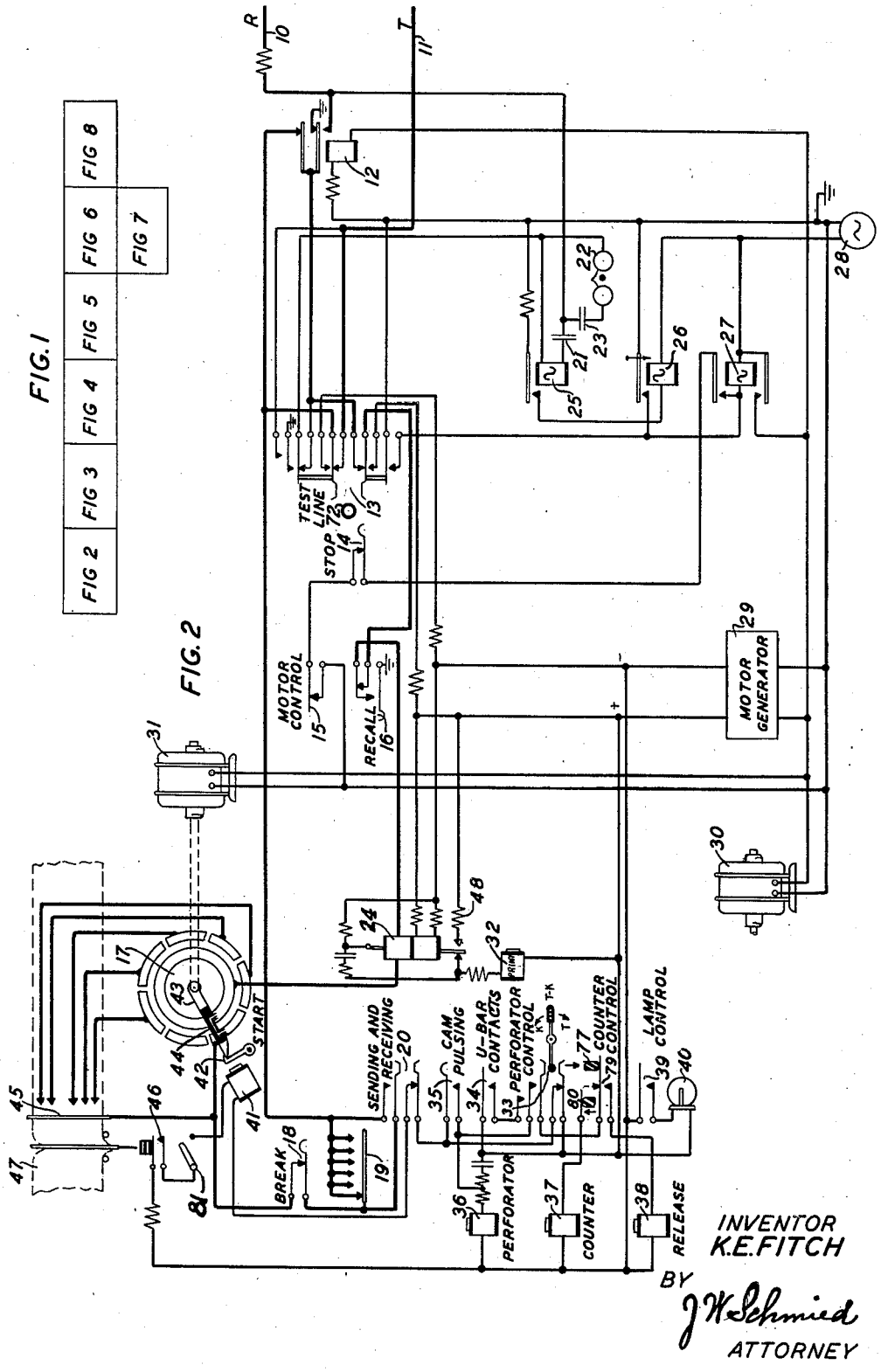
Sept. 19, 1939. K. E. FITCH 2,173,551

COMMUNICATION SYSTEM

Filed Dec. 16, 1937 7 Sheets-Sheet 1

FIG. 1

FIG 2	FIG 3	FIG 4	FIG 5	FIG 6	FIG 8
				FIG 7	



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COMMUNICATION SYSTEM

Filed Dec. 16, 1937 7 Sheets-Sheet 2

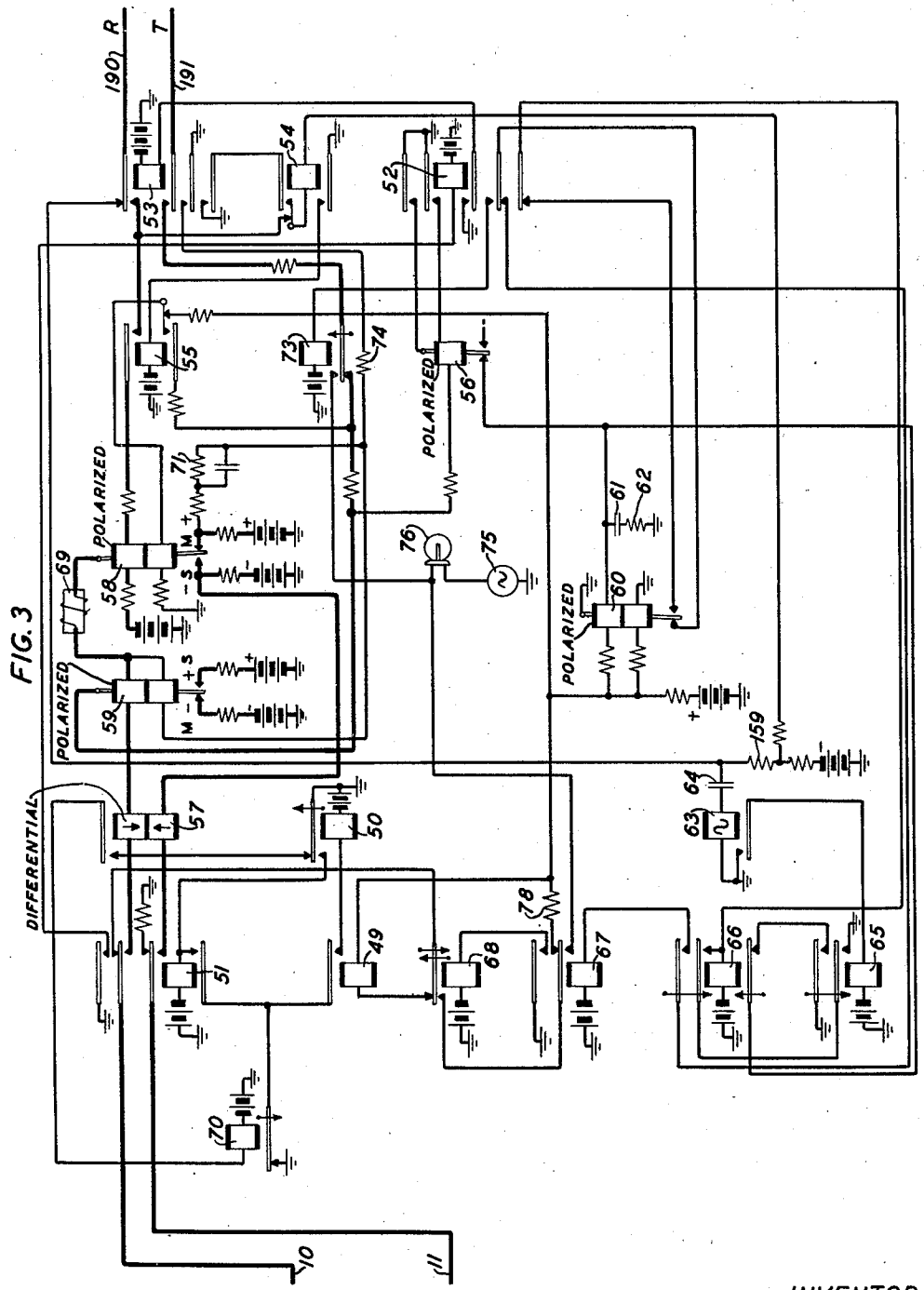

FIG. 3

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COMMUNICATION SYSTEM

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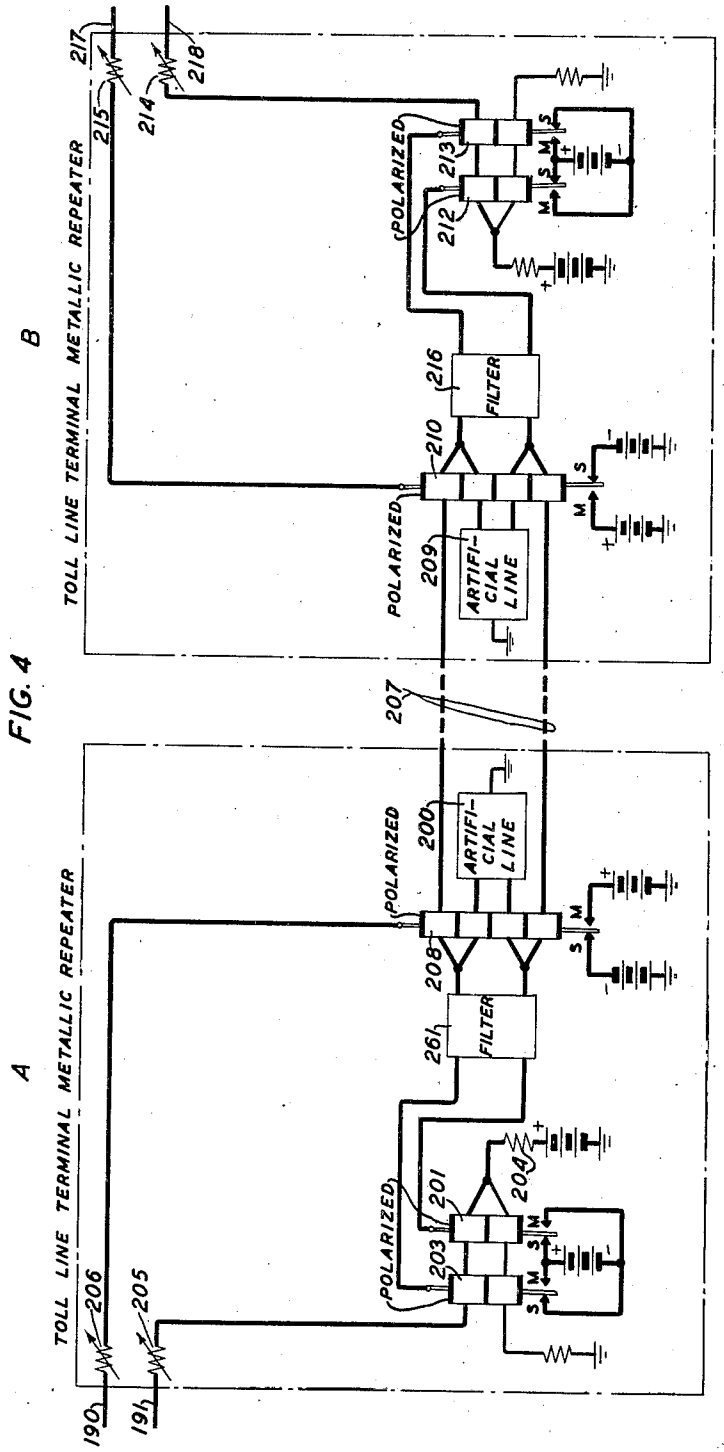

FIG. 4

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COMMUNICATION SYSTEM

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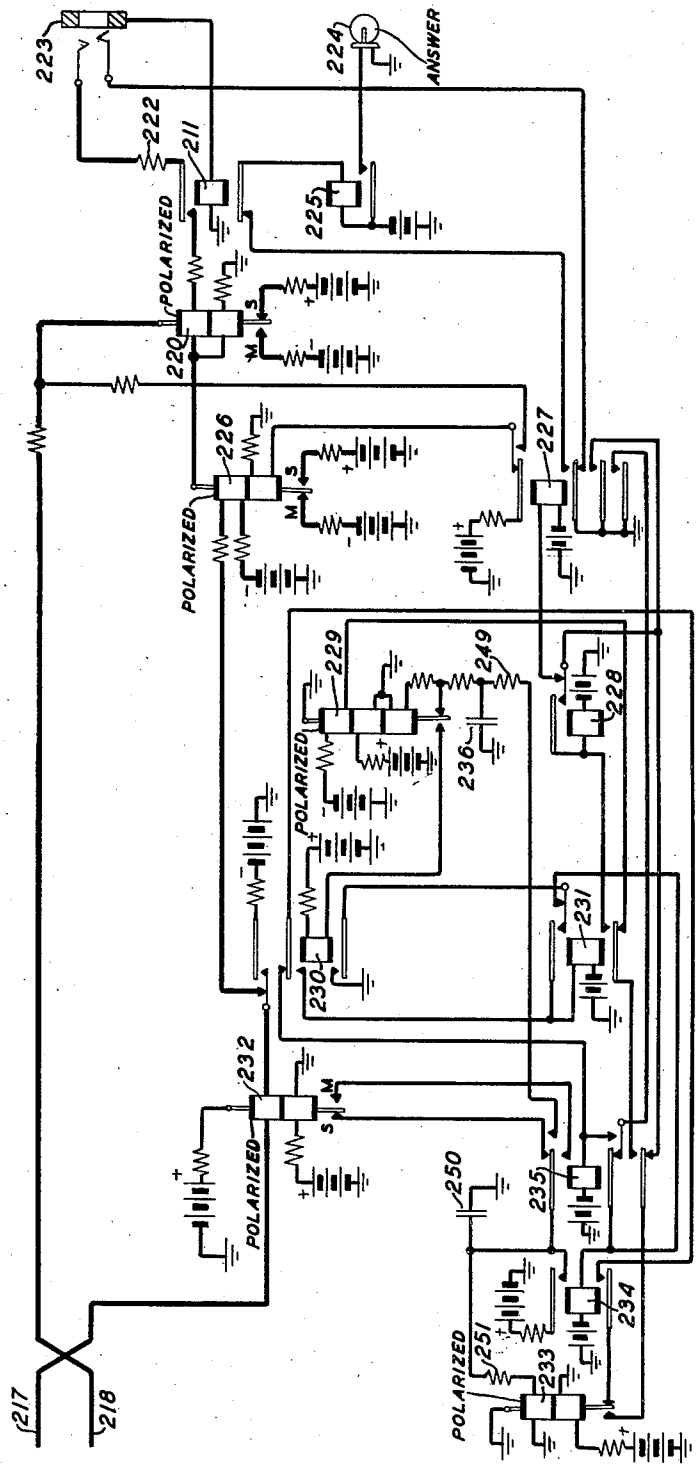

FIG. 5

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COMMUNICATION SYSTEM

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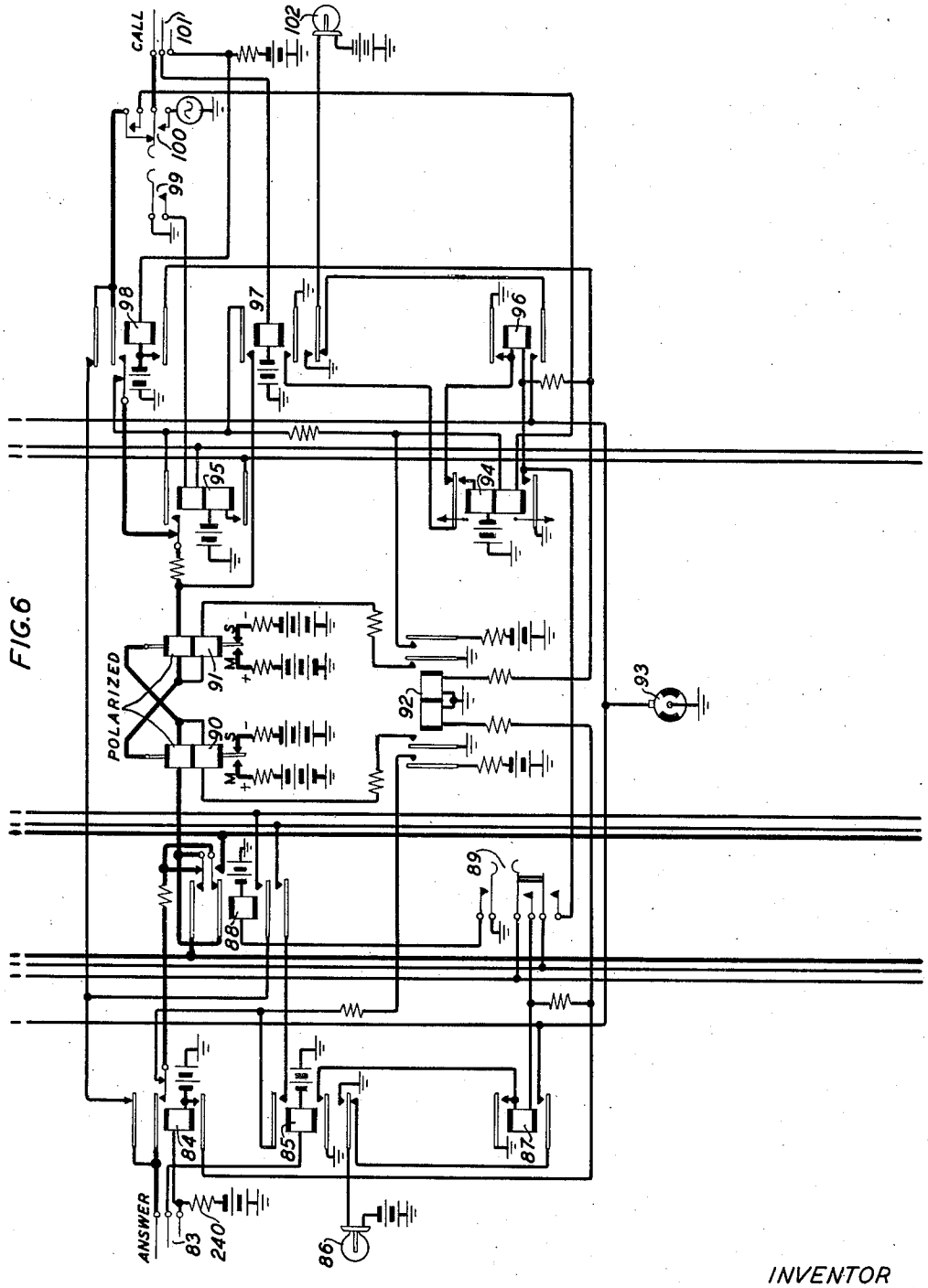

FIG.6

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COMMUNICATION SYSTEM

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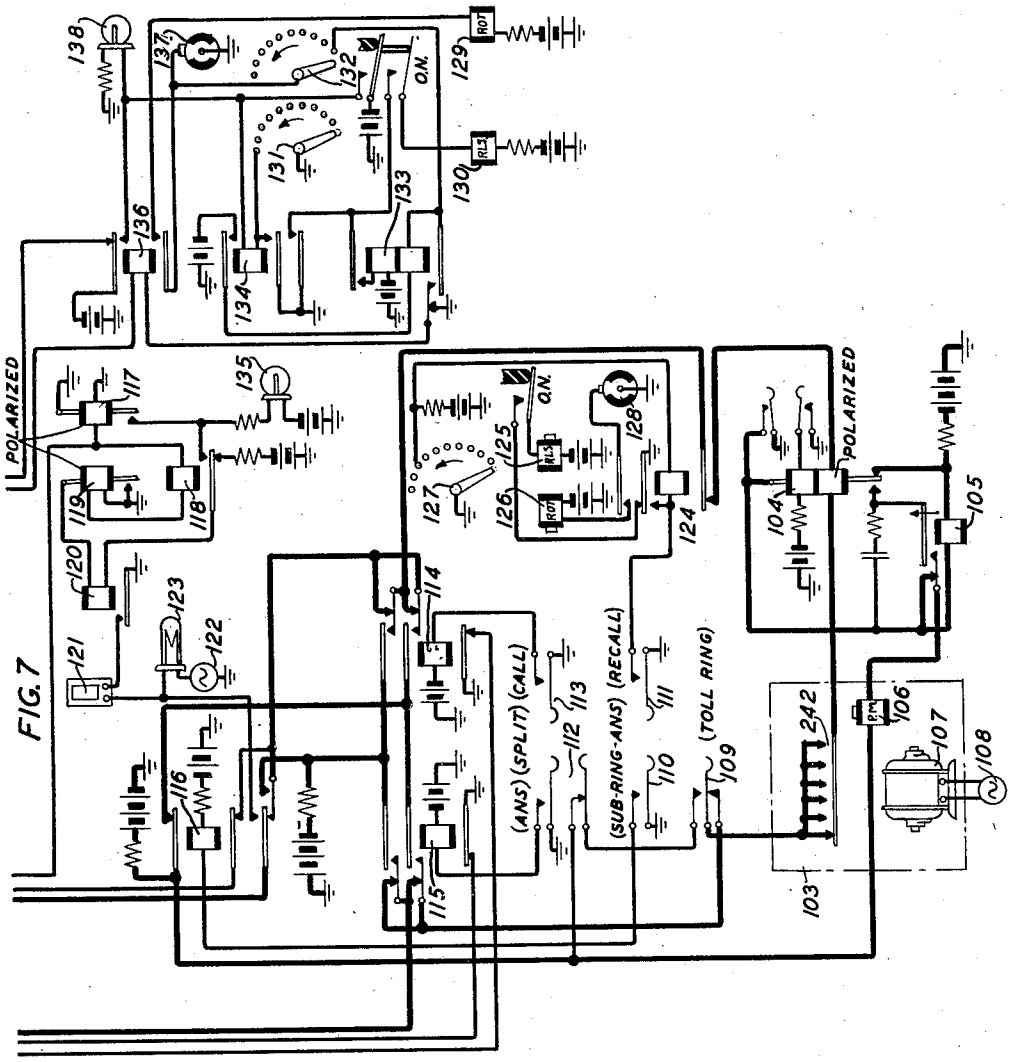

FIG. 7

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COMMUNICATION SYSTEM

Filed Dec. 16, 1937 7 Sheets-Sheet 7

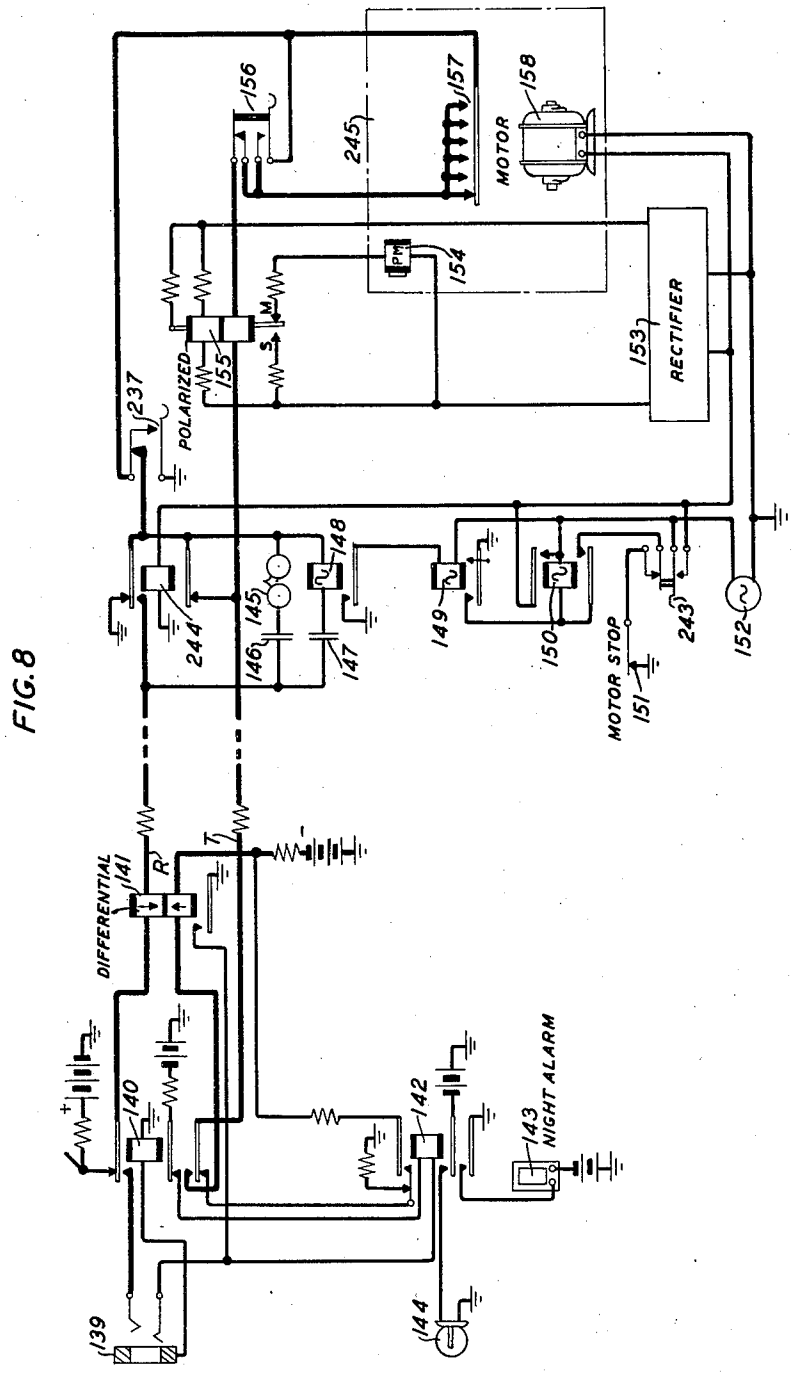

FIG. 8

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2,173,551

UNITED STATES PATENT OFFICE

2,173,551

COMMUNICATION SYSTEM

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Application December 16, 1937, Serial No. 180,075

7 Claims. (Cl. 178—2)

This invention relates to communication systems and more particularly to telegraph switching systems.

In the past it has been the practice to supervise over the intermediate sections of long multisection subscribers' lines by the use of either marking or spacing signals of different lengths or periods of time. Disconnect, recall, and break signals were distinguished from each other only by their length. With this arrangement the time required to transmit the supervisory signals over the system becomes quite long and the method of operation rather cumbersome. In addition, the equipment is usually set in a particular condition and remains in that condition until some signal is received to change the condition.

An object of this invention is to provide supervisory arrangements for long multisection subscribers' lines in which the supervisory signals are transmitted through the system without material delay.

Another object of this invention is to provide a supervisory system for long multisection subscribers' lines in which the supervisory signals at each end of the system are continuously controlled from the other end.

A further object of this invention is to provide supervisory arrangements for the intermediate sections of long subscribers' line circuits in which it is possible to distinguish between ringing signals, marking current, spacing current, break signals, disconnect signals and recall signals.

Another object of this invention is to provide supervisory signals over the usual well-known types of telegraph circuits.

Another object of this invention is to provide terminal equipment for long multisection subscribers' line circuits which cooperate with the switching apparatus at the central exchange in the same manner as local line circuits cooperate therewith.

Another object of this invention is to provide an intermediate supervisory circuit arrangement which cooperates with the same subscriber's station circuit and equipment as employed at local subscriber stations.

Another object of this invention is to transmit over a telegraph line arranged to transmit only two signaling conditions all the signals transmitted over a connecting line which transmits at least three different signaling conditions.

Another object of this invention is to distinguish between break signals and supervisory signals by transmitting either ringing current or a series of uniform length impulses over the system in at least one direction during break signals and to transmit continuous marking and spacing currents to indicate supervisory signals.

In a preferred embodiment of this invention a multisection subscriber's line circuit is provided which employs the same subscriber station circuits and equipment as employed at local subscriber stations. The long line circuit is arranged to cooperate with the switching apparatus or cord circuit at the central station in the same manner as local subscribers' line circuits cooperate therewith. At least one intermediate repeater station is provided between the central exchange and the subscriber's station. Between the subscriber's station and the intermediate station substantially the same types of signals are transmitted as are transmitted between the local subscriber station and the central exchange equipment.

Between the central station and the intermediate station one or more sections of a full duplex telegraph channel are provided. Any form of full duplex telegraph channel is suitable including both differential and bridge type full duplex circuits arranged for operation over either open wire lines or cable circuits and which employ either a ground return or a full metallic circuit. In addition, any type of full duplex carrier current channel is suitable for the intermediate section. The carrier current channels may be either of the voice frequency or higher carrier current frequencies and may also include radio channels. Furthermore any suitable or available combination of the various types of full duplex circuits may be employed between the intermediate point and the central exchange. The transmission of break signals in at least one direction over the system is distinguished from supervisory signals by transmitting a series of signal impulses of uniform length over the full duplex channel during the break signal. In the preferred embodiment of this invention this series of impulses of uniform length is generated by applying alternating current and preferably 20-cycle ringing current to the terminal equipment of the full-duplex channel. The relays of this equipment respond by following the alternations of the applied alternating current and transmit a series of uniform signaling impulses of alternate marking and spacing current of substantially unit length.

These and other objects and features of the invention, the novel features of which are particularly pointed out in the claims appended hereto, may be more fully understood from the following description when read with reference to the attached drawings in which:

Fig. 1 shows the manner in which Figs. 2, 3, 4, 5, 6, 7 and 8 are arranged to form a typical telegraph system embodying the present invention;

Fig. 2 shows the circuit arrangement at the subscriber's station;

Fig. 3 shows the circuit arrangement at an intermediate station;

Fig. 4 shows an intermediate line section;

Fig. 5 shows a terminal circuit arrangement at the central exchange which cooperates with the cord circuit;

Fig. 6 shows a circuit arrangement of the cord circuit;

Fig. 7 shows the operator's equipment; and

Fig. 8 shows typical local subscriber's line circuit and station equipment.

General description

In the embodiment of this invention shown in Figs. 2, 3, 4, 5, 6, 7 and 8 the line circuit is open at the subscriber's station during the idle condition, i. e., when it is not desired to communicate therewith. The line circuit extends from the subscriber's station to an intermediate station at which one of the conductors is normally connected to ground and the other to battery. The intermediate sections of the full duplex channel extending between the intermediate station and the central station are normally maintained in the spacing condition in both directions and the circuit is disconnected at the central exchange. When a subscriber desires to originate a call he completes the line circuit at his station. This closure is repeated at the intermediate station by changing the signaling condition transmitted from the intermediate station to the central exchange, from a spacing condition to a marking condition. The marking condition, when received at the central exchange, causes the lamp associated with the subscriber's line to light to attract the operator's attention.

The operator answers the call by inserting the answering plug in the jack associated with the line circuit. This causes the terminal equipment to transmit a marking condition from the central exchange to the intermediate station, which completely establishes the transmitting circuits between the subscriber's station and the central exchange.

During the transmission of signaling impulses between the subscriber's station and the central office the various transmitting circuits and systems operate in the usual manner. However, in case a break signal is transmitted from the subscriber's station which exceeds the normal length of spacing signals usually encountered in the telegraph signaling combinations ringing current is transmitted from the intermediate point to the central exchange during the remainder of the break signal to differentiate it from a disconnect or recall signal. At the central office the final response to a spacing signal is delayed a short interval. If ringing current is received during this interval, final response is further delayed during the reception of the ringing current.

An alternating ringing current is employed which has a frequency of 20 cycles. This ringing current passes over the intermediate telegraph lines and circuits as unit impulses of alternate marking and spacing current.

A subscriber transmits a recall signal by momentarily interrupting the line circuit at his station and connecting ground to one of the wires. This causes the equipment at the intermediate station to momentarily transmit a spacing signal over the intermediate sections to the central office. At the central office the prolonged spacing signal causes the cord circuit supervisory lamp to light, and then flash if automatic recall is provided, or to relight and then follow the operations of the recall key at the subscriber's station. Disconnect signals are transmitted from a subscriber's station by opening the line at the subscriber's station and connecting ground to one of the line wires. This causes the equipment at the intermediate station to transmit a spacing current or condition over the intermediate section to the central office. When the prolonged spacing signal is received at the central office it causes the cord circuit supervisory lamp to light continuously. This indicates to the operator that the subscriber has completed the call, whereupon the operator disconnects by removing the cord from the jack associated with the subscriber's line. This causes a spacing condition to be transmitted from the central exchange to the intermediate station where it causes the circuits to return to normal.

When the operator desires to call a subscriber she inserts a calling plug in the jack associated with the subscriber's line. This causes the terminal equipment at the central exchange to transmit a marking current to the intermediate station. However, the apparatus at the intermediate station does not respond to the marking current received at this time. The operator then operates the ringing key associated with the cord circuit and transmits ringing current to the terminal equipment. The ringing current is transmitted over the intermediate line sections as alternate marking and spacing impulses of unit length. When these impulses are received at the intermediate point, they cause ringing current to be applied to the line extending to the subscriber's station and ring a bell to call a subscriber. The subscriber answers as before and the various circuits operate as described above.

In case it is desired to provide unattended service at the subscriber station the operator holds the ringing key operated for a prolonged period of approximately nine or ten seconds. This causes a slow relay to operate at the subscriber's station equipment after which a message can be transmitted to the subscriber's station and recorded by his teletypewriter. During the transmission of the message to the subscriber's station the circuits operate as described above. At the completion of the call it is necessary to send a motor stop signal over the system. This causes the teletypewriter to close a particular contact which deenergizes the subscriber's station motors and other equipment.

Idle condition

The idle condition of the relays remain as shown in Fig. 2 except relay **24** which may be in either the position shown or in its right-hand position. At the intermediate station (Fig. 3) the relays remain in the position shown. Relay **60** is maintained in its left-hand position by an obvious circuit through its lower winding. Relay **56** may be in the position shown or in the opposite or right-hand position. Its contacts, however, are disconnected at this time so that it is immaterial which position it is in. Relay **58** is maintained in its right-hand position by current flowing through the lower winding in a circuit

from battery through the lower break contacts of relay 55, through lower winding of relay 58 to ground. Relay 59 may be either in its right-hand or left-hand position when the circuit is idle.

The relays of the full duplex section shown in Fig. 4 are maintained in their spacing positions as shown. Relays 201 and 203 are maintained in their left-hand positions by an obvious circuit through their lower windings. These relays serve to maintain relay 210 at the distant end in its spacing or right-hand position. Relays 212 and 213 are maintained in the right-hand or spacing position by an obvious circuit through their lower winding and in turn cause relay 208 at the other end of the circuit to be maintained in its left-hand or spacing position. Current flowing through the lower windings of relays 201, 203, 212 and 213 maintains them in their spacing position because no current flows through their upper windings at this time.

The relays are shown in Fig. 5 in their normal condition. Relay 232 is maintained in the position shown by current flowing in an obvious circuit through its lower winding. Relay 229 is maintained in its right-hand position by current flowing through its middle winding, in an obvious circuit. Relay 226 is maintained in its marking or left-hand position by current flowing in a circuit from ground through its lower winding and the upper break contacts of relay 227 to battery. Relay 220 is maintained in its spacing or right-hand position by current flowing in a circuit from ground through its lower winding and the marking contacts of relay 226 to negative battery. Relays 220, 226 and 232 are controlled by the current flowing through their lower windings at this time because no current flows through their upper windings. Relay 233 is maintained in its right-hand position by current flowing in a circuit from ground through its upper winding, upper break contacts of relay 235 and spacing contacts of relay 232 to positive battery. Current flowing through the lower winding of relay 233 in an obvious circuit tends to operate this relay to its left-hand position but is overpowered by the current flowing through the upper winding which holds it in its right-hand position.

The relays are shown in their normal positions in Figs. 6, 7 and 8. Relays 90 and 91 of Fig. 6 may be in the position shown or in the opposite position.

Subscriber originates a call

When a subscriber desires to originate a call he momentarily operates key 72 to a position where it operates the right-hand contacts. With the right-hand springs 13 of key 72 operated, a circuit is completed for the operation of relay 27 from source of power 28 through the winding of relay 27 and the lowermost right-hand springs 13 of key 72 to the grounded side of the source of power 28. Relay 27 in operating completes a locking circuit from source of power 28 through the winding of relay 27, upper contacts of relay 27, stop contacts 14 of key 72, motor control contacts 15 to ground. Relay 27 in operating also completes an operating circuit for relay 12 from source of power 28 through the lower contacts of relay 27 to ground through the winding of relay 12. Relay 27 in operating also connects source of power to motors 30 and 31 and to the motor generator set 29. Motor generator set 29 causes current to flow through the lower winding of receiving relay 24 which tends to operate this relay to its right-hand position.

The operation of relay 12 and the restoration of key 72, which permits the right-hand springs to return to normal, closes the line circuit through the subscriber's station.

This causes the operation of relay 49 at the intermediate station (shown in Fig. 3) in a circuit from battery through the winding of relay 49, the upper break contacts of relay 68, upper break contacts of relay 51, line 10 to the subscriber's station circuit shown in Fig. 2, the upper operated contacts of relay 12, normal upper contacts of the lower set of contacts of key 72, normal contacts of recall key 16, upper winding of relay 24, distributor 17, break key 18, transmitting contacts 19, lower normal contacts of the upper set of contacts of key 72, line 11 to ground through the inner upper break contacts of relay 51.

Relay 49 in operating completes a circuit for the operation of relay 50 from battery through the winding of relay 50, operated contacts of relay 49 and break contacts of relay 70 to ground. Relay 50 in operating completes an obvious circuit for the operation of relay 51. Relay 51 operating completes a locking circuit from battery through its winding and lower contacts to ground through the break contacts of relay 70. Relay 51 in operating completes an obvious circuit for the operation of relay 52. Relay 51 in operating also transfers the circuit of lines 10 and 11 from ground and relay 49 to the windings of relay 57 and interrupts the operating circuit of relay 49, allowing this relay to release. Relay 49 in releasing interrupts the operating circuit of relay 50 which in turn releases.

The subscriber's line now extends from negative battery through the lower winding of relay 57, and the upper inner operated contacts of relay 51, line 11 to subscriber's station equipment, through contacts of key 72, sending contacts 19, break key 18, tape transmitting distributor 17, upper winding of relay 24, normal contacts of recall key 16, contacts of key 72, upper inner contacts of relay 12, line 10 to the intermediate station, middle set of upper operated contacts of relay 51, upper winding of relay 57, upper winding of relay 59, choke coil 69 to the armature and transmitting contacts of relay 58. Current flowing in this path through the upper winding of relay 59 causes the armature of this relay to move to its marking contact if it had been resting on its spacing contact. Current flowing in this line circuit flows through the upper and lower windings of relay 57 in opposite directions so that they neutralize each other and produce substantially no magnetic effect upon relay 57. Relay 57 accordingly remains in its normal position.

Current flowing through the upper winding of relay 24 in this circuit to the subscriber's station causes relay 24 to operate to its left-hand contacts and completes a circuit for the operation of printer magnet 32 from the positive terminal of motor generator 29, winding of printer magnet 32, left-hand contacts of relay 24 to the negative terminal of motor-generator 29. Current flowing through the upper winding of relay 24 is in the opposite direction and overpowers the current flowing through the lower winding of relay 24.

Relay 52 (Fig. 3) in operating, as described above, completes an obvious circuit for the operation of relay 53. Relay 52 in operating also connects ground to the armature and of winding

of relay 56. Relay 56 operates to its left-hand position in a circuit from negative battery through the marking contacts of relay 59, winding of relay 56 to ground through the upper inner operated contacts of relay 52. In this position relay 56 completes a circuit for the operation of relay 60 to its right-hand position from battery through the winding of relay 60, left-hand contacts of relay 56 to ground through the upper outer operated contacts of relay 52. Relay 52 in operating also interrupts the circuit of the right-hand contact of relay 60 and transfers the circuit of the left-hand contact of relay 60 to the winding of relay 73. These circuits perform no useful functions at this time.

The operation of relay 53 connects ground to the potentiometer comprising resistance 74 and network 71 and supplies the proper potential to the lower or biasing winding of relay 59. This conditions relay 59 for receiving telegraph signaling impulses from the subscriber's station. The operation of relay 53 extends lines 190 and 191 to contacts of relays 55 and 73, respectively and prepares a circuit for the operation of relay 54 from negative battery through the winding of relay 54, upper break contacts of relay 54, upper operated contacts of relay 53, line 190, resistance 206 to negative battery through the spacing contacts of relay 201. Relay 54, however, does not operate this circuit because negative battery is connected to both of its winding terminals.

However, when relay 53 operated as pointed out above it extended line 191 to the contacts of relay 73. This completed the circuit for operating relays 201 and 203 to the marking positions. This circuit may be traced as follows: From positive battery through resistance 204, upper windings of relays 201, 203, resistance 205, line 191, operated lower contacts of relay 53, break contacts of relay 73 to negative battery through the armature and marking contact of relay 59. Current flowing through the upper windings of relays 201 and 203 overpowers the current flowing through the lower windings of these relays and causes these relays to move to their marking positions. The operation of relays 201 and 203 to the marking positions transmits marking current through the noise suppression filter 261, the upper and lower windings of relay 208, line 207, upper and lower windings of relay 210, noise suppression filter 216 through the spacing contacts of relays 212, 213.

The armature of relay 210 responds to this marking condition and moves to its marking contact. This causes the operation of relay 232 of the terminal equipment shown in Fig. 5 in the circuit from positive battery through the marking or left-hand contacts of relay 210, resistance 215, line 217, upper winding of relay 232, upper break contacts of relay 230, to negative battery through the upper winding of relay 226.

Relay 232 in operating interrupts the circuit through the upper winding of relay 233. When the circuit of the upper winding of relay 233 is interrupted by the operation of relay 232 to its right-hand or marking position, condenser 250 starts to discharge through the upper winding of relay 233. The constants of the upper winding of relay 233, resistance 251 and condenser 250 are so arranged that the discharging current of condenser 250 is sufficient to maintain relay 233 in its right-hand position for approximately .2 of a second. At the end of about .2 of a second this discharge current falls to such a value that the current flowing through the lower winding of relay 233 overpowers it and causes the armature of relay 233 to move to its left-hand position. In the left-hand position of the armature of relay 233 a circuit is completed for the operation of relay 227 from ground through the left-hand contacts of relay 233, lower outer break contacts of relay 235, break contacts of relay 228 to battery through the winding of relay 227. Relay 227 in turn completes a locking circuit from ground through its center set of lower operated contacts, the break contacts of relay 228, to battery through the winding of relay 227.

Relay 227 in operating completes a circuit for the operation of relay 225 from ground through the lower inner make contacts of relay 227, lower break contacts of relay 211 to battery through the winding of relay 225. Relay 225 in operating completes an obvious circuit for lighting the answering lamp 224 associated with jack 223.

Relay 227 in operating transfers the lower or biasing winding of relay 226 from positive battery to the armature of relay 220 and prepares relay 226 for receiving telegraph signaling impulses from a subscriber's station.

Relay 227 in operating also completes a circuit for the operation of relay 234 from ground through its lower outer make contacts, lower inner break contact of relay 235 to battery through the winding of relay 234. Relay 234 in operating connects battery to condenser 250 and the upper winding of relay 233. This charges condenser 250 to battery potential and causes the armature of relay 233 to move to its right-hand position where a circuit is completed for the operation of relay 235 from ground through the right-hand contacts of relay 233, lower contacts of relay 234, upper inner break contacts of relay 230 to battery through the winding of relay 235.

Relay 235 in operating interrupts the operating circuit of relay 234 which releases. Relay 235 in operating completes a locking circuit from battery through its winding and inner lower make contacts to ground through the lower outer operated contacts of relay 227. Relay 235 in operating also transfers the circuit of the upper winding of relay 233 to marking contact of relay 232. Inasmuch as relay 232 is now in its marking position a circuit is completed for maintaining relay 233 in its right-hand position from ground through its upper winding, the upper inner operated contacts of relay 235 to battery through the marking contacts of relay 232.

Operator answers

The operator at the central station, noting lamp 224, will answer and insert plug 83 in jack 223 or a jack in multiple with jack 223 in case jack 223 is multipled before a number of operators. It is to be understood that long multisection subscribers' line circuits in accordance with this invention may be used equally well with many different types of switchboards and switching equipment at the central station including both single section and multisection switchboards. In case the switchboard is provided with a number of sections, both lamp 224 and jack 223 may appear before a number of operators. If this is the case, the first operator to answer will find the circuit idle and will insert the plug 83 in jack 223. The other operators, if they start to answer the call, will find that the jacks in multiple with jack 223 will test busy so that they know that the call has already been answered.

When the operator inserts plug 83 in jack 223 a circuit is completed for the operation of relays 211 of terminal equipment and relay 84 of the cord circuit in series in a circuit from battery through winding of relay 84, sleeve of plug 83 and jack 223 to ground through the winding of relay 211. The operation of relay 84 completes an obvious circuit for the operation of relay 92 and conditions the cord circuit and extends the tip of the cord to the armature of relay 91 which is maintained on its marking contact at this time due to the operation of relay 92. If the operator has the printing key 89 associated with this cord circuit operated, the transmission circuit extends from the tip of plug 83 and operated upper contacts of relay 84 through the operator's circuit equipment and upper winding of relay 90 to the armature of relay 91.

In the terminal circuit relay 211 in operating interrupts the operating circuit of relay 225 which in turn releases and extinguishes the lamp 224. Relay 211 in operating extends the transmission circuit from the tip of jack 223 through the upper winding of relay 220 to the armature of relay 226. Current flowing through this transmission circuit from negative battery connected to the marking contacts of relay 226 through the upper winding of relay 220, upper contacts of relay 211, tip of jack 223, tip of plug 83, upper make contacts of relay 84, upper contacts of relay 88, operator's equipment, upper contacts of relay 88, upper winding of relay 90 to positive battery through the armature and marking contacts of relay 91 causes relay 220 to be operated to its marking contact.

Relay 220 in operating to its marking contact causes relays 212 and 213 to be operated to their marking contacts in a circuit from positive battery through the upper windings of relays 212 and 213, resistance 214, line 218 to negative battery through the marking contacts of relay 220. Curernt flowing through the upper windings of relays 212 and 213 overpowers current flowing through the lower windings of these relays causes the armature of these relays to be operated to their marking positions. The operation of relays 212 and 213 to their marking positions transmits a marking condition over line 207 to the terminal repeater A at the intermediate station.

The armature of relay 208 responds to this marking condition and moves to its marking position and completes the operating circuit of relay 54 described above since now negative battery is connected to one winding terminal and positive battery from the marking contacts of relay 208 to the other winding terminal of relay 54.

Relay 54 in operating completes a locking circuit from battery through its winding and upper break contacts to ground through the lower outer contacts of relay 53. Relay 54 in operating also completes an obvious circuit for the operation of relay 55.

Relay 55 in operating transfers the circuit of the lower winding of relay 58 from positive battery to the armature of relay 59. Relay 55 in operating also completes a transmission circuit from negative battery through the upper winding of relay 58, the upper operated contacts of relay 55, upper operated contacts of relay 53, line 190, resistance 206 to the armature and contacts of relay 208. These circuits condition relay 58 for responding to telegraph signal impulses.

The circuits are now in condition to enable the subscriber to communicate with the operator and indicate the other subscriber with which he wishes to be connected. The operator will then complete the call by inserting calling plug 101 into a jack associated with the calling line. In case the called subscriber is connected to the central station by local line calling plug 101 will be inserted into the subscriber's jack 139. It is to be understood, however, that the called subscriber may be located a distance from the central exchange, whereupon the calling plug would be inserted into a jack similar to jack 223. If the called subscriber is located at a still greater distance and associated with a different exchange, the calling plug 101 would be inserted in the trunk circuit extending to that exchange, where a second operator would complete the circuit to the called subscriber.

The long multisection subscribers' line circuits described herein operate in the same manner when connected to all of these different types of called subscribers' circuits. Hence, this description of typical local subscribers' line and station equipment will illustrate the features of the long multisection subscribers' line circuits. Assume, then, that plug 101 is inserted in jack 139. This completes a circuit for the operation of relays 98 and 140 in series from ground through the winding of relay 140, sleeve of jack 139 and plug 101 to battery through the winding of relay 98. These relays operate and extend the transmission circuit to the subscriber's station.

When the operator desires to call the subscriber she will operate ringing key 100 which connects ringing current over the tip of calling plug 101 and jack 139, the upper operated contacts of relay 140, upper winding of relay 141 to ground through condenser 146 and the winding of ringer 145 and the upper break contacts of relay 244.

The operation of relay 140 completes a circuit for the operation of relay 141 from negative battery through the lower winding of relay 141, operated lower make contacts of relay 140, T lead to the subscriber's station, lower contacts of relay 244 to ground through the upper contacts of relay 244. Relay 141 in operating connects ground through its lower contacts to the ring of jack 139 and plug 101 and causes relay 97 to operate. Relay 97 in operating completes an obvious circuit for lighting lamp 102.

When the subscriber answers by operating key 243, a circuit is completed from source of power 152 through the lower contacts of switch 243 and the winding of relay 244 to ground for the operation of this relay.

Relay 244 in operating removes the ground connected to the T lead and to the winding of ringer 145 and extends the line circuit from the R lead, upper operated contacts of relay 244, the normal contacts of recall key 237, transmitting contacts 157, send-receive and break contacts 156 and lower winding of relay 155 to the T lead.

Relay 244 in operating and removing ground from the T lead interrupts the operating circuit through the lower winding of relay 141 and completes the line circuit through both windings of relay 141. These windings are connected so that the current flows through them in opposition and produces substantially no magnetic effect on the relay. This permits the relay to release, which in turn interrupts the operating circuit of relay 97. The release of relay 97 extinguishes the light 102. Under these circumstances, the communication path between the subscriber's station circuit, shown in Fig. 2, and the subscriber's station circuit, shown in Fig. 8, is completed.

Transmission circuit

The subscriber shown in Fig. 2 may operate his station equipment in a number of different ways. The subscriber's station shown in Fig. 2 is provided with both a keyboard transmitter and a tape perforator and tape controlled transmitter. It is to be understood, however, that any suitable subscriber's station equipment may be employed at the end of the long multisection line. The equipment at the intermediate point is arranged to work with all the different subscribers' station circuits usually employed at local stations. For example, the distant subscriber's station may be provided with the equipment shown at the subscriber's station illustrated in Fig. 8. The arrangement shown in Fig. 2 illustrates that the subscriber's station may provide all the services provided for a local subscriber.

In case it is desired to employ only the keyboard transmitter, the switch **33** is operated to the K position where it interrupts the circuit through the lower contacts. This interrupts the circuit through the start magnet **41** of the tape control transmitter distributor **17**. In order to transmit, the subscriber must also operate the send-receive switch **20** to the position shown so the transmission circuit extends through the transmitting contacts **19**. When the subscriber operates the keyboard, transmitting contacts **19** transmit telegraph signaling impulses in accordance with the keys operated by the subscriber by opening and closing the line to the intermediate point.

The line relay **24** at the subscriber's station will follow the signal impulses and repeat them to the printer magnet **32** which records the transmitted signals on the local teletypewriter and provides a home copy for the subscriber. Relay **24** in its spacing position connects resistance **48** between the positive and negative terminals of the motor generator **29** to compensate for the load of the printer magnet **32** and thus maintain the load on the motor generator substantially constant and so the voltage output of the motor generator remains substantially constant when relay **24** is in both its marking and spacing positions.

In case the subscriber wishes to perforate tape at the same time the message is transmitted from the keyboard, key **33** is operated to the T—K position so that the lower contacts of this key are closed. This completes a circuit from the positive terminal of the motor generator through the lower contacts of key **33** to the cam pulsing contacts **35**. These cam pulsing contacts are controlled by the cams which actuate transmitting contacts **19**. Thus during each rotation of the cams controlling transmitting contacts **19** during which the impulses representing a particular character are transmitted, the cam pulsing contacts **35** are closed once. When these cam pulsing contacts are closed a circuit may be traced through them for the operation of the tape perforating magnet **36** from the positive terminal of motor generator **29**, lower contacts of key **33** and cam pulsing contacts through the winding of perforator magnet **36** to the negative terminal of motor generator **29**. This causes perforator magnet to operate and perforate a series of holes in the tape in accordance with the particular key depressed. The depression on the key mechanically controls and determines in what positions holes will be perforated in the tape when perforator magnet **36** operates.

Where the subscriber wishes to transmit from the keyboard, it is essential that the transmitter distributor switch **81** remain open so that the brush arm **43** of the distributor **17** will remain at rest and not interfere with the transmission from the transmitting contacts **19**.

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 **72** to the test position and leaves it in this position. With key **72** in test position, the power supply circuit is closed, as described above for the subscriber originating a call. However, in this case the line circuit extending to the intermediate station, shown in Fig. 3, is interrupted and remains open so that the equipment at the intermediate station as well as at the central station remains in its idle condition.

In case a subscriber wishes to secure a printed copy of his message at the same time that he perforates the tape he will leave key **33** in its center or T—K position. The operation of the equipment at the subscriber's station with the keys in these positions is substantially the same as described above when messages were transmitted from the keyboard and a record of them simultaneously printed on the teletypewriter and perforated in the tape except that now no signals are transmitted over the line to the central station because key **72** has been operated so that it does not connect the transmitting equipment to the line but instead establishes a local circuit through the transmitting contacts and the line winding of the receiving relay **24**.

The printed copy of the message perforated in the tape may be used for editing and correcting purposes so that the message may be edited before it is transmitted.

In case a subscriber merely wishes to perforate the tape without transmitting it and without securing a printed copy of it at this time the subscriber will operate the perforator control key **33** to its T position in addition to operating key **72** to its test line position. The operation of key **33** to its T position closes all of the contacts of this key. In this position a mechanical connection between key **33** and the cams controlling the transmitting contacts **19** functions to prevent the operation of these transmitting contacts **19**. Consequently, the cam pulsing contacts are unable to operate for each depression of a key. Instead, the U-bar contacts **34** are employed. These contacts operate every time a key is depressed but are disconnected unless key **33** is in the T position. These contacts cause the perforator magnet **36** to operate every time a key is depressed. It should be noted that the release of the perforator magnet **36** causes the tape to advance so that it will be in position to receive perforations representing the next character.

Under these conditions the line relay **24** and printer magnet **32** are maintained in their marking position in a circuit from the positive terminal of motor generator **29** through operated contacts of key **72**, normal contacts of recall key **16**, upper winding of relay **24**, transmitter distributor **17**, break contacts **18**, transmitting contacts **19**, operated contacts of key **72** to the negative terminal of motor generator **29**. Inasmuch as transmitting contacts **19** 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. The counter is operated by magnet 37 which is energized in a circuit from negative terminal of motor generator 29 through the winding of counter magnet 37, counter contacts 79, upper contacts of key 33 and U-bar contacts to the positive terminal of motor generator 29. Thus every time the U-bar contacts are operated by the operation of one of the keyboard keys, counter magnet 37 is operated to count the character. However, in case a shift or unshift signal or certain other signals are transmitted, the lever 80 moves in the direction indicated and mechanically operates the counter contact 79 so as to interrupt the circuit of the counting magnet 37 since these particular signals do not cause any character to be printed on the teletypewriter. At the end of the line counter contacts 79 are operated by lever 77 in response to a carriage return signal and cause the operation of release magnet 38 which restores the counter to zero.

Details of the arrangement of the equipment at the subscriber's station and the mechanical connections between the various parts is more fully described in U. S. Patents 1,965,572, granted July 10, 1934, to Burcky et al.; 1,965,602, granted July 10, 1934, to Lake; and 1,969,891, granted August 14, 1934, to Lake et al.

The counter light 40 is provided which may be energized by closing the lamp control switch 39 and serves to illuminate the counter dial.

In this way, a supply of tape may be perforated without transmitting the information over the line to the central office. If it is desired to return the equipment to normal without transmitting the information at this time key 72 is moved from the test position through the line position to the stop position and then to the normal or line position. This interrupts the locking circuit of relay 27. Relay 27 in releasing restores the apparatus at the subscriber's station to its normal or idle condition. It is to be noted that the equipment at the subscriber's station cannot be deenergized so long as key 72 is in the test position. This arrangement tends to prevent the subscriber from leaving his equipment unattended with key 72 in the test position.

When it is desirable to transmit from the tape, the transmission circuit is established as described above, and key 72 returned to its normal or line position without first being operated to the stop position. Key 33 is operated to T position and switch 81 closed. This completes a circuit from the negative terminal of motor generator 29 through the tape control contacts 46, switch 81, winding of start magnet 41, send-receive contacts 20 and lower contacts of key 33 to positive terminal of motor generator 29. Start magnet 41 operates in this circuit and withdraws the stop latch 42 from engagement with the brush arm 43 carrying brush 44. This brush arm is driven through a friction clutch (not shown) from motor 33. As the brush arm 43 carries brush 44 over the segments of distributor 17, the line circuit extending to the central office is interrupted in accordance with the perforations of tape 47 under the tape control contacts 45. So long as the supply of perforated tape is available, tape control contacts 46 remain closed and the transmitter distributor continues to transmit over the line to the intermediate station. During this transmission relay 24, which is in series with the line, as described above, follows the signals transmitted by the distributor 17 and repeats them to the printer magnet 32 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 47 becomes exhausted, the tape control contacts 46 will open and interrupt the circuit of the magnet 41 which will in turn release latch 42. Latch 42 will then engage the brush arm 43 and interrupt the transmission over the line to the intermediate and central stations.

It should be noted that telegraph signal impulses are transmitted from the subscriber's station over the line extending to the intermediate station, shown in Fig. 3, as impulses of current and no-current, independently of how or what equipment is used to transmit the impulses. Relay 57 at the intermediate station does not respond to these impulses, since they pass through both windings of the relay in opposite directions. Relay 59, however, responds to the impulses transmitted from the subscriber's station and repeats them to relays 203 and 201 in the circuit extending through its contacts, the break contacts of relay 73, the innermost lower operated contacts of relay 53, line 191, resistance 205 and upper windings of relays 203 and 201.

Relay 56 follows the signals repeated by relay 59 in a circuit from the contacts of relay 59 through the winding of relay 56 to ground through the upper operated contacts of relay 52. In response to spacing impulses transmitted by relay 59, relay 56 is operated to its right-hand position and in response the marking impulses transmitted by relay 59, relay 56 is operated to its left-hand position. In the left-hand position relay 56 completes a circuit from ground through the outer upper operated contacts of relay 52, contacts of relay 56 to battery through the upper winding of relay 60. Relay 60 is maintained in its right-hand position by current flowing in this circuit. When relay 56 is operated to its right-hand position it interrupts this circuit. Condenser 61 then starts to charge from battery through the upper winding of relay 60. The constants of the condenser 61, resistance 62 and relay windings are so chosen that this charging current of the condenser 61 will maintain relay 60 in its right-hand position for approximately .3 second. During the normal transmission of signaling impulses over the system, relay 59 will not remain in its spacing position for .3 second before moving to its marking position. When relay 56 moves to its marking position it immediately discharges condenser 61 so that the .3-second interval will start again when relay 56 moves to its spacing position. Consequently, relay 60 will remain in its right-hand position throughout the transmission of signal impulses from the subscriber's station.

Relays 203 and 201 also follow the signals and repeat them over the intermediate sections of line 207 to the terminal repeater B at the central station. Relay 210 of the terminal repeater follows the signal impulses received over line 207 and repeats them over line 217 to the terminal equipment shown in Fig. 5. Here relays 232 and 226 follow the signal impulses.

Relay 232 in following the signaling impulses interrupts the circuit through the upper winding

of relay 233 from ground through the upper winding of relay 233 and upper inner operated contacts of relay 235 to battery through the marking contacts of relay 232. This permits condenser 250 to start to discharge through the upper winding of relay 233. However, as described above, the discharge current of condenser 250 flowing through the upper winding of relay 233 will maintain the armature of relay 233 in its right-hand position for approximately .2 second. However, during the normal transmission of telegraph signal impulses, relay 232 will not remain in its spacing position for .2 second. When relay 232 moves to its marking position before the termination of the .2-second interval it immediately recharges condenser 250 and completes the holding circuit for relay 233. Consequently, relay 233 will remain in its right-hand position throughout the transmission of signal impulses from the subscriber's station shown in Fig. 2.

Relay 226 repeats the signal impulses over the transmission circuit extending from its contacts through the upper winding of relay 220, upper operated contacts of relay 211, resistance 222, tip of jack 223 and plug 83, contacts of relays 84 and 88 to the upper winding of relay 90 and thence to the armature of relay 91. Relay 90 repeats the signal impulses to the transmission circuit extending to the subscriber's station circuit shown in Fig. 8, from the contacts of relay 90 through the upper winding of relay 91, the upper break contacts of relay 95 and inner upper operated contacts of relay 98, normal contacts of ringing key 100, tip of plug 101 and jack 139, the upper operated contacts of relay 140, the upper winding of relay 141, the R lead to the subscriber's station, upper operated contacts of relay 244, normal contacts of recall key 237, transmitting contacts 157, break contacts of the send-receive and break contacts 156, lower winding of relay 155, T lead to the line circuit at the central station and lower operated contacts of relay 140 to battery through the lower winding of relay 141. The line relay 155 at the subscriber's station responds to these signal impulses and repeats them to the printer magnet 154 of the teletypewriter 245. Thus the teletypewriter 245 records the signals transmitted from the distant subscriber's station shown in Fig. 2.

In case the operator has the printing key 89 operated, relay 88 will be operated, in an obvious circuit. With relay 88 operated, the transmission circuit extends from the tip of plug 83, through operated contacts of relay 84, the operated contacts of relay 88, and the operator's position circuit to the repeating relays 90 and 91 of the cord circuit. This circuit through the operator's position circuit may be traced from the inner upper make contacts of relay 88, lower normal contacts of relay 116, normal contacts of relay 114, lower normal contacts of relay 124, lower winding of the line relay 104, transmitting contacts 242 of the operator's teletypewriter, normal contacts of toll ringing key 109, normal contacts of relay 115, to the upper outer operated contacts of relay 88. Splitting keys 112, 113 and associated relays 115 and 114 are provided to enable the operator to communicate with either subscriber without communicating to the other subscriber.

Signal impulses are transmitted, either from the subscriber's station shown in Fig. 8 or from the operator's equipment shown in Fig. 7 to the outlying subscriber's station shown in Fig. 2, over the same circuits between the operator's circuit and plug 83 and also between the subscriber's circuits shown in Fig. 8 and plug 83, as described above for transmission from the subscriber's station shown in Fig. 2 to these respective teletypewriters. In case the transmitting contacts 242 of the operator's teletypewriter 103 or 157 of the subscriber's teletypewriter 245 are operated to transmit the impulses, relay 220 of the terminal circuit shown in Fig. 5 repeats the impulses over line 218 to relays 212 and 213 of the terminal repeater B. These relays in turn repeat the impulses over line 207 to the terminal repeater A at the intermediate station. Here relay 208 repeats the impulses through resistance 206, line 190, the upper operated contacts of relay 53, upper operated contacts of relay 55 and upper winding of relay 58. Relay 58 follows the signals and repeats them to the subscriber's line. At the subscriber's station relay 24 follows the signals and repeats them to the printer magnet 32 of the subscriber's teletypewriter which records the signals.

Break signals

In case it is desired to interrupt the transmission being received at the subscriber's station shown in Fig. 2, break key 18 is operated. This break key is associated with the send-receive key 20 so that it is necessary to operate the send-receive key first before the break key 18 can be operated. This merely short circuits the transmitting contacts 19 and interrupts the circuit of start magnet 41. However, since transmission is being received at the station shown in Fig. 2 at this time, the operation of the send-receive key performs no useful function at this time. Break key 18 in operating, however, interrupts the line circuit extending to the intermediate station. This causes relay 59 at the intermediate station to move to its spacing position. This repeats the spacing impulse over the transmission circuit, as described above, and also causes relay 56 to operate to its spacing position. In this case, however, relay 56 will remain in its spacing position longer than the .3-second period required for relay 60 to operate to its left-hand position. At the end of the .3-second interval, relay 60 operates to its left-hand position and completes a circuit for the operation of relay 73 from battery through the winding of relay 73, the lower outer make contacts of relay 52 to ground through the left-hand and armature contacts of relay 60. Relay 73 in operating transfers the transmission path over lead 191 from the contacts of relay 59 to a source of 20-cycle ringing current 75 through a protective lamp 76. Relays 203 and 201 follow the ringing current and transmit alternate impulses of marking and spacing currents of substantially a single unit in length. Relay 210 at the central station repeats these impulses to the terminal circuit shown in Fig. 5.

When the break signal is originally received by the equipment shown in Fig. 5, relays 232 and 226 respond by moving to their spacing positions. Relay 226 repeats the break signal either to the operator or the subscriber's station circuit shown in Fig. 8. Relay 232, however, will remain in its spacing position over .2 second in this case and permit condenser 250 to become sufficiently discharged to allow relay 233 to operate to its left-hand position. Relay 233 in operating to its left-hand position completes a circuit for the operation of relay 229 from ground through the

left-hand contacts of relay 233, the lower operated contacts of relay 235, the lower normal contacts of relay 231 to battery through the upper winding of relay 229.

Relay 229 in operating removes the short circuit from its lower winding so that current may now flow from ground through the lower winding, resistance 249, the upper operated contacts of relay 235 to battery through the spacing contact of relay 232. Current flowing through this winding tends to maintain relay 229 operated.

Relay 229 in operating also completes an obvious circuit for the operation of relay 230. Relay 230 in operating completes a circuit for the operation of relay 234 from ground through its lower contacts, upper break contacts of relay 231, to battery through the winding of relay 234.

Relay 234 in operating completes a circuit through its upper contacts for charging condenser 250 and for operating relay 233 to its right-hand position. In the right-hand position the armature of relay 233 completes a circuit for the operation of relay 231 from ground through its armature and right-hand contacts, the lower operated contacts of relay 234, the inner upper operated contacts of relay 230, to battery through the winding of relay 231. Relay 231 in operating interrupts the operating circuit of relay 234 and completes a locking circuit from ground through the lower operated contacts of relay 230, upper operated contacts of relay 231 to battery through the winding of relay 231. Relay 234 in releasing interrupts the circuit through the upper winding of relay 233, whereupon condenser 250 again starts to discharge.

However, ringing current transmitted by the operation of relay 73 is received by relay 232 before the end of the second .2-second interval. Relay 232 follows the ringing current and during alternate half cycles, connects ground to the upper winding of relay 233 and fully charges condenser 250. This prevents relay 233 from moving to its left-hand position at this time. During the half cycles during which relay 232 is connected to its spacing contact it connects battery to the lower winding of relay 229 and tends to hold this relay in its left-hand position. Relay 232 at this time also tends to charge condenser 236 through resistance 249. During the half cycles during which relay 232 is not in its spacing position, condenser 236 will discharge through the lower winding of relay 229 and maintain this relay in its left-hand position.

It should be noted that when relay 230 operated it interrupted the transmission circuit to relay 226 so that this relay will remain in it spacing position and not receive or follow the ringing current transmitted from the intermediate station.

It should be further noted that when the break signal is first received by relay 59, relay 59 operated to its spacing position during the next marking impulse transmitted by relay 58 to the subscriber's station shown in Fig. 2. When relay 59 operates to its spacing position it reverses the bias current through the lower winding of relay 58 so that it will tend to maintain relay 58 in marking position so long as the break impulses are received from the subscriber's station. This insures the proper retransmission of the break signal to the central station and prevents the impulses being transmitted from a distant station from interfering with the break signal.

At the central exchange relay 226 is operated to its spacing position during the first marking impulse transmitted by relay 220 after the break signal has been received by relay 226. Relay 226 repeats the break signal to relay 90 at this time, which relay in turn repeats it to the subscriber's station shown in Fig. 8. With relay 90 in its spacing position it is impossible for the subscriber's station shown in Fig. 8 to transmit marking signal impulses so that the line relay 155 at this station will be operated to its spacing position and remain in this position independently of the operation of the transmitting contacts 157 at the subscriber's station shown in Fig. 8. So long as the subscriber at the station shown in Fig. 2 maintains the break contacts 18 open, the circuits remain in the condition described above. It should be noted that the reception of the break signal by the teletypewriter 245 at the subscriber's station shown in Fig. 8 causes the send-receive contacts 156 to be operated so that the transmitting contacts 157 are short-circuited. However, these contacts are not operated sufficiently to interrupt the line circuit through the lower winding of relay 155.

When the subscriber at station shown in Fig. 2 restores break key 18 to normal the line circuit to the intermediate station is reclosed. This causes the armature of relay 59 to move to its marking position, which in turn causes the armature of relay 56 to move to its marking position. Relay 56 in operating to its marking or left-hand position completes a circuit through the upper winding of relay 60, which causes its armature to move to the right-hand position and interrupt the circuit through the winding of relay 73. Relay 73 releases, disconnects the source of ringing current 75 from the transmission circuit and connects the transmission circuit to contacts of relay 59. This causes the transmission of the marking impulse over lead 191 to relays 203 and 201. These relays in turn transmit a marking impulse over line 207 to the central station. This marking impulse is repeated over line 217 to relay 232. Relay 232 operates to its marking position and remains in this position. In the marking position, relay 232 completes a circuit through the upper winding of relay 233 for maintaining the armature of this relay in its right-hand position. Relay 232 in remaining in its marking position interrupts the locking circuit of relay 229 and permits condenser 236 to discharge, after which relay 229 will be operated to its right-hand position by current flowing in an obvious circuit through its center winding.

Relay 229 in operating to its right-hand position interrupts the circuit for relay 230. Relay 230 releases and in turn releases relay 231. Relay 230 in releasing reconnects the upper winding of relay 226 to lead 217. Relay 226 is then operated to its marking position by the marking impulse received over lead 217. Relay 226 will repeat this marking impulse to the local subscriber's station shown in Fig. 8, whereupon the transmission circuits are restored to their normal condition and the subscriber at station shown in Fig. 2 may now transmit over the system as described above.

If it is desired to interrupt the transmission from the subscriber's station shown in Fig. 2 a break signal may be transmitted either by the operator or by the subscriber at the subscriber's station shown in Fig. 8. This transmits a break or spacing signal over the tip of plug 83 to relay 220. Relay 220 operates to its spacing position during the transmission of the first marking im-

pulse by relay 226 after the reception of the break signal and retransmits the break signal over line 218 to relays 212 and 213. Relay 220 in operating to its spacing position reverses the bias current through the lower winding of relay 226. This causes relay 226 to remain in its marking position and prevents it from interfering with the break signal received by relay 220.

Relays 212 and 213 repeat the break signal over line 207 to relay 208 of repeater A. Armature of relay 208 moves to its spacing position and repeats the break signal over line 190 to relay 58. The armature of relay 58 in turn moves to its spacing position during the first marking impulse repeated by relay 59 after reception of the break impulse and repeats the break signal to the subscriber's line. With the armature of relay 58 in its spacing position relay 59 is maintained in its marking position so that if any succeeding impulses are transmitted by the subscriber's station they will not interfere with the break signal.

Relay 24 at the subscriber's station responds to the break signal by moving to its spacing position and remaining there independently of the operation of the transmitting contacts 19 or of the impulses transmitted by transmitting distributor 17. This indicates to the subscriber that the distant subscriber wishes to interrupt the transmission. The teletypewriter also causes the send-receive contacts 20 to be operated to the receive position at this time . This interrupts the circuit of the start magnet 41 of transmitting distributor 17 which in turn interupts the transmission from distributor 17 had the subscriber been transmitting from tape. The operation of the send-receive contacts 20 also short circuits the transmitting contacts 19 and thus prevents the subscriber from transmitting from the keyboard until this switch has been again operated to the sending position.

Recall

In case the subscriber at the station shown in Fig. 2 wishes to recall the central exchange operator, the subscriber will momentarily operate recall key 16. This interrupts the line circuit at the subscriber's station and connects ground to conductor 11 from the operated contacts of recall key 16 and interrupts the circuit through the upper winding of relay 57 and connects ground to the circuit through the lower winding of relay 57. This circuit for the operation of relay 57 may be traced from ground through the operated contacts of recall key 16, the upper winding of relay 24, transmitting distributor 17, contacts of the break key 18, contacts of the transmitting device 19, contacts of the line test key 72, line 11, the inner upper operated contacts of relay 51, lower winding of relay 57 to negative battery.

Relay 57 in operating completes a circuit for the operation of relay 70 from ground through the upper contacts of relay 50, contacts of relay 57 to battery through the winding of relay 70. Relay 70 operates and interrupts the locking circuit of relay 51. Relay 51 thereupon releases and releases relay 52. Relay 52 in turn releases relay 53 which causes the release of relays 54 and 55. The release of these relays restores the circuit to its idle condition. The release of relay 51 interrupts the operating circuit of relay 57 which in turn interrupts the operating circuit of relay 70. Relay 70, however, is made slow in releasing so that relay 51 will have sufficient time to fully release before the contacts of relay 70 reclose. This insures the release of relay 51 at this time.

Relay 59 releases when the subscriber operates the recall key 16 and transmits a spacing signal over conductor 191 to relays 203 and 201 which in turn repeat the spacing impulse over channel 207 to the central exchange. At the central exchange relay 210 repeats the spacing signal over line 217 to relays 232 and 226. Relay 226 serves to repeat the spacing signal to the cord circuit and other subscriber's station. The armature of relay 232 responds to the spacing signal by moving to its spacing position. This causes the operation of relay 233 to its left-hand position after approximately .2 second. In the left-hand position relay 233 completes a circuit for the operation of relay 229 to its right-hand position. Relay 229 in operating to its right-hand position removes the shunt from its lower locking winding so that it will lock in its left-hand position under control of the spacing contacts of relay 232. Relay 229 also causes the operation of relay 230. Relay 230 in operating interrupts the transmission circuit to relay 226 and also completes a circuit for the operation of relay 234. Relay 234 in operating completes a circuit for the operation of relay 233 to its right-hand position through its upper winding. Relay 233 in turn completes a circuit for the operation of relay 231. Relay 231 locks operated under control of relay 230 and interrupts the operating circuit of relay 234 which then releases. The operating circuits of these relays shown in Fig. 5 are the same as for a break signal described above. In case of a disconnect signal, however, relay 232 will remain upon its spacing contact at this time, since no ringing current is transmitted over the system. This permits relay 233 to again operate to its left-hand position at the end of the second .2-second interval. In the left-hand position the armature of relay 233 completes a circuit for the operation of relay 228 from ground through the left-hand contacts of relay 233, lower outer operated contacts of relay 235, the lower operated contacts of relay 231 to battery through the winding of relay 228. Relay 228 in operating completes a locking circuit from battery through its winding and operated contact to ground through the middle set of lower contacts of relay 227.

Relay 228 in operating interrupts the locking circuit of relay 227 from battery through the winding of relay 227 and the break contacts of relay 228 to ground through the center set of lower operated contacts of relay 227. This permits relay 227 to release which in turn causes the release of relays 235, 228, 229, 230 and 231. The release of these relays restores the circuit to its idle condition except that relay 211 remains operated.

The release of relay 227 also connects ground through its inner lower break contacts to the ring of jack 223 and plug 83 which causes the operation of relay 85. The operation of relay 85 causes the supervisory lamp 86 to light. The operation of relay 85 also completes a circuit for the operation of relay 87 which locks operated through its upper contact.

When the subscriber releases the recall key it disconnects ground from line 11 and completes the circuit between lines 10 and 11. The apparatus at the intermediate station shown in Fig. 3 and the apparatus of the intermediate line sections shown in Fig. 4, as well as the terminal apparatus shown in Fig. 5 operate as described when the subscriber initiates a call. The operation of relay 227 in Fig. 5 at this time removes ground from the ring of jack 223 and plug 83. This permits relay 85 of the cord circuit to release. How-

ever, relay 87 remains operated until the operator operates the printing key 89. Until the operator operates this key, the interrupter 93 is connected to the circuit of the supervisory lamp 86 and causes this light to flash. When the operator operates key 89, relay 87 is released and this extinguishes the supervisory lamp 86.

In case the automatic recall features are not provided in the cord circuit, the supervisory lamp 86 will follow the operation of the recall key 16. At the subscriber's station, recall signals may be sent by momentarily operating the line key 72 first to the stop position, then to the test position and finally restoring it to the line position.

The operation of key 72 to the stop position interrupts the locking circuit of relay 27 and permits this relay to release. The release of relay 27 disconnects the power supply from the motor generator 29 and motors 30 and 31 at the subscriber's station. It also causes the release of relay 12. The release of relay 12 interrupts the line circuit to the subscriber's station and connects ground to lead 11 which extends to the intermediate station shown in Fig. 3 in the same manner the operation of recall key 16 connects ground to this lead. This causes the circuits at the intermediate station and central office to operate as described above when the recall key was operated.

Usually recall key 16 will only be provided when automatic recall is not provided at the central office so that the subscriber can readily flash the supervisory lamp in the cord circuit at the central office. However, when the automatic recall feature is provided in the cord circuit, the recall key is not necessary and usually will not be provided because a single recall signal may be readily transmitted by line key 72.

However, it is to be understood that either or both of these keys may be provided when the cord circuit at the central office is equipped to provide a flashing recall signal.

Disconnect

When the subscriber has completed the transmission of the message he will operate the line key 72 to the stop position. This will deenergize the equipment at the subscriber's station and connect ground to lead 11 extending to the intermediate station just as described under "Recall" except that the line key is returned to the line position instead of being operated to the test position after being operated to the stop position. The circuits at the intermediate station and the central exchange will operate as described under "Recall" excepting that the supervisory lamp 86 remains lighted and does not flash. The operator at the central exchange will then remove plug 83 from jack 223. This causes relays 84 and 211 to release. Relay 211 in releasing interrupts the transmission circuit through the upper winding of relay 220 so that the armature of this relay will move to its spacing position and transmit a spacing signal over line 218. This spacing signal is repeated by relays 212 and 213 over line 207. Relay 208 moves to its spacing position in response to this spacing signal. Relay 208 in moving to its spacing position at this time performs no useful function since the circuits have all returned to their normal or idle position.

A disconnect signal may be transmitted from the outlying subscriber's station in response to a motor stop signal transmitted from the subscriber's station or received by this station. The motor stop signal operates contacts 15 which interrupt the locking circuit of relay 27 in the same manner that key 72 interrupts this circuit and permits relay 27 to release. The circuits then function and are returned to normal as described above.

Operator calls

When the operator desires to call the outlying subscriber's station shown in Fig. 2, she will insert calling plug 101 in jack 223. Of course the answering plug 83 of the cord will usually be inserted in the jack similar to jack 139 of the line to the calling subscriber's station. When the calling subscriber desires to communicate with the subscriber's station shown in Fig. 2, as pointed out above, the calling plug 101 is inserted in jack 223. This causes the operation of relays 211 and 98 in series. The operation of relay 211 completes a transmission circuit from the tip of plug 101 through the winding of relay 220 to the contacts of relay 226. This causes the armature of relay 220 to operate to its marking contact and to transmit a marking signal over line 218. This signal is repeated by relays 212 and 213 over line 207 to the intermediate station. At the intermediate station the armature of relay 208 responds by moving to the marking contact. However, this performs no useful function at this time.

When the operator inserts calling plug 101 in jack 223 as described above, a circuit is completed for the operation of relay 97 from ground through the lower inner break contacts of relay 227, ring of jack 223, ring of plug 101 to battery through the winding of relay 97. Relay 97 in operating completes an obvious circuit for lighting the supervisory lamp 102.

The operator will then operate ringing key 100 in the cord circuit. This applies ringing current to the transmission circuit through the upper winding of relay 220. Relay 220 will follow the ringing current and transmit alternate impulses of marking and spacing current of substantially unit length over line 218. Relays 212 and 213 repeat these impulses over line 207. Relay 208 of the intermediate station in turn repeats these impulses over line 190.

Alternating current relay 63 responds to these impulses. Condenser 64 is alternately charged and discharged through the windings of relay 63 from the positive and negative batteries connected to the contacts of relay 208 over a circuit extending from the armature of relay 208, resistance 206, lead 190, upper break contacts of relay 53 to the condenser 64. The same terminal of condenser 64 is also connected to negative battery through resistance 159. This resistance tends to charge or discharge condenser 64 during the time the armature of relay 208 is passing from one contact to the other. Relay 63 is an alternating current relay and tends to operate and remain operated so long as these impulses are received.

Relay 63 in operating completes an obvious circuit for the operation of relay 65. Relay 65 in turn completes a circuit for the operation of relay 66 to its right-hand position from ground through the upper operated contacts of relay 65, lower break contacts of relay 66 to battery through the upper winding of relay 60. Current flowing in this circuit opposes and overcomes the current flowing through the lower winding of relay 60 so that relay 60 will operate to its right-hand position. With the armature of relay 60 in its right-hand position a circuit is completed for the operation of relay 66 from ground through

the armature and right-hand contacts of relay 60, the lower break contacts of relay 52 to battery through the winding of relay 66. Relay 66 in operating completes a locking circuit from battery through its winding and inner upper operated contacts to ground through the inner upper operated contacts of relay 65. Relay 66 in operating interrupts the operating circuit of relay 60 so that relay 60 starts to release at this time. However, condenser 61 starts to charge through the upper winding of relay 60 at this time. The charging current of this condenser is sufficient to maintain relay 60 in its right-hand position for approximately .3 second in the preferred embodiment of this invention. At the end of this time interval, relay 60 will be operated to its left-hand position by current flowing through its lower winding in an obvious circuit. With the armature of relay 60 in its left-hand position at this time a circuit is completed for the operation of relay 67 from ground through the armature and left-hand contacts of relay 60, lower break contacts of relay 52, upper operated contacts of relay 66 to battery through the winding of relay 67. Relay 67 in operating completes an obvious circuit for the operation of relay 68. The operation of relays 67 and 68 connects the source of 20-cycle ringing current 75 to line 10 extending from the subscriber's station in the following circuit: from ground through the source of ringing current 75, protective lamp 76, inner operated contacts of relay 67, operated contacts of relay 68, middle set of normal contacts of relay 51, line 10, condenser 23, ringer 22 at the subscriber's station to ground through the contacts of key 72 and the inner break contacts of relay 12.

When the operator releases ringing key 100, ringing current is disconnected from the tip of plug 101 and marking potential is connected thereto. This causes a marking condition to be transmitted to the intermediate station. Relay 63 will not remain operated under this condition since condenser 64 will become fully charged. Hence, no current will flow through the winding of relay 63 so relay 63 will release and in turn release relay 65 which in turn releases relay 66. Relay 66 releases relay 67 which in turn releases relay 68. The release of these relays disconnects source of ringing current 75 from the line extending to the subscriber's station. Relay 68 is slow in releasing. During its release time the capacity of the lines 10 and 11 is charged to battery potential in a circuit from positive battery through resistance 78, break contacts of relay 67, operated contacts of relay 68, and break contacts of relay 51. Then when relay 68 releases relay 49 is connected to line 10. Since the line is charged to battery potential, this relay does not falsely operate by any line charging current.

The above relays follow the operation of ringing key 100 in the cord circuit as described above. In addition, ringer at the subscriber's station rings when the ringing key 100 in the cord circuit is operated. The subscriber answers in the same manner as when orginating a call by momentarily operating key 72 to the test position and then returning it to its normal or line position. This starts the equipment at the subscriber's station and completes the line circuit at the subscriber's station. During the next interval during which the operator has released ringing key 100 relays 49, 50, 51, etc., at the intermediate station will operate as described above when a subscriber originates a call. When relay 227 of the terminal equipment shown in Fig. 5 operates in response to the starting of the equipment at the subscriber's station shown in Fig. 2, it will disconnect ground from the ring of jack 223 and thus permit relay 97 to release. The release of relay 97 allows the supervisory lamp 102 to be extinguished. This indicates to the operator that the subscriber has answered so that the operator will not reoperate the ringing key to ring the subscriber. The subscribers may communicate between themselves and the operator at the central exchange, if necessary, as described above, and at the termination of the call, disconnect by operating the line key to the stop position for a short interval of time and then releasing it.

Unattended service

In case it is desired to provide unattended service for the outlying subscriber's station, condenser 21 and relay 25 are connected in parallel with the condenser 23 and ringer 22. In case the subscriber does not answer after the operator has rung bell 22 several times, the operator will hold ringing key 100 operated for at least ten seconds. This will apply ringing current to the subscriber's line for a similar interval of time. Relay 25 will operate at this time and complete a circuit for the operation of relay 26 from source of power 28 through the winding of relay 26 and the contacts of relay 25 to ground. Relay 26 is slow to operate and does not close its contacts for at least six or eight seconds. Consequently, if ringing current is applied for nine or ten seconds continuously, so that relay 25 remains operated during this time, relay 26 will operate. Relay 26 in operating completes a circuit for the operation of relay 27 from source of power 28, winding of relay 27, contacts of relay 26 to ground. Relay 27 in operating locks operated and energizes the equipment at the subscriber's station, as described above when the subscriber initiates a call. Relay 12 is also operated when relay 27 operates and completes the line circuit through the subscriber's station. Then when the operator releases the ringing key after approximately ten seconds, relays 63, 65, 66, 67, and 68 release whereupon, if the equipment at the subscriber's station has responded as described above, relays 49, 50, 51, 52, etc., operate as described when the subscriber initiates a call. These relays in turn eventually cause relay 227 of the terminal equipment shown in Fig. 5 to operate. The operation of relay 227 removes ground from the ring of jack 223 which in turn permits relay 97 to release and in turn extinguish the supervisory light 102 which indicates to the operator that the subscriber's equipment is in condition to receive signaling impulses. The operator will then notify the other subscriber who can transmit the desired message to the outlying subscriber. At the termination of the message it is necessary to transmit a motor stop signal to the subscriber's station shown in Fig. 2. This motor stop signal operates the motor control contacts 15 through the teletypewriter equipment. The operation of the motor control contacts interrupts the locking circuit of relay 27. This relay then releases and restores the circuit to its idle condition which in turn causes the circuit of the intermediate station and central station to operate as described above under "Disconnect".

If the subscriber's equipment did not become energized before the operator released ringing key 100, the supervisory lamp 102 in the cord circuit would remain lighted because relays 49, 50, etc.,

would not operate when relays 63, 65, 66, 67 and 68 released. The operator would then again attempt to start the subscriber's equipment by holding the key 100 operated for a long interval of time. The circuits would then again operate as described above.

It is to be understood that the foregoing description describes certain typical circuits, including the subscriber's station circuits and the central station circuits. However, it is to be understood that the circuit arrangement at the intermediate point will cooperate with other types of subscriber's station circuits such as commonly employed in telegraph systems. Also, the terminal equipment at the central exchange may be arranged to cooperate with any suitable type switching equipment, including various types of single-section and multisection switchboards as well as with machine switching circuits. It is to be further understood that the invention defined in the claims appended hereto is not limited to the specific circuit arrangement at the intermediate point or central office nor to the specific time intervals described.

What is claimed is:

1. In a telegraph exchange system a long subscriber's line circuit comprising subscriber's station equipment, an intermediate repeater station, central interconnecting station equipment, terminal equipment connected to said long subscriber's line circuit at said interconnecting station, a telegraph line connecting said subscriber's station and said intermediate station, a full duplex channel connecting said intermediate station and said central station, means at said subscriber's station for continuously controlling supervisory signals at said central station comprising means for transmitting a series of signals of alternate character and of uniform length from said intermediate station during break signals which exceed the length of spacing signals encountered in transmitting code combinations of telegraph signaling impulses.

2. A method of supervising over a long multisection subscriber's line circuit which comprises transmitting a break signal over the intermediate sections of said system for a short interval of time in response to a break signal transmitted from the subscriber's station and then transmitting a series of uniform length impulses of alternate character over the intermediate sections during the remainder of the break signal transmitted from the subscriber's station.

3. A telegraph exchange system comprising a central interconnecting station, a plurality of local subscriber stations, lines connecting said subscribers' stations to said central station, interconnecting means at said central station for interconnecting said local stations, a distant subscriber's station, telegraph equipment similar to the telegraph equipment at said local stations located at said distant station, an intermediate repeater station, a line connecting said distant subscriber's station to said intermediate station, a full duplex telegraph channel connecting said intermediate station and said central station, terminal equipment located at said central station connected to said full duplex channel for cooperating with said switching equipment in the same manner that said local station lines cooperate therewith, and means at said repeater station for transmitting ringing current over said intermediate line section in response to break signals which exceeds a predetermined short interval of time.

4. A method of distinguishing between break signals and disconnect and recall signals transmitted over an intermediate section of a long subscriber's line which comprises the step of first transmitting said supervisory signaling conditions over said line and then applying ringing current to said intermediate section in response to one of said signals which exceeds a predetermined minimum interval of time.

5. In a telegraph system comprising a plurality of local subscribers' stations, a central interconnecting station, telegraph lines connecting said subscriber's station, means at each of said subscribers' stations and said central station for transmitting and responding to at least three signaling conditions in addition to two signaling conditions employed for transmitting code combinations of telegraph signaling impulses, an outlying subscriber's station and an intermediate repeater station, and apparatus located at said outlying subscriber's station and said intermediate station for transmitting and responding to the same signaling conditions as transmitted between said local subscribers' stations and said central station, a full duplex telegraph channel arranged to transmit only two different signaling conditions connecting said intermediate station and said central station, and means for transmitting and receiving to all of said signaling conditions to and from said full duplex channel which comprises transmitting impulses of uniform length and of alternate character over said full duplex channel in response to one of said signaling conditions which exceeds a predetermined interval of time.

6. In combination, a first communication line circuit capable of transmitting three signaling conditions and a second communication line capable of transmitting only two signaling conditions, means for transmitting three signaling conditions in addition to code combinations of impulses of two of said signaling conditions over said first line circuit, and means for transmitting all of said signal conditions over said second line circuit which comprises transmitting a series of impulses of uniform length and of alternate character over said second line in response to one of said signaling conditions transmitted over said first line circuit.

7. A multisection subscriber's line circuit comprising a subscriber's station, an intermediate repeater station, a line connecting said subscriber's station and said intermediate station, a central telegraph exchange station, a full duplex telegraph channel connecting said intermediate station and said central exchange station, means for transmitting signaling impulses of substantially unit length and of alternate character over said full duplex channel from said intermediate station to said central station in response to break signals exceeding a predetermined minimum period transmitted from said subscriber's station, and means for transmitting a series of impulses of subtantially unit length and alternate character over said full duplex channel from said central station to said intermediate station to call said subscriber's station, and means at said intermediate station for responding to said series of impulses and for applying ringing current to a line extending to said subscriber's station in response thereto.

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