.

Returning "stuck" director to service

After the trouble is cleared the director can be made available by momentarily operating release key **1857** which removes holding ground from relay **1800** and marking ground from relays **1827** and **1833** returning the circuit to normal.

Miscellaneous alarm circuit

The circuit shown in Figs. 23 and 24 is designed for use primarily to time the interval during which the sequence circuit is in use and is arranged to give appropriate alarms if a specified time limit is exceeded giving at the same time an indication of the possible circuits in trouble. The circuit is also arranged to give an alarm when the battery or grounded chain of the se-

quence remains open. The functions of the circuit may be summarized as follows:

1. On an outward call from the local subscriber the miscellaneous alarm circuit times the interval in which the sequence circuit is used to see that it does not exceed two seconds.

2. On on outward call when the sequence circuit is in use for more than two seconds the miscellaneous alarm circuit is arranged to indicate whether the trouble is in the trunk alone or in an of the other circuits called into use. In case the miscellaneous alarm circuit decides that the trunk is in trouble it is arranged to give a minor alarm flash on a trunk lamp and to cause the removal of a particular trunk circuit from service. In case the miscellaneous alarm circuit determines that any of the other circuits in use on the particular call are in trouble the circuit is arranged to light a lamp **2309** and to give a minor alarm and to cause the removal of the subgroup of subscribers containing the calling subscriber from outward service.

3. After removing the particular trunk or the particular subgroup of subscribers from service the miscellaneous alarm circuit is arranged to detect the ability of the sequence circuit to return to normal and to light a lamp **2400** and to bring in a major alarm if it fails to do so within a half second.

4. On an inward call to the local subscriber the miscellaneous alarm circuit begins timing as soon as the inward call has received preference from the sequence circuit being arranged to time the interval required to obtain a director circuit and to give an alarm if this period exceeds two seconds. In this case the miscellaneous alarm circuit is arranged to cause the removal from service of the trunk in trouble, flash the lamp associated with the trunk and at the same time to light lamp **2309** and to bring in a minor alarm. The alarm circuit continues to function as indicated in paragraph 3 above.

5. When informed over conductor **1819** that the director circuit has moved off normal, the miscellaneous alarm circuit waits a total of four seconds for the director to place ground on conductor **1855**. The director places ground on conductor **1855** if the distributor motor has attained speed, if the director ready signal reached the associated loop repeater and if a mark signal sent over the trunk from the central office has been registered in the distributor circuit.

6. If the miscellaneous alarm circuit times out before conductor **1855** is grounded but after conductor **1819** was grounded, the alarm circuit is arranged;

a. To cause the associated director circuit to lock in a "stuck" condition.

b. To bring in an audible and visible alarm associated with the director circuit.

c. After the director has been locked up in a "stuck" condition to remove the trunk circuit from service under control of a key and cause a lamp associated with this trunk to flash or if the conductors **1818** and **1856** are grounded when the alarm circuit times out to remove the trunk circuit from service temporarily under control of a mark signal sent from the central office causing a lamp associated with the trunk to light steadily.

d. After allowing approximately one-half second the director has been locked on a "stuck" condition the miscellaneous alarm circuit is arranged to test for failure of the sequence circuit to release and to bring in an audible major alarm and light lamp **2400**, if the sequence circuit fails to release.

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

7. If the conductor **1855** is grounded the miscellaneous alarm circuit permits the director circuit ten seconds to complete all its functions.

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

a. Removes the trunk circuit used on the particular call from service under control of a mark signal received from the distant end lighting a lamp associated with this trunk but returns the director back to service.

b. After approximately one-half second test for failure of the sequence circuit to release and if the sequence circuit fails to release brings an audible major alarm and lights lamp **2400**.

9. The alarm circuit in taking a director out of service will give a minor alarm provided a spare director is available and not in trouble. If the second director is in trouble the circuit will give a major alarm.

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

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

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

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

14. This circuit is arranged to light lamp **2315** as an indication that a selector magnet of the link circuit has operated.

15. This circuit is arranged to prevent the director from interfering with the miscellaneous alarm circuit when both directors fail.

16. If the battery or ground chain of the sequence circuit remains open for approximately forty-five seconds this circuit is arranged to give a major alarm and light either lamp **2316** or **2317** to indicate which chain is open.

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

Description of Operation

Timing of the sequence circuit on an outward call

When a subscriber originates an outward call and the sequence circuit is called into use, battery is placed on the conductor leading to relay **2306**. Relay **2306** in operating (1) removes ground from the contact of key **2401** to prevent manual transfer from director **1** to director **2**, (2) causes the operation of the common start relay **2305** and (3) furnishes ground to supple-

ment one on the key 2401 to nullify the return to normal of that same key and to continue the particular director in use during the routing of the call in the office. The operation of the common start relay 2305 removes ground from the ground lead to the sequence circuit preventing further use of the sequence circuit on a new call, connects locking ground to the time measuring relays and connects a sixty interruption per minute interrupter 2318 to relay 2402 which follows the one-half second open, the one-half second closed interrupter.

The interrupter relay 2402 works three sets of counting relays, the first comprising relays 2403 and 2404, the second comprising relays 2405 and 2406 and the third comprising relays 2407 and 2408. The action of these relays is well known and therefore no detailed description will be given. The complete cycle of operations of the counting relays 2403 and 2404 start with one closure of the contact of relay 2404 and ends with the end of the second closure of this contact and thus occupies two full seconds. Since the connection of the interrupter 2318 to relay 2402 may take place at any time the completion of the operation of the first set of counting relays will therefore occur either exactly at the two-second interval or within one-half second either side thereof. Assuming hereafter, that the operation of the common start relay 2305 which connects the interrupter 2318 to the relay 2402 occurs exactly at such a time that the relay 2404 will be operated for a full one-half second, then it will be found that relay 2403 immediately operates at what may be termed zero time, relay 2404 operates at the end of one-half second, relay 2403 releases at exactly one second, relay 2404 releases at exactly one and one-half seconds and relay 2403 again operates at exactly two seconds.

Relay 2403 is therefore regularly operated for one second and released for one second and relay 2404 is also regularly operated for one second and released for one second. Relay 2405 will be operated at the end of one-half second and released at the end of two and one-half seconds, again operated at the end of four and one-half seconds and released at the end of six and one-half seconds. Relay 2406 will be operated at exactly one second and released at exactly three seconds, again operated at exactly five seconds and released at exactly seven seconds. Relay 2407 will be operated at exactly two and one-half seconds, released at six and one-half seconds and again operated at ten and one-half seconds and relay 2408 will be operated at exactly three seconds, released at exactly seven seconds and again operated at exactly eleven seconds and relay 2409 will come into operation at exactly six and one-half seconds.

Providing the relay 2306 and therefore the common start relay 2305 are still operated at the two-second point when relay 2403 again operates, a circuit may be traced from the winding of relay 2319, the inner upper armature and back contact of relay 2320, the back contact and outer upper armature of relay 2404, the front contact and outer upper armature of relay 2403, the front contact and upper outer armature of relay 2406, the back contact and lower armature of relay 2321, the back contact and outer upper armature of relay 2410 to conductor 2411 which is grounded through the front contacts and inner armatures of common start relay 2305. The operation of relay 2319 (1) closes the operating winding of relay 2412 through its front contact and inner upper armature and the inner upper armature and back contact of relay 2322, the outer upper armature and back contact of relay 2321 to ground, (2) connects ground available on the contact of the start relay 2306 through its inner lower armature and front contact through the inner lower armature of relay 2319 to hold relay 2301 operated and (3) opens at its lower outer armature and back contact a path which may extend through the inner upper armature of relay 2321 to the winding of transfer relay 2413. Relay 2322 and relay 2321 being unoperated at this time, relay 2412 operates immediately at this time and locks in a circuit through its lower winding, its front contact and inner lower armature, the lower armature and back contact of relay 2320, the front contact and upper outer armature of relay 2403, the front contact and upper outer armature of relay 2406, the back contact and lower armature of relay 2321, the back contact and outer upper armature of relay 2410 to ground on conductor 2411. Relay 2412 in operating through its front contact and outer lower armature places a supplemental ground on the winding of the common start relay 2305. Relay 2412 also prepares a path for testing the subsequent release of the sequence circuit and extends the ground from the contacts of relay 2306 through its middle upper armature and front contact to the lower armature of relay 2301.

During the routing of the outward call the trunk circuit sends the calling-in signal to the distant end and awaits the reception of ringing sent automatically from the distant end. If this calling-in signal was not received at the distant end due to a faulty conductor or if the calling-in signal fails to be registered at the distant end or if in any event the ringing fails to be received in the line concentrating unit, ground on lead 1108 would continue to keep relay 2301 operated causing it to lock the moment the relay 2319 operates. Therefore, the ground furnished by relay 2306 and directed to the contacts of relay 2301 by means of relays 2319 and 2412 can be applied to conductor 2325 leading to a contact on the start relay of all trunks. The ground will also be extended through the outer upper armature of relay 2301 to the upper winding of relay 2323. Relay 2323 operates and causes the minor alarm lamp 2324 to light and to lock in through the release key 2347. Ground on lead 2325 operates relay 2303 which releases the sequence circuit chain by opening the main sequence circuit ground chain at its contacts, thereby causing the removal of the particular trunk circuit from service. This will permit the subscriber's call to receive service over another trunk after the alarm circuit has tested and found the sequence circuit normal and when connected to the new trunk the sequence circuit will return to normal and remove battery from the lead to relay 2306 causing this relay to release and in turn release the common start relay 2305. The common start relay will release all counting relays operated at that time returning the circuit to normal except for the locked in alarm 2324.

If the selected trunk has operated satisfactorily and registered the received ringing, or if the trunk circuit was not even preselected, relay 2301 of the miscellaneous alarm circuit would be normal when relay 2319 operated and ground available at the contact of relay 2306 directed to the contacts of relay 2301 by means of relays 2319 and 2412 would be applied over the lower arma-

ture and back contact of relay 2301 to conductors 2326 and 2327, connecting respectively to conductors 1217 and 1218, for the operation of such relays as 1201 and 1203. This ground would also be extended over the upper outer armature and back contact of relay 2301 to the winding of relay 2328, causing this relay to operate and light the minor alarm lamp 2309 under control of release key 2329. Ground on conductor 2326 will extend through conductor 1217 to conductor 1014 where it will operate a relay such as 1009 to remove from outward service the particular subgroup of subscribers containing the calling subscriber. In either case, after a half second has elapsed, relay 2402 again releases, causing the operation of relay 2404 which in turn causes the release of relay 2319 and this relay in releasing applies the upper winding of relay 2414 through the back contact and upper outer armature of relay 2319 to the ground on the contact of the start relay 2306. If, therefore, in the half second that relay 2403 was operated alone and in which relays 2319 and 2412 function to apply ground to the contacts of relay 2301 and in which an attempt was made to free the sequence circuit, relay 2306 did not release ground on its front contact would cause the operation of relay 2414 as soon as relay 2319 released. Relay 2414 would lock under control of key 2415, light lamp 2400 and bring in a major alarm as an indication that the sequence circuit itself was in trouble. If, however, relay 2306 released during this interval, the miscellaneous alarm waits for another one-half second until relay 2403 releases, which permits the release of relay 2412. The release of this relay removes the ground from the winding of the common start relay 2305 which now, in releasing, removes the sixty interruption per minute interrupter 2318 from the winding of relay 2402, removes the locking ground from conductor 2411 to the time measuring relays and reconnects ground to conductor 2330, being the main ground in the sequence circuit chain, thus permitting the sequence circuit to handle a new call.

The removal of holding ground from the time measuring relay and the disconnection of sixty interruption per minute interrupter from the relay 2402 causes the release of relays 2402, 2403, and 2404, returning the miscellaneous alarm circuit to normal except for the locked-in trouble indication and thus permitting the alarm circuit to handle the timing of a new call. As indicated in this paragraph, relays 2328, 2323 and 2414 will remain operated depending upon the type of trouble the miscellaneous alarm circuit has discovered. The operation of the associated keys will permit the silencing of the audible alarm and will lock in the lamp indicating the trouble brought in. Each of these relays also has associated with it a release key such as key 2329 associated with relay 2328, the operation of which after the trouble has been cleared eliminates the locked-in trouble indication. Restoring the release key such as key 2331, extinguishes the trouble indicating lamp provided the locked-in trouble indicating relay has been released. With the trouble indicating lamp extinguished the circuit has returned to normal.

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

When a trunk circuit on an inward call receives permission to use the sequence circuit, battery supplied to the conductor leading to start relay 2306 causes the operation of this relay which in turn results in the operation of the common start relay 2305. The operation of the common start relay permits relay 2402 to operate periodically and thereby cause the functioning of the counting relays 2403 to 2408. If after approximately two seconds when relay 2406 operates, relay 2321 should still be non-operated as a result of the failure of the sequence circuit to seize a director, relay 2319 will operate as indicated above, followed by the operation of relay 2412. If relay 2306 is still operated at this particular time ground on its contacts directed by means of relays 2319 and 2412 to relay 2301 will be applied to conductors 2326 and 2327 leading to conductors 1217 and 1218 of the sequence circuit. This will result in the removal of the particular trunk used in originating the call from service and at the same time permit the operation of relay 2328 as hereinbefore described. Thereafter the miscellaneous alarm circuit functions exactly as described above under the condition when it timed out a period in excess of two seconds on an outward call in which the trunk circuit called into use was found unsatisfactory. In this case, therefore, the trunk will be removed from service as indicated by a flashing red lamp 1220 energized by the sixty interruption per minute interrupter 1403 which, together with the lamp 2309 and minor alarm, will serve to indicate the type of trouble.

Timing the interval used by the sequence circuit when conductor 1819 alone is grounded

When the sequence circuit is seized, relay 2306 operates, causing in turn the operation of common start relay 2305. As described before, the common start relay connects interrupter 2318 to the counting relays for the purpose of counting the interval. Under the assumption that lead 1819 from the director circuit has been grounded, relay 2332 operates and (1) connects conductor 2333 extending from the winding of relay 1833 through the back contact and upper outer armature of relay 2322, thence through the front contact and middle upper armature of relay 2332 to the front contact of relay 2319, (2) connects a supplementary holding path to the operating winding of the common start relay, (3) locks under control of the start relay 2306, (4) connects the operating path of relays 2416 and 2417 to contacts of relay 2319, and (5) causes the operation of relay 2321. The operation of relay 2321 connects conductor 2334, which is an extension of conductor 1858 leading to relay 1827, to the contacts of relay 2319, partially prepares the path for operating relay 2413 and locks under control of ground from the common start relay, at the same time removing ground at the back contact of the outer upper armature of relay 2321. The operation of relay 2321 also permits the operation of relay 2320 which, among other things, places ground on the upper outer armature of relay 2408 of the third counting relay combination. Relays 2403 to 2406, inclusive, function and at the conclusion of the two-second interval, relay 2321 being operated, the miscellaneous alarm circuit does not cause the operation of relay 2319. At the conclusion of four and one-half seconds, however, relays 2408, 2404 and 2403 being operated, ground furnished by relay 2320 will cause the operation of relay 2319. The circuit for this may be traced from battery, the winding of relay 2319, the inner upper armature and front contact of relay 2320, the front contact and outer

upper armature of relay 2404, the front contact and outer upper armature of relay 2403, the front contact and outer upper armature of relay 2408, the outer upper armature and front contact of relay 2320 to ground on the contacts of the common start relay 2305. Relay 2319, in operating, (1) connects ground to conductor 2330 leading to the director circuit where it causes the operation of relay 1833 which results in bringing the director into a "stuck" condition, (2) connects relay 2412 to conductor 2334, (3) causes the operation of either relay 2416 or 2417 depending upon the director in service, and (4) opens the operating path of relays 2413 and 2418. The operation of relay 2417, assuming director No. 1 to be in use, results in the locking of the relay operated under control of its associated release key and brings in an audible alarm and a lamp associated with the director in trouble, and prepares a path for either the operation of relays 2413, 2418 or 2419, the functions of which will be described later.

After the director circuit is locked in the "stuck" condition ground is placed on conductor 2334 which causes the operation of relay 2412. This relay, in operating, (1) locks under control of relay 2404, (2) places a supplementary ground on the winding of the common start relay to hold it operated, (3) connects ground under control of the start relay 2306 through the contacts of relays 2301 and 2319 to the leads 2326 and 2327 to the sequence circuit, and (4) helps prepare a path for the testing of the failure of the sequence circuit to release and for transferring the directors, both of which functions take place in the next one-half second. If, however, lead 1818 or 1856 from the director circuit had been grounded so as to cause the operation of relay 2335 at the moment that relay 2319 operated, relay 2336 would have operated and ground extended to conductor 2326 would now be also extended to conductor 2327. With both leads 2326 and 2327 to the sequence circuit grounded, the trunk circuit is taken out of service permanently under key control, but if the director circuit has so requested, the operation of relay 2336 will permit the grounding of only conductor 2326, in which case the trunk circuit will be removed from service temporarily under control of the mark signals received from the distant central office. In either case, however, the sequence circuit in taking the trunk out of service releases, removing battery from the conductor leading to start relay 2306 and causing the release of this relay. All this occurs within a half second and at the conclusion of this, relay 2403 releases, causing the release of relay 2319 but relay 2412 still remains locked up for an additional one-half second. With relay 2319 released, if for some reason or other relay 2306 is still operated, indicating, of course, that the sequence circuit has failed to release, ground furnished by the start relay 2306 through the back contacts of relay 2319 and the front contacts of relay 2412 causes relay 2414 to operate and lock under control of its associated release key and to bring in a major alarm in addition to a lamp indicating that the sequence circuit failed to release. With relay 2306 released, however, ground furnished by relay 2412 through back contacts of relays 2322, 2306 and 2319 and front contacts of relay 2321, which is still locked up under control of the common start relay, is connected to the upper outer armature and back contact of relay 2416 and thence through the lower operating winding of transfer relay 2413.

If relay 2416 is normal, indicating that director No. 2 is available, this ground causes the operation of the transfer relay 2413 which locks under control of relay 2417 and places a ground through its front contact and upper outer armature on the conductor leading therefrom to conductor 1706 where it is instrumental in causing the operation of the transfer relays 1700 to 1705, inclusive, thereby replacing director No. 1 by director No. 2. If relay 2416 is operated and relay 2417 is normal, indicating that director No. 1 is satisfactory and available, relay 2418 operates, causing the release of relay 2413 which removes ground from conductor 1706 and places director No. 1 in service instead of director No. 2. In transferring to the new director, all leads to the old director from the alarm circuit are opened, causing the release of relay 2332 and relays 2335 and 2336, if operated. If both the relays 2416 and 2417 are operated when conductor 2419 is grounded, indicating that both directors are in trouble and not available, ground on this conductor causes the operation of relay 2410 which locks under control of its associated release keys, brings in a major alarm and lights a lamp 2420. The operation of relay 2410 also removes holding ground from relay 2321 and the locking path of the common start relay which was prepared by relay 2332 while it prevents the "stuck" director from interfering with the placing and timing of outward calls. At the conclusion of the additional one-half second relay 2404 releases, causing the release of relay 2319 which in turn removes the additional holding ground from the common start relay. The common start relay 2305 in releasing (1) causes relays 2321 and 2320 to release, (2) opens the holding ground to the counting relays, (3) disconnects the interrupter 2318 from relay 2402, and (4) reconnects ground to conductor 2330, making the sequence circuit available.

Extension of the timing interval if conductor 1855 is grounded

If the director circuit places ground upon conductor 1855 relay 2313 operates and locks under control of ground furnished by the common start relay 2305. Relay 2313, in operating, causes the release of relay 2320 and this, in releasing, removes ground from the outer upper armature of relay 2408. The time counting circuit comprising relays 2403 to 2409, inclusive, therefore, continues to count time until ten seconds have elapsed, at which time relays 2409, 2406 and 2403 are operated, and ground furnished by relay 2409 through the contacts of the others causes the operation of relay 2319. Therefore, if the miscellaneous alarm circuit is off normal the absence of ground on conductor 1819 causes it to time out and operate the relay 2319 in two seconds. The presence of ground on conductor 1819 causes the alarm circuit to time out in four seconds, the additional presence of ground on conductor 1855, causing the release of relay 2320, permits the miscellaneous alarm circuit an interval of ten seconds before it operates relay 2319.

Timing out after an interval of ten seconds

As indicated in the previous paragraphs, the alarm circuit continues to count time as long as the sequence circuit is in use and until it receives notification that a certain time limit should not be exceeded. On an inward call the director makes a preliminary study of its own condition and if satisfied, places a ground on leads 1855

and 1856, causing the operation of relays 2313 and 2335.

Relay 2335 causes the operation of relay 2336 and relay 2313 operates relay 2322 and all lock under control of the common start relay 2305. Since relay 2322 opens conductor 2333 and since relay 2336 opens conductor 2327, the alarm circuit in case it does time out must return the director back to service and only remove the trunk temporarily from service. When, therefore, the miscellaneous alarm circuit has counted out an interval of ten seconds, relays 2409, 2406 and 2403 being operated, ground furnished by relay 2409 causes relay 2319 to operate. Relay 2319 causes the immediate operation of relay 2412 from ground on relay 2322. Relay 2412, operated, locks under control of relay 2403, places a supplementary ground on the winding of the common start relay 2305, prepares an operating path for relay 2414 and connects ground to conductor 2326. Ground on this conductor is used in the sequence circuit to disconnect the director from the trunk circuit, returning the director to normal, freeing the sequence circuit and removing battery from the conductor connected to the start relay 2306, while a characteristic out-of-order signal is connected to the trunk involved in addition to steady lighting of the red trunk lamp 1220. If the director returns to normal and battery is removed from the conductor leading to the start relay, both relays 2332 and 2306 return to normal. After one-half second has elapsed relay 2404 operates and relay 2319 releases. If the start relay 2306 has not released by the time the relay 2319 releases, the sequence alarm is given as indicated above. If, however, the start relay has released, the alarm waits for another one-half second until relay 2403 releases, causing the release of relay 2412 and in turn the release of the common start relay. The common start relay, released, causes relays 2321, 2313, 2336 and 2322 to release, disconnects the interrupter from relay 2402 and the holding ground from the time counting relays, releasing all of them and connecting ground to the chain lead thus returning the circuit to normal and in a position to permit the routing and timing of a new call.

Manual transfer of directors

The operation and release of key 2401 permits the manual transferring between the two directors placing either one in service. If director No. 1 is in service the operation of the key to its alternate position will place director No. 2 in service if director No. 2 is satisfactory and provided a call is not at the time being routed through the office. If director No. 2 is in service and it is desired to replace it by director No. 1 the release of key 2401 to the position shown will remove director No. 2 and replace it by director No. 1 provided director No. 1 is available and not in trouble and provided a call is not being routed through the office.

Delaying the operation of the hold magnet of the cross-bar switch

Due to the inherent design of the cross-bar switch the directing finger actuated by the selecting magnet "chatters" on being operated. To prevent the hold magnet, therefore, from snagging two sets of contacts while the directing finger is chattering, ground for the application of the hold magnet is delayed for a short period. The operating of the selecting magnets of the cross-bar link places a ground on conductor 902 which extends to conductor 2302 and thence to relay 2300. Relay 2300 is slow to operate but when it does move its armatures it extends ground to the winding of relay 2307, thence through normal contacts of relay 2310 to conductor 2312 which eventually operates a hold magnet after a time sufficient to permit the directing fingers permanently to come to rest. The operation of relay 2300 also causes the illumination of lamp 2315 as an indication that a selecting magnet has operated, and in addition it removes ground from conductor 2337 to a test circuit (not shown) to warn that circuit that a selecting magnet is operated. The application of ground to conductor 2312 causes both the hold magnet and relay 2307 to operate in series. Relay 2307, in operating, causes the slow operating relay 2310 to operate, locking to ground on the contact of relay 2307 and then increasing the resistance to ground in the lead 2312 by the resistance 2311. The hold magnet, therefore, has closed its locking contact and, therefore, locks in series with the sleeve relay of the trunk circuit. When the selecting magnets return to normal ground is removed from conductor 902, relay 2300 releases and this in turn releases relays 2307 and 2310, extinguishing the lamp 2315 and grounding conductor 2337, returning the circuit to normal.

Function of lamps and keys

The miscellaneous alarm circuit is equipped with an alarm cut-off key 2338 which upon being operated prevents the miscellaneous alarm circuit from timing out a call and at the same time flashes a lamp 2339. The circuit is also provided with a sequence busy lamp 2340 as an indication to the maintenance man whenever the sequence circuit is off normal. Relays 2328, 2323, 2414, 2417, 2416 and 2410 have associated with them a release alarm key which silences an audible alarm, permanently locking the lamp indicating the type of trouble. The illumination of lamp 2309 is an indication that the subscriber line circuit or subscriber line equipment on an outward call has failed or that on an inward call the sequence circuit failed to set a director off normal. The illumination of lamp 2324 is an indication that on an outward call the continuity of the two trunk conductors has been found in trouble. The operation of lamp 2400 is an indication that the sequence circuit failed and is in trouble. The operation of lamp 2421 or lamp 2422 indicates the particular director in trouble and the operation of lamp 2420 indicates that both directors are in trouble. After the maintenance man has cleared the trouble indicated, the miscellaneous alarm circuit is brought to normal as far as the alarm indications are concerned by the return of the release alarm key to normal if it had been operated to silence the audible alarm and the momentary operation of the release key associated with the particular alarm. This causes the release of such relays as 2328 and 2323 that were operated, removing both audible and visual alarms.

Sequence battery and ground chain alarm

Relay 2341 remains operated from ground supplied by the common start relay through the ground chain of the sequence circuit. Similarly, relay 2304 remains operated from battery supplied by relay 2303 through the battery chain of the sequence circuit. With both relays 2341 and 2304 operated, the plate and filament voltages for the vacuum tube 2342 remain unconnected while

the grid remains grounded and condenser **2343** is in a discharged condition. However, with the sequence circuit in an idle condition if either the ground or battery chain circuit becomes open, relay **2341** or relay **2304** releases, depending upon the particular chain affected. With the sequence circuit in use during the routing of a call both of these relays also release. With ground removed from the grid terminal of the tube and filament and plate potential applied by the release of either or both of the relays **2341** and **2304**, the grid immediately assumes a negative potential relative to the filament and no plate current flows. A positive charge leaking through resistance **2344** gradually raises the potential of the condenser **2343** and also continues to alter the potential of the grid. After approximately forty-five seconds the grid having reached a definite potential relative to the filament, a plate current of sufficient magnitude causes relay **2345** to operate and this in turn causes the operation of relay **2346**. Relay **2346**, in operating, locks to ground supplied by key **2415** and causes the operation of relay **2414** which acts as described above, giving a sequence failure alarm. Relay **2346** also causes the illumination of lamps **2316** and **2317** to indicate the chain in trouble. After the trouble is cleared, relays **2341** and **2304** operate, removing tube **2342** from circuit and releasing relay **2345**. Relay **2346** releases when key **2415** is momentarily operated, returning the circuit to normal.

Falsely operated selector magnet of the line circuit

If a selector magnet is falsely operated relay **2300** of the miscellaneous alarm circuit operates due to ground available on conductor **902**. Relay **2300**, in operating, opens the main ground chain lead, preventing the routing of any call through the unit. If the condition persists for forty-five seconds the ground chain alarm operates, giving a major alarm and lighting the lamps **2316** and **2317** as described above. Lamp **2315** is also lighted and these indications reveal to the attendant the type of trouble.

All-trunks-busy circuit

The circuit shown in Fig. 20 is an originating source of "all-trunks-busy" signals and "K" signals sent the calling subscribers under certain conditions, at the same time providing all-trunks-busy time integrating registers in addition to subscribers' overflow registers. The functions of this circuit may be summarized as follows:

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

(2) When all trunks in the entire unit are busy this circuit is designed to

(*a*) produce and send to each calling subscriber a "letters" all-trunks-busy signal connecting each new calling line in turn during the mark portion of the signal,

(*b*) register on the subscriber's overflow register the number of attempts subscribers make during the all-trunks-busy period,

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

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

(3) Whenever a trunk becomes idle this circuit is arranged to produce "K" signals at the rate of approximately nine per second and send these signals instead of the "letters" signals to the waiting subscribers.

DESCRIPTION OF OPERATION

All trunks of a group busy

When all of the trunks reaching a given outlet are busy the sequence circuit in the case of Fig. 12 extends a ground over the chain starting with the upper outer armature and front contact of relay **1200** and thence over conductor **1210** finally reaching conductor **1221** which extends to conductor **2021** thereby energizing relay **2001** associated with this outlet. Relay **2001** connects interrupter **2004**, giving interruptions at the rate of sixty interruptions per minute, to register **2005** which thereupon registers the number of seconds that all trunks of the group are busy. Relay **2001** also partially closes the circuit to relay **2006**.

All trunks of the unit busy

When all trunks of the line concentration unit are busy both relays **2007** and **2001** are energized, with the result that a circuit is closed for relay **2006** which thereupon becomes energized. This relay removes the connection between the right-hand contact of relay **2008** and condenser **2009** and establishes a connection between the condenser **2009** and the contacts of the interrupter relay **2010**. This transfer, as will be described hereinafter, results in the production of "letters" signals once per second instead of "K" signals at the rate of about nine per second.

Origination of call during all-trunks-busy period

When a subscriber originates a call during the all-trunks-busy period described above the sequence circuit places a ground on conductor **1620** extending to conductor **2020** and causing the operation of relay **2011**. Relay **2011**, operated, (*a*) connects ground to conductor **2012** leading to the armature of relay **2008**, the armature of relay **2010** and the upper winding of relay **2013**, (*b*) connects ground to resistance **2014** to complete a potentiometer used to obtain potential for the spacing current of the signal, and (*c*) continues the ground on conductor **2020** to the winding and front contact of relay **2015** and the right-hand contact of relay **2016**. Assuming for the moment that relay **2006** is not energized, then the connection of ground to conductor **2012** and thus to condenser **2017** and the winding of relay **2008** causes current to flow in both the upper and lower windings of this relay, the current in the lower winding tending to operate the relay to its left-hand contact and that in the upper winding tending to keep the relay on its right-hand contact. When the charging current of condenser **2017** flowing through the upper winding of relay **2008** has decreased sufficiently, this relay operates on its lower winding and moves its armature to its left-hand contact. As soon as this contact is closed the current is reversed in the lower winding, tending to drive the armature to its right-hand contact. The charge on condenser **2017**, however, causes a current to flow through the upper winding in a direction tending to hold relay **2008** on its left-hand contact. When this discharge current has been sufficiently dissipated, relay **2008** is driven to its right-hand

contact under the influence of the reverse current in the lower winding. When the left-hand contact is opened the reverse current in the lower winding ceases and the current through the upper winding and the operating current through the lower winding again begin to flow, causing a repetition of the complete cycle. The relay **2008**, therefore, operates and releases at a rate of about nine cycles per second due to the proper proportioning of the electrical constants in the circuit. As relay **2006**, however, is operated at this particular time and battery for relay **2008** is not available, relay **2008** does not function at this time.

The relay **2010**, however, which has been operating and releasing once every second, connects ground to resistance **2018** and condenser **2009**. Relay **2013** which has normally held to its right-hand contact under the influence of its lower winding receives a greatly increased current in the upper winding every time the ground is removed from condenser **2009**. This current is a result of the charging of condenser **2009** and is of sufficient value to drive the armature of relay **2013** to its left-hand contact. When this charging current has decreased to a sufficiently small value, relay **2013** moves its armature back to its right-hand contact. The armature of relay **2013** remains on its left-hand contact for approximately .022 second. Thus as a result of the action of relay **2013** and relay **2010** a pulse of about .022 second occurring once per second is produced. This signal is correctly timed to produce a series of "letters" signals on the subscriber's teletypewriter. The operation and the release of relays **2013** causes relays **2019** and **2016** to follow in unison. Relay **2019**, therefore, connects to the subscriber line circuit over conductor **602** a mark pulse of approximately twenty-five mils, interrupted once per second by a space pulse of approximately five mils for a duration of .022 second. This signal will indicate to the subscriber that all trunks are busy. He is instructed to stay on the line to await the freeing of a trunk.

Connection to a subscriber line

When relay **2016** follows in unison with relay **2013** as above described, the ground continued through the front contact and outer right-hand armature of relay **2011** and through the right-hand contact of relay **2016** causes the operation of relay **2022** which locks temporarily to this same ground and continues the ground to the armature of relay **2016** so that when the armature of relay **2016** moves to its left-hand contact this ground is extended to the winding of relay **2000**. Relay **2000** operates and locks to the ground on conductor **2020** and releases relay **2022**. Relay **2000**, operated, places a ground on conductor **2023** to the sequence circuit where it appears as conductor **1016** and is extended through the armature of relays such as **1008** and **1007** to conductor **623** to operate the busy relay such as **606** of the particular subscriber's calling line circuit. The operation of relay **606** connects the subscriber's line to conductor **602** of the all-trunks-busy circuit and places a ground on conductor **603** extending to conductor **2003** to form a holding circuit for relay **2001** independently operated, while at the same time it dismisses the sequence circuit which in functioning removes the ground from conductor **2020**.

Ground on conductor **2020** causes the operation of relay **2015** in series with the register **2024**. Relay **2015** through its armature insures the continuance of this ground connection until the register **2024** has completed its operation. Register **2024**, in attracting its armature, closes a direct ground from the armature of relay **2015** through the armature of register **2024** and its winding to battery. When this connection is made, the winding of relay **2015** is short-circuited and the register **2024** is locked to the ground on conductor **2020** and the register will stay in this condition until the ground is removed from conductor **2020**. If by this time relay **2015** and register **2024** have completed their functions the removal of the ground from conductor **2020** will cause the release of relay **2000** and the register **2024**. Relays **2013**, **2010**, **2019** and **2016** will continue to function so long as relay **2011** is held operated from a ground received from any subscriber line circuit, and all trunks remain busy.

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

When a subscriber calls during the all-trunks-busy period ground that is placed on conductor **2020** by the sequence circuit is continued through the operated contact of relay **2011** to the winding of relay **2015**, causing it to operate as described above. The register **2024**, since it locks to the ground on conductor **2020**, therefore operates only once on any single grounding of lead **2020** by the sequence circuit. The function of relay **2015** is to insure the application of ground for a sufficient period to enable the slow-acting message register to function. If the all-trunks-busy circuit and the line circuit and the sequence circuit function speedily and tend to remove the ground from conductor **2020** before the register has operated, the ground on relay **2015** will insure the operation of the message register. In this particular case this ground on the armature of relay **2015** will be continued back on conductor **2020** and prevent the sequence circuit from dealing with another call until relay **2015** has been released or, in other words, until the message register has functioned. Therefore, as the signals are connected to each subscriber line, the subscriber's call is registered on message register **2024**.

A trunk becomes idle while "letters" are being sent out to subscribers

As soon as a trunk becomes idle under this condition ground is removed from one of the leads to relay **2001** or **2007**, causing the release of such relay and in turn the release of relay **2006**. The release of relay **2006** opens the contact and winding circuit of relay **2010**, causing its release, and at the same time connects battery to the lower winding of relay **2008**, permitting relay **2008** to connect ground to resistance **2018** and condenser **2009** and to operate at a rate of approximately nine times per second. Space pulses of .022 second, nine times per second, create a "K" character on the subscriber's teletypewriter as a signal that a trunk is now available. Thus at this time the slow rate (one per second) "letter" signal which produces an audible signal in the teletypewriter is changed to a fast rate (nine per second) visible signal through the printing of the letter "K" on the subscriber's teletypewriter. The subscriber disconnects and tries again. If several subscribers have been waiting, only one will be served by the available trunk and the others, of course, in turn will be again connected

to the all-trunks-busy circuit which by that time will be producing "letters" signals.

Timing the interval "letters" are being produced

When relay **2011** operates during an all-trunks-busy period ground on conductor **2003** is extended to the winding of relay **2025**. This relay starts the relay interrupter comprising relays **2026, 2027** and two sets of counting relays **2028** and **2029** in one instance and **2030** and **2031** in the other.

Ground placed on conductor **2032** extends through the back contact and armature of relay **2027** to the winding of relay **2026** and causes the operation of this latter relay. Relay **2026** then connects ground on the conductor **2032** to the winding of relay **2027**, which operates. Relay **2026** and relay **2027** are both slow in releasing and since due to the operation of relay **2027** the circuit of relay **2026** is opened, this latter relay in time releases and thereby opens the circuit of relay **2027**. Thus relay **2026** and relay **2027** will operate and release continuously at a rate depending upon the slow-operating characteristics of these relays. This action will put an interrupted ground on conductor **2033** and this will operate the counting relays **2029** and **2028** in a well-known manner. Through its right-hand armature relay **2028** supplies an interrupted ground to the counting relays **2031** and **2030** which in turn operate periodically in a well-known manner but at one-half the rate of the operation of the first pair. Thus during the periods that relays **2031** and **2030** are operated a ground connection is extended over conductor **2034** through the front contact and outer right-hand armature of relay **2025** to the rotary magnet **2035**, operating the step-by-step switch arm **2036**. The interrupter relays are designed to operate in such a manner that rotary magnet **2035** will be operated approximately once every six seconds. In any case, if the all-trunks-busy condition persists, each grounding of conductor **2034** causes the magnet **2035** to step the selector one terminal. On terminal 9 ground is connected to rotary magnet **2037**, causing it to step its associated brush **2038**. When the arm **2036** reaches terminal 10, relay **2039** will be operated and this in turn will cause the energization of release magnet **2040** which returns the arm **2036** to normal where it begins stepping around again. When the arm **2038** of the second stepping switch reaches a predetermined terminal, relay **2041** will be operated and this relay will lock to ground under control of release key **2042**. At the same time the signal lamp **2043** will be operated as an indication to the attendant that the all-trunks-busy condition has lasted too long. The attendant can, by operating key **2042**, extinguish the lamp **2043**. If at any time prior to the operation of relay **2041** a trunk becomes idle relay **2006** releases, causing the release of relay **2025**. The release of relay **2025** places ground on both release magnets **2040** and **2044**, thus returning both of the stepping switches to normal.

Practice circuit—General

Fig. 7 shows a means for terminating subscriber lines within the concentration unit to permit the subscriber to practice on the station teletypewriter. When connected to a subscriber line this circuit will not interfere with the establishment of normal inward and outward calls to and from the subscriber. The functions of this circuit may be summarized as follows:

1. The practice circuit may be connected to or removed from a subscriber line without disrupting normal service or placing false calls.
2. A test circuit may be introduced into the practice circuit for supervisory practice.
3. A termination is provided for the line during the period subscriber is practicing.
4. The practicing subscriber may dismiss the practice circuit by transmitting a disconnect signal. In this case, the disconnect lamp will light and although the connections may not as yet be removed, subsequent calls may proceed without interruption.
5. An inward call for the subscriber will cause the practice circuit to interrupt the subscriber's practicing by a series of "K" signals. The subscriber may accept the inward call and dismiss the practice circuit by transmitting a recall signal.

DESCRIPTION OF OPERATION

General traffic operation

Since it is undesirable to utilize a trunk to the master office for each practicing subscriber, this circuit has been provided to terminate the subscriber line locally within the concentration unit. In requesting a practice connection the subscriber will place a call which will be answered by an operator in the normal manner. Upon learning that the subscriber desires a practice connection the operator will instruct the subscriber to disconnect, which when accomplished will permit the operator to release the trunk. The operator will then call the concentration unit test attendant to request the practice connection. Upon acknowledging the request the test attendant will disconnect and thus the trunk may be dismissed.

Practice connection

To establish a practice connection the test attendant should patch jacks **702** and **703** of the practice circuit to jacks **704** and **705**, respectively, of the test circuit. Patching cords are then inserted, first in jacks **700** and **701** of the practice circuit and the other ends thereof then inserted in jacks **609** and **612**, respectively, of the subscriber's line circuit. Under this condition the tip side of the subscriber's line will be extended through the tips of jacks **700, 702** and **704**, through the pulsing contacts **706** of the attendant's teletypewriter **707**, the upper winding of relay **708** to negative battery in the test circuit. The ring side of the subscriber's line will be extended through the tips of jacks **612, 701, 703** and **705** to the winding of relay **709** and thence to ground. Relay **709** is provided to indicate a subscriber-calling condition. The ring conductor of the subscriber line circuit in the direction from the master office will be extended through the sleeves of jacks **701, 703** and **705** where it will be opened. The tip conductor of the subscriber line circuit in the direction from the master office will be extended through the sleeves of jacks **700, 702, 704**, condenser **710**, winding of relay **711** to ground. Relay **711** is a ringing relay in the test circuit provided to indicate call signals from the master office. If a call should come from the master office for the subscriber in question, connection will be established in the link circuit in the normal manner except that relay **720** will be operated when the holding magnet of the crossbar switch is operated. The operation of relay **728** will perform no function, since the auxiliary contacts of the test jacks **702** and **703** are oper-

ated. Ringing current from the trunk circuit will operate the ringing relay 711 in the test circuit to light the trunk call lamp 712 as an indication to the test attendant who should then remove the patching cords from the jacks 609 and 612 of the subscriber line circuit to allow the call to proceed.

If no call is coming in, the attendant proceeds to operate the subscriber ringing key 713 of the test circuit which will apply ringing current to the tip side of the line to signal the subscriber. In the case of a toll subscriber, such as either one of those shown in Figs. 2 and 3, closure of ground on the ring of jacks 705, 703, 701 and 612 will cause the toll subscriber line circuit to repeat ringing current to the subscriber's line. When the subscriber answers, current will flow in the ring side of the line to operate relay 709 in the test circuit, which will light the subscriber's calling lamp 714. Operation of the teletypewriter key 715 of the test circuit will extinguish this lamp and condition the test circuit so that the test attendant's typewriter will be connected into the circuit for purposes of communication. The test attendant may then inform the subscriber to proceed with the practice and may retire from the connection by removing the patching cords from jacks 702 and 703.

When the cords were first put into jacks 702 and 703 ground on the auxiliary contacts of jack 703 will, through the auxiliary contacts of jack 702, close a circuit through the outer left-hand armature and back contact of relay 717 to the winding of relay 716 which thereupon locks up directly to ground through the auxiliary contacts of jack 703. The operation of relay 716 will open the winding of relay 718 and cause the operation of relay 719. When the cords are placed in jacks 700 and 701 (and these should be the last cords to be so handled) ground on the auxiliary contacts of jacks 700 and 701 will operate relay 717. Relay 717, operated, will extend ground through the right-hand armature and front contact of relay 719 to the right-hand armature of relay 716 in preparation for the operation of relay 718. Relay 717 will also place ground on the biasing winding of relay 720 which will cause such relay to go to its spacing position, locking relay 719 under control of relays 717 and 720. Relay 717 will also open the operating winding of relay 716 but relay 716 is still held operated through the auxiliary contacts of jack 703.

When the cords are removed from jacks 702 and 703, relay 716 will release and by closing the circuit for relay 718 will cause the latter to operate, which in turn will operate relay 721. The operation of relay 721 will terminate the tip side of the subscriber line to negative battery through resistances 722 and 723. The ring side of the subscriber line will be terminated to ground via the lower winding of relay 720. Relay 720 will then move to its marking contact, unlocking relay 719 but keeping relay 718 operated. Relay 719 is slow to release, however, so that relay 721 will be completely operated by the time the back contact of relay 719 is closed thus preventing even the momentary illumination of the disconnect lamp 724. Relay 719 will permit application of ground to the sleeve lead to a toll subscriber's line circuit.

The practicing subscriber may dismiss the practice circuit by transmitting a disconnect signal which will open the tip and ring conductors of relay 720 and allow it to move its armature to its spacing contact for a period long enough to allow the slow-releasing relay 718 to release. Relay 718 in releasing, in turn will release relay 721. The release of relay 721 will through its outer left-hand armature and front contact remove ground from the sleeve conductor of the toll subscriber's line circuit and light the disconnect lamp 724, indicating to the attendant that the practice cords may be removed. Subsequent calls to or from the subscriber may progress in the normal manner, since relay 721 is released. The test attendant may remove the connection from the jacks 700 and 701 without interrupting signals on a subsequent call.

If a call should be placed for a practicing subscriber from the master office, relay 725 will operate when the holding magnet of the link circuit is operated. Relay 725, operated, will cause relay 726 to operate which through its outer right-hand armature and front contact will lock to the ground supplied by the armature of relay 718. Relay 726, operated, will place ground on the common lead 727 which will result in the energization of relay 728. Relay 726 will also connect the tip side of the subscriber's line through the armature of relay 729 to marking or spacing battery potential, depending upon the position of relay 729.

Relay 728 places battery on conductor 730 to start the relay interrupter circuit and connects conductor 731 to the winding of relay 732. Battery on conductor 731 is extended through the left-hand armature and front contact of relay 734 to the winding of relay 733, causing the operation of the latter. Relay 733, operated, extends the battery on conductor 731 to the winding of relay 734 whereupon the circuit for relay 733 is opened. Relays 733 and 734 are slow-releasing and in this circuit will open and close each other's circuit at a rate which depends upon their slow-releasing characteristics. This places an interrupted ground from the right-hand armature of relay 733 on to conductor 735 which operates a pair of counting relays 736 and 737. These relays in turn will place an interrupted ground on conductor 738 to operate another pair of counting relays 739 and 740. When both relays 739 and 740 are operated a ground is placed on conductor 731 to cause the operation of relay 732 so that relay 732 is operated periodically.

Relay 728 will apply ground to the windings of relay 729 and battery to the windings of relay 741. The connection of battery to relay 741 causes current flow in both the lower and upper windings of this relay, the current in the lower winding tending to operate the relay to its right-hand contact and that in the upper winding tending to keep the relay on its left-hand contact. When the charging current for condenser 742 flowing through the secondary winding of relay 741 has decreased sufficiently, relay 741 operates on its lower winding. As soon as its right-hand contact closes, the current is reversed in the lower winding of relay 741, tending to drive the armature to its right-hand contact. The charge on condenser 741, however, causes a current to flow through the upper winding in a direction tending to hold relay 741 on its right-hand contact. When this discharge current has been sufficiently dissipated, relay 741 is driven to its left-hand contact under the influence of the reversed current in the lower winding. When the right-hand contact is opened, the reverse current in the lower winding ceases and the current through the upper winding and the operating current through the lower

winding again begin to flow, causing a repetition of the complete cycle. Relay 741, therefore, operates and releases at a rate of about nine cycles per second. Relay 729 which is normally held to its left-hand contact under the influence of its upper winding, receives a greatly increased current in the lower winding every time that relay 741 opens its left-hand contact if relay 732 is released. This current is a result of the charging of condenser 143 and is of sufficient value to drive the armature of relay 729 to its right-hand contact. When this charging current has decreased to a sufficiently small value, relay 729 moves its armature back to its left-hand contact. The armature of relay 729 remains on its right-hand contact for approximately .022 second. Thus as a result of the action of relays 741 and 729 a pulse of about .022 second, occurring nine times per second, is produced. This signal is correctly timed to produce a series of "K" signals on the subscriber's teletypewriter. Relay 732, however, at intervals according to the interrupted ground discharges condensers 743 so that relay 729 remains on its left-hand contact. Therefore, the subscriber receives groups of "K" signals at intervals, indicating to the subscriber that a call is waiting for him. The subscriber may accept the inward call by sending a recall signal which will release relay 721 which in turn will release relay 726. The disconnect lamp 724 is thus lighted and the "K" signals are cut off. The test attendant may then remove the cords, restoring all relays to normal, but even if this is not done the practice circuit is rendered ineffective to interfere with either incoming or outgoing service from the subscriber's line.

What is claimed is:

1. In a communication system, a subscriber's line terminating at one end in a subscriber's station and at the other end in means to automatically extend the said line to an idle line in a plurality of groups of lines leading to a like plurality of switching points, means individual to the said line for predetermining the order of preference between said groups of lines and means at the said subscriber's station for altering the said predetermined order of preference.

2. In a communication system, a subscriber's line, a subscriber's station on said line, a plurality of switching points, a group of lines leading to each said switching point, means for automatically connecting said subscriber's line to any one of said lines leading to said switching points, means individual to said subscriber's line for predetermining the group which shall first be searched for an idle line, and means controlled from said subscriber's station for causing another group to be first to be searched for an idle line.

3. In a communication system, a plurality of subscribers' lines each terminating in a subscribers' station, a plurality of switching points, a group of lines for each said switching point for extending said subscribers' lines to said switching points. means for automatically connecting a calling one of said subscribers' lines to one of said other lines primarily in a group leading to a preferred switching point and secondarily in a group leading to another of said switching points, means individual to each said subscriber's line for fixing the order of preference between said groups as to said individual line and means individual to each said station for altering the said fixed order of preference.

4. In a communication system, incoming lines, groups of outgoing lines, means for connecting any given incoming line to the first idle one of said outgoing lines beginning with the lines of any given group as a starting point, means for fixing the said starting point for the said given incoming line, and means for changing the said starting point.

5. In a communication system, incoming lines, groups of outgoing lines, means for connecting an incoming line to the first idle one of said outgoing lines beginning with the lines of any given group as a starting point, means individual to the said incoming line for fixing the said starting point therefor, and means controlled over said incoming line for changing the said starting point.

6. In a communicating system, incoming lines, groups of outgoing lines, means responsive to a calling condition on an incoming line for connecting said calling line to the first idle one of said outgoing lines beginning with the lines of a given group as a starting point, means individual to the said calling line for fixing the normal starting point therefor, and means operable over the said calling line for temporarily changing said normal starting point.

7. In a communication system, incoming lines, groups of outgoing lines, means for automatically connecting a calling incoming line to the first idle one of said outgoing lines beginning with the lines of a given group as a starting point, means individual to each incoming line for fixing a normal starting point therefor, and means controlled over each said incoming line for temporarily rendering effective an abnormal starting point therefor.

8. In a communicating system, incoming lines, groups of outgoing lines, an automatically operated switch for connecting said incoming lines to said outgoing lines, a sequence circuit for controlling the order in which said outgoing lines are used beginning at any given point, means individual to each incoming line for fixing the normal point from which said sequence circuit will work with respect to such incoming line, and means operable over each incoming line for shifting the said normal point for such line.

9. In a communication system, incoming lines, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled over each incoming line for temporarily changing said starting point, and means responsive to a condition established when all of said outgoing lines are busy for signalling said calling incoming line.

10. In a communication system, incoming lines, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line, starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled over each incoming line for temporarily changing said starting point, means responsive to a condition established when all of said outgoing lines are busy for signaling said calling incoming line and means for changing the character of said signal responsive to an outgoing line becoming available for service.

11. In a communication system, incoming lines, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each

incoming line for predetermining said starting point, means controlled over each incoming line for temporarily changing said starting point, and means responsive to a condition established when all of said outgoing lines are busy for signaling said calling incoming line at a slow rate.

12. In a communication system, incoming lines, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled over each incoming line for temporarily changing said starting point, means responsive to a condition established when all of said outgoing lines are busy for signaling said calling incoming line at a given rate and means for changing the character of said signal and increasing the rate thereof responsive to an outgoing line becoming available for service.

13. In a communication system, incoming lines, a teletypewriter at the distant terminal of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled from the teletypewriter on said calling incoming line for temporarily changing the starting point for said line, and means responsive to a condition established when all of said outgoing lines are busy for causing an audible signal in said terminal teletypewriter.

14. In a communication system, incoming lines, a teletypewriter at the distant terminal of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled from the teletypewriter on said calling incoming line for temporarily changing the starting point for said line, and means responsive to a condition established when all of said outgoing lines are busy for causing a continuous slow rate audible signal in said terminal teletypewriter.

15. In a communication system, incoming lines, a teletypewriter at the distant end of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled from the teletypewriter on said calling incoming line for temporarily changing the starting point for said line, means responsive to a condition established when all of said outgoing lines are busy for causing an audible signal in said teletypewriter, and means for changing said audible signal to a different character visible signal when an outgoing line becomes available for service.

16. In a communication system, incoming lines, a teletypewriter at the distant end of each said incoming line, outgoing lines, means for automatically connecting a calling incoming line to an available outgoing line, means responsive to a condition established when all of said outgoing lines are busy for sending a particular teletypewriter operating signal to said teletypewriter for indicating an all-trunks-busy condition, and means responsive to any one of said busy trunks becoming idle for changing said signal to another particular teletypewriter operating signal for indicating an idle trunk condition.

17. In a communication system, incoming lines, a teletypewriter at the distant end of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled from the teletypewriter on said calling incoming line for temporarily changing the starting point for said line, means responsive to a condition established when all of said outgoing lines are busy for causing a continuous slow rate audible signal in said teletypewriter, and means for changing said continuous slow rate audible signal to a continuous fast rate visible signal when one of said outgoing lines becomes available for service.

18. In a communication system, incoming lines, a teletypewriter at the distant end of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of said outgoing lines, means responsive to a condition established when all of said outgoing lines are busy for sending a non-printing code combination at a slow rate to said teletypewriter, and means for repeatedly sending a character code combination at a faster rate to said teletypewriter when an outgoing line becomes available for service.

19. In a communication system, incoming lines, a teletypewriter connected to the distant end of each said incoming line, outgoing lines, means for automatically connecting a calling incoming line to the first idle one of said outgoing lines, means responsive to a condition established when all of said outgoing lines are busy to cause a slow and audible signal in the teletypewriter on said calling line and means responsive to a condition established when one of said outgoing lines becomes available for causing said teletypewriter to type a series of characters at normal rate.

20. In a communication system, incoming lines, a teletypewriter at the distant terminal of each said incoming line, groups of outgoing lines, means for automatically connecting a calling incoming line to the first available idle outgoing line starting from a given group of outgoing lines, means individual to each incoming line for predetermining said starting point, means controlled from the teletypewriter on said calling incoming line for temporarily changing the starting point for said line, means responsive to a condition established when all of said outgoing lines are busy for giving an appropriate signal at the teletypewriter on said calling incoming line and an integrating time register for giving an alarm when said all-lines-busy condition has existed over a given time interval.

21. In a communication system, incoming lines, a teletypewriter connected to the distant end of each incoming line, outgoing lines, means for automatically connecting a calling incoming line to the first idle one of said outgoing lines, means responsive to a condition established when all of said outgoing lines are busy to cause a slow and audible signal in the teletypewriter on said calling line, and an integrating time register responsive to the transmission of said signal for giving an alarm after a predetermined time.

22. In a teletypewriter exchange system, the method of signaling an all-trunks-busy condi-

tion to a calling station, which consists in sending at a slow rate a signal which causes some mechanical movement of the teletypewriter mechanism and changing the signal when a trunk becomes idle to a normal rate character typing signal.

23. In a teletypewriter exchange system, the method of signaling an all-trunks-busy condition to a calling station, which consists in sending to said station a non-character printing code at a slow rate for producing an audible signal only at said distance and changing to a character printing code at a normal printing rate when one or more trunks become idle, for producing a visible signal at said station.

24. In a teletypewriter switching system, the method of signaling an unavailable trunk condition to a calling line and the termination of said condition which comprises automatically impressing upon the calling line one character code signifying no trunk available and causing said character code to be changed by a trunk becoming available signifying the termination of said condition.

25. In a communication system, a plurality of subscribers' lines, a plurality of groups of central office trunks, means for connecting each subscriber's line for outgoing service to said trunks in a predetermined order of preference, subscriber-controlled means for altering said predetermined order, means for connecting said trunks for incoming service under directive control to said subscribers' lines, and a set of polar relays responsive to said directive control for selecting said subscribers' lines.

26. In a communication system, a plurality of subscribers' lines each terminating in a premutation code operated teletypewriter, a plurality of groups of central office trunks, means for connecting each subscriber's line for outgoing service to said trunks in a predetermined order of preference, subscriber-controlled means for altering said predetermining order, means for connecting said trunks for incoming service under directive control to said subscribers' lines, and a set of polar relays responsive to permutation code trains for selecting said subscribers' lines and operating said last means.

27. In a communication system, a plurality of subscribers' lines each terminating in a permutation code operated teletypewriter, a plurality of groups of central office trunks, means for connecting each subscriber's line for outgoing service to said trunks in a predetermined order of preference, subscriber-controlled means for altering said predetermined order, means for connecting said trunks for incoming service under directive control to said subscribers' lines, a distributor and a set of polar relays operated therethrough and responsive to permutation code trains for selecting said subscribers' lines and operating said last means.

28. In a communication system, a subscriber's line terminating in a teletypewriter, central office lines, means for automatically connecting said subscriber's line to an idle one of said central office lines for outgoing service, means responsive to directive control for connecting said central office lines to said subscriber's line for incoming service, a subscriber's practice circuit connectable to said subscriber's line, means in said practice circuit responsive to an incoming call over one of said central office lines for automatically and periodically causing the teletypewriter on said subscriber's line to type a given character as a signal to the subscriber thereat and subscriber-controlled means for dismissing said practice circuit and accepting the said incoming call.

29. In a communication system, a subscriber's line terminating in a teletypewriter, groups of central office lines, means for automatically connecting said subscriber's line for outgoing service to the first idle one of said central office lines beginning with a given group as a starting point, subscriber-controlled means for temporarily changing said starting point, means responsive to directive control for connecting said subscriber's line for incoming service to a calling one of said central office lines, a subscriber's practice circuit connectable to said subscriber's line, means in said practice circuit responsive to an incoming call over one of said central office lines for automatically causing the said teletypewriter on said subscriber's line to repeatedly type a given character as a signal to the subscriber thereat and subscriber-controlled means for dismissing said practice circuit and accepting the said incoming call.

30. In a communication system, a subscriber's line terminating in a teletypewriter, groups of central office lines, means for automatically connecting said subscriber's line for outgoing service to the first idle one of said central office lines beginning with a given group as a starting point, subscriber-controlled means for temporarily changing said starting point, means responsive to directive control for connecting said subscriber's line for incoming service to a calling one of said central office lines, a subscriber's practice circuit connectable to said subscriber's line, subscriber-controlled means for effectively disconnecting said practice circuit from said subscriber's line to clear said line for either outgoing or incoming service, and means in said practice circuit responsive to an incoming call for said subscriber's line for automatically and periodically causing the said teletypewriter thereon to repeatedly type a given character as a signal to the subscriber thereat.

31. In a communication system, a subscriber's line terminating in a teletypewriter, central office lines, means for automatically connecting said subscriber's line to an idle one of said central office lines for outgoing service, means responsive to directive control for connecting said central office lines to said subscriber's line for incoming service, a subscriber's practice circuit connectable to said subscriber's line, circuit means automatically operating to form chains of impulses simulating the code of a given character, means for periodically energizing said circuit means, means in said practice circuit responsive to an incoming call for said subscriber's line for feeding the output of said circuit means to said subscriber's line, subscriber-controlled means for effectively disengaging said practice circuit from said subscriber's line, and means responsive thereto for signaling for the disconnection of said practice circuit from said subscriber's line.

32. In a communication system, a teletypewriter responsive to permutation code impulses, a circuit comprising interacting relays and elements having given electrical characteristics for automatically producing a series of impulses simulating a given permutation code, means for periodically energizing said circuit and means for connecting said periodically energized circuit to said teletypewriter.

33. In a communication system, a subscriber's line terminating in a teletypewriter, central office lines, means for automatically connecting said subscriber's line to an idle one of said central office lines for outgoing service, means under directive control for connecting one of said central office lines to said subscriber's line for incoming service, a practice circuit connectable to said subscriber's line and over which a subscriber may practice the transmission of permutation code signals and break signals, means in said practice circuit responsive to an incoming call to notify the practicing subscriber of the existence of such incoming call, and means responsive to a disconnect signal from said teletypewriter for effectively disconnecting said practice circuit from said subscriber's line and rendering said subscriber's line free for service.

34. In a communication system, a short subscriber's line terminating at its distant end in a teletypewriter, a long subscriber's line terminating at its distant end in a teletypewriter, a termination circuit at the near end of said long subscriber's line for translating the signals over said long line into signals equivalent to the signals over said short line, central office lines, means for automatically connecting said subscriber's lines to idle central office lines for outgoing service, means under directive control for connecting said central office lines to said subscribers' lines for incoming service, a practice circuit connectable to either of said subscribers' lines and over which a subscriber may practice the transmission of permutation code signals and break signals, means in said practice circuit responsive to an incoming call to notify the practicing subscriber of the existence of such incoming call, and means responsive to a disconnect signal from the said teletypewriter for effecting disconnecting said practice circuit from said subscriber's line and rendering said subscriber's line free for service.

35. In a signaling system, a subscriber's line, a trunk circuit comprising a subscriber's termination, a line and a central office termination, means for establishing a connection between said subscriber's line and said trunk, means in said subscriber's termination responsive to a change from a marking condition in said subscriber's line to a spacing condition for timing said spacing condition to differentiate between spacing signals of code signal length and spacing signals of break signal and disconnect signal length, additional testing means in said subscriber's termination responsive to a spacing condition of break signal and disconnect signal length for differentiating between break signals and disconnect signals, and means responsive thereto for transmitting different signals over said line to said central office termination, said break signal consisting of a short spacing signal followed by steady transmission of low frequency alternating current and said disconnect signal consisting of steady transmission of spacing signal current.

36. In a signaling system, a subscriber's line, a trunk circuit comprising a subscriber's termination, a line and a central office termination, means for establishing a connection between said subscriber's line and said trunk, means in said subscriber's termination comprising a condenser and space discharge tube timing circuit responsive to a change from a marking condition in said subscriber's line to a spacing condition for timing said spacing condition to differentiate between spacing signals of code signal length and spacing signals of break signal and disconnect signal length, additional means rendered operative by said condenser and tube circuit for differentiating between break signals and disconnect signals, and means responsive thereto for transmitting different signals over said line to said central office termination.

37. In a communication system, incoming lines, groups of outgoing lines each said group leading in a different direction, each said incoming line terminating in a cross-bar switch having sets of permanently paired contacts for connecting said incoming line to each of said outgoing lines, a sequence circuit for controlling the order in which said outgoing lines are used, said sequence circuit effectively placing all said outgoing lines in a closed ring in respect of the order of use, means individual to each said line for causing said sequence circuit to begin selection of an outgoing line at a particular point in said closed ring, and means controlled over each said incoming line for controlling said sequence circuit to change the said particular point in said closed ring at which selection of an outgoing line will be begun, said cross-bar switch being operated under control of said sequence circuit in response to a calling condition on one of said incoming lines.

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