March 25, 1924. 1,487,996

S. B. WILLIAMS, JR

TELEPHONE EXCHANGE SYSTEM

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Fig. 10

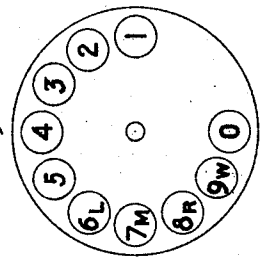
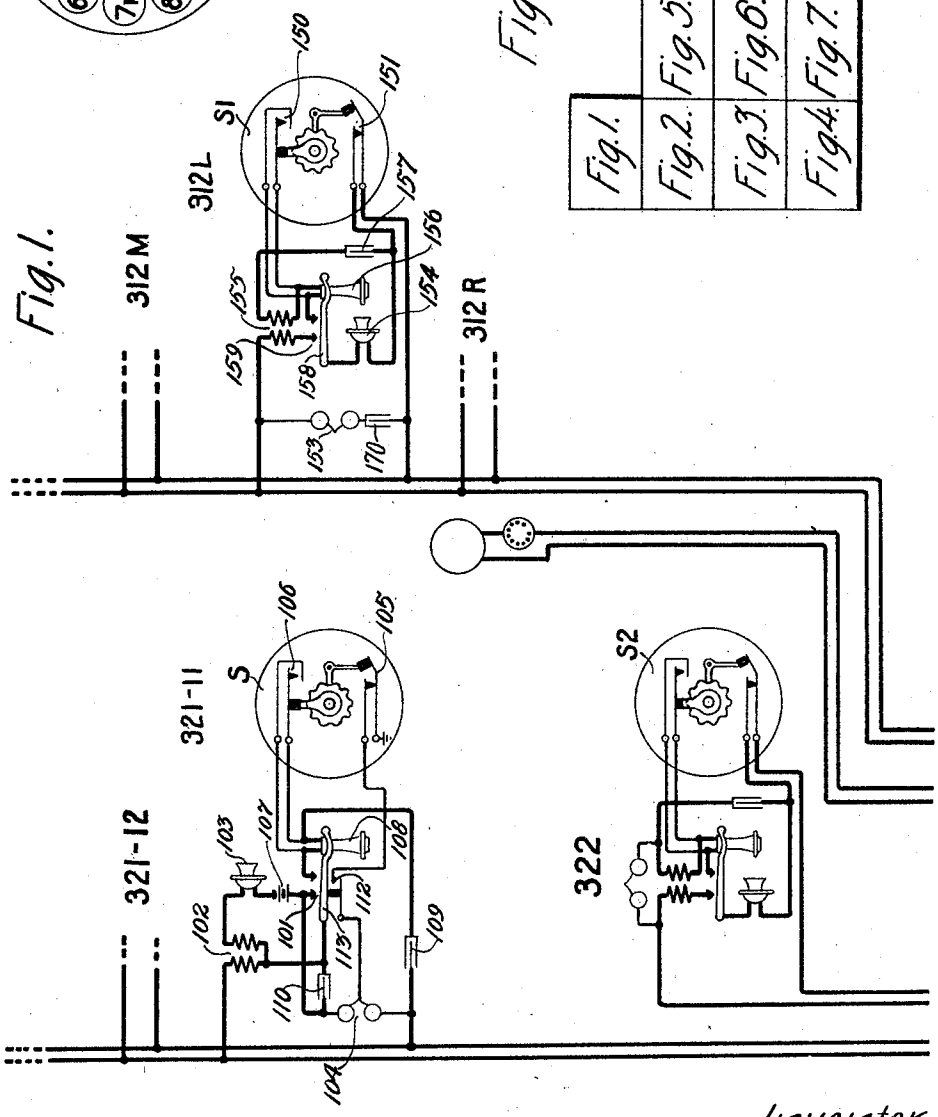


Fig. 11.

Fig. 1.	Fig. 2.	Fig. 3.	Fig 4.
	Fig. 5.	Fig 6.	Fig 7.
	Fig. 8.	Fig 9.	

Fig. 1.



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TELEPHONE EXCHANGE SYSTEM

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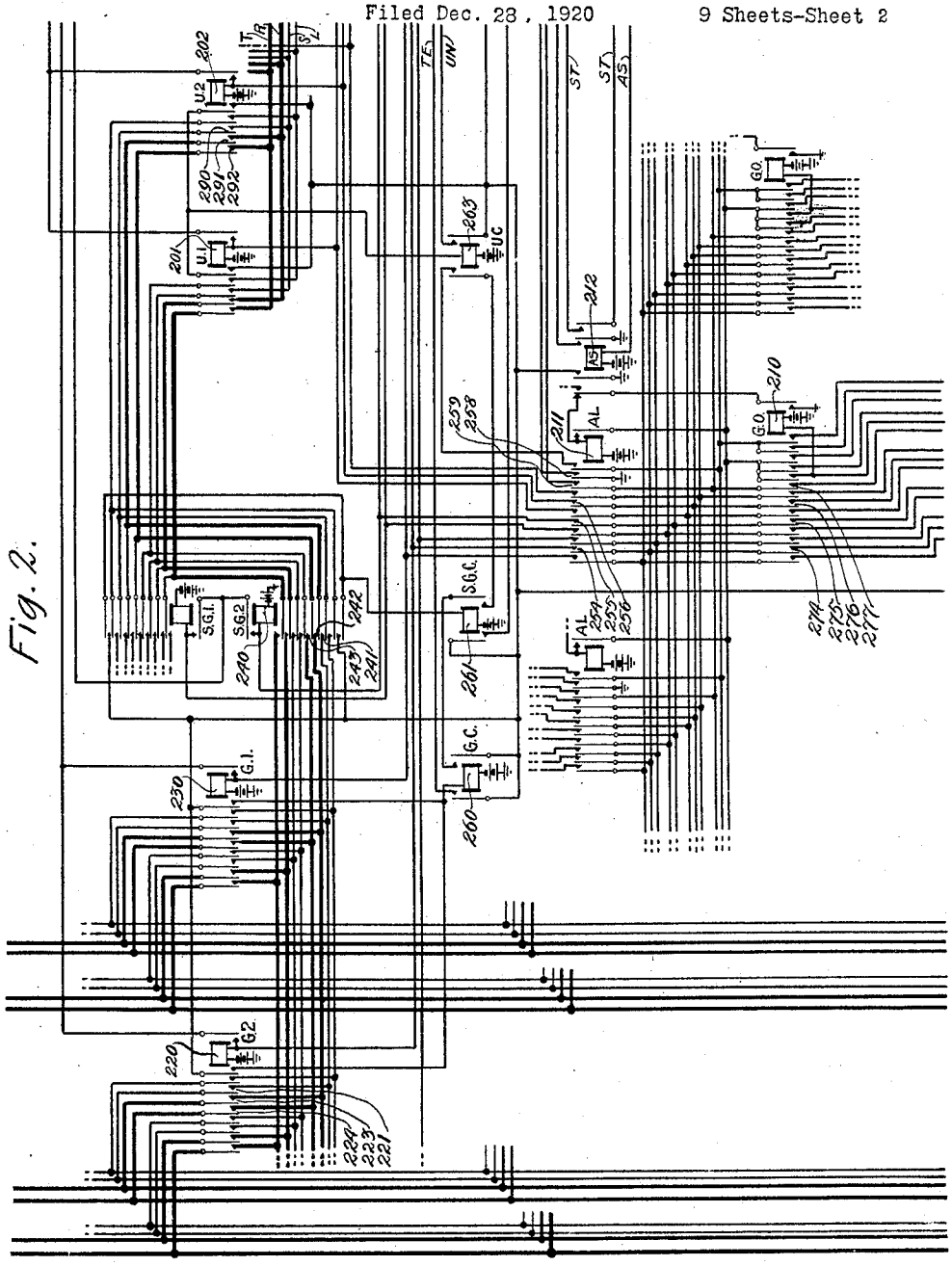


Fig. 2.

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TELEPHONE EXCHANGE SYSTEM

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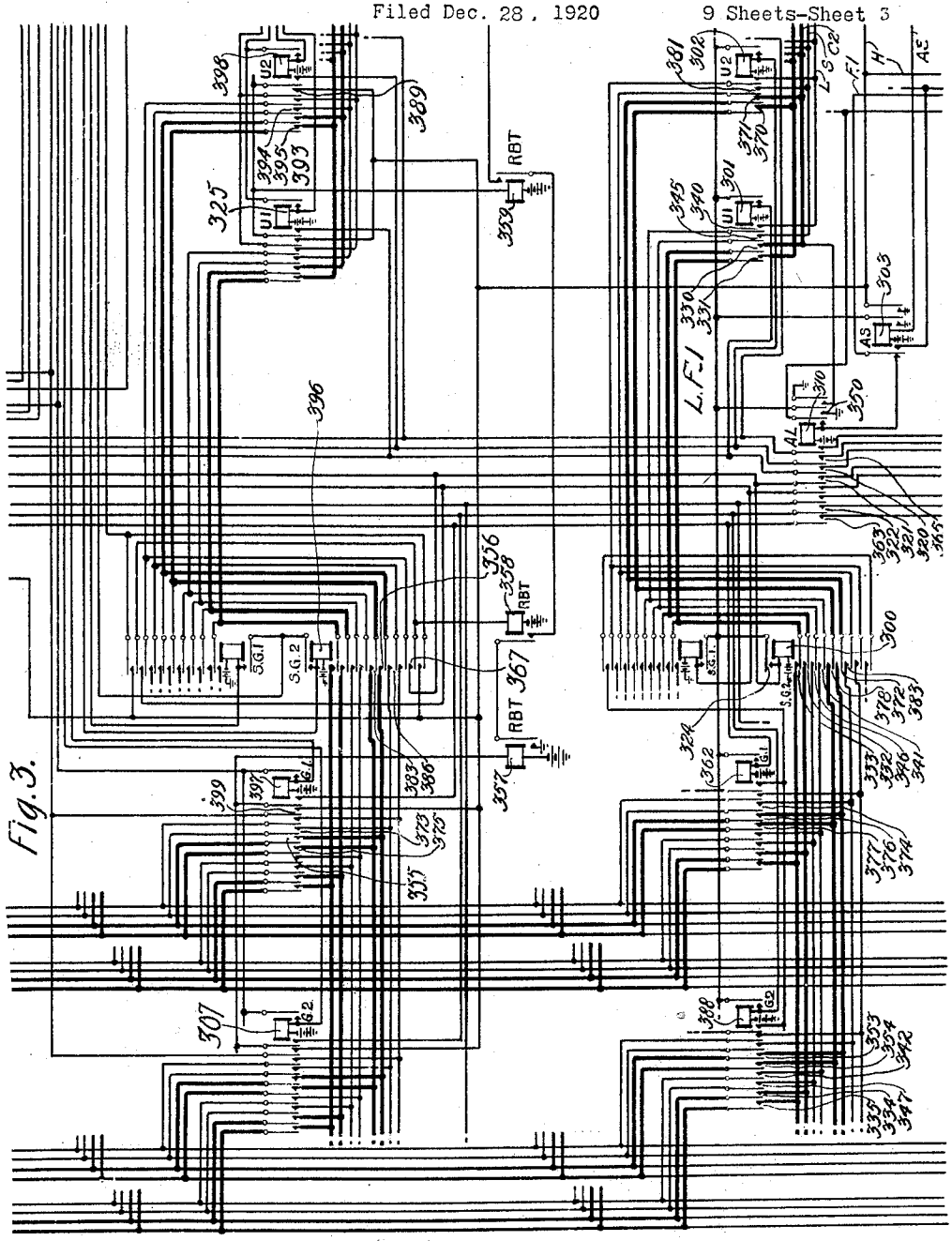


Fig. 3.

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TELEPHONE EXCHANGE SYSTEM

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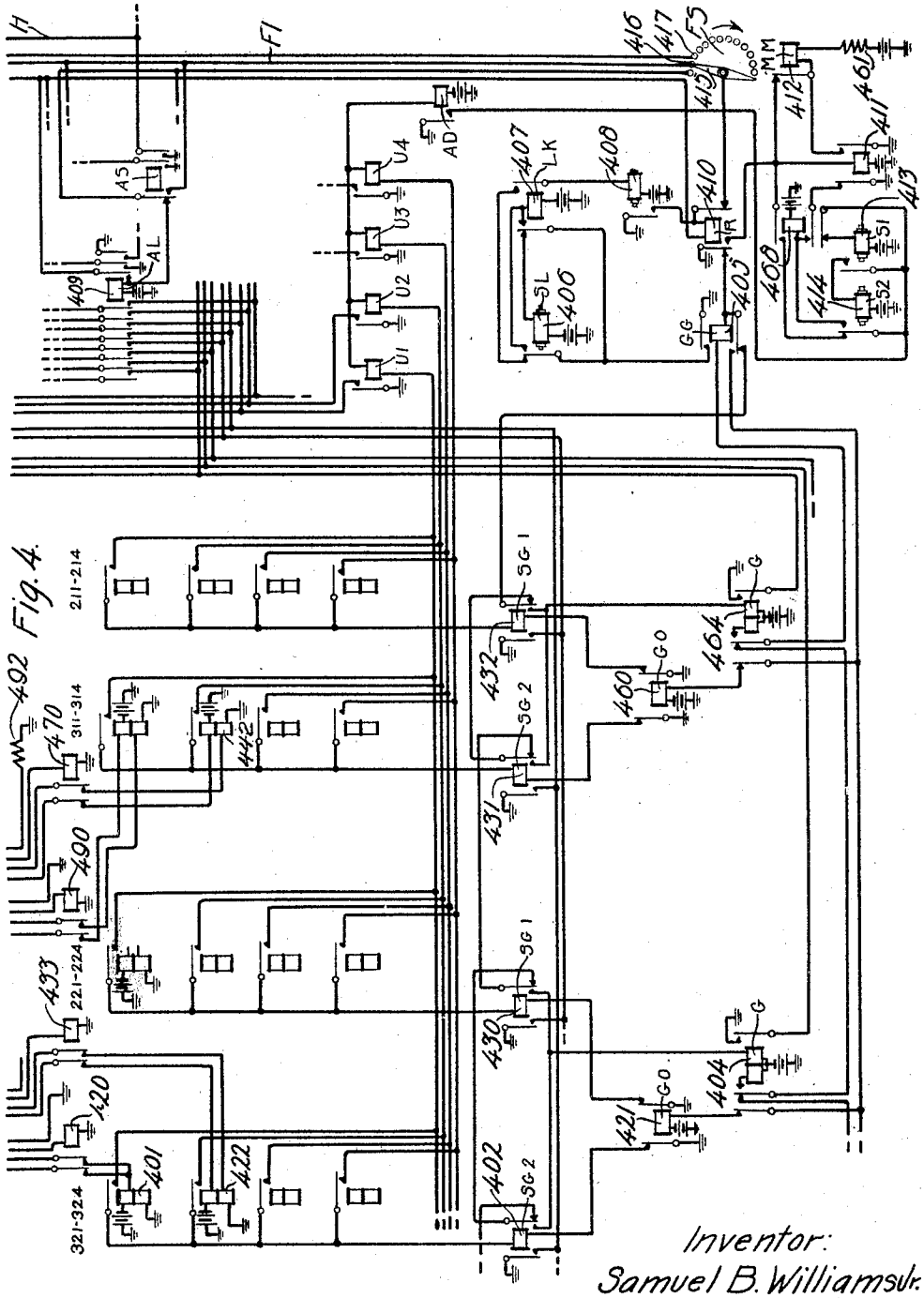


Fig. 4.

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TELEPHONE EXCHANGE SYSTEM

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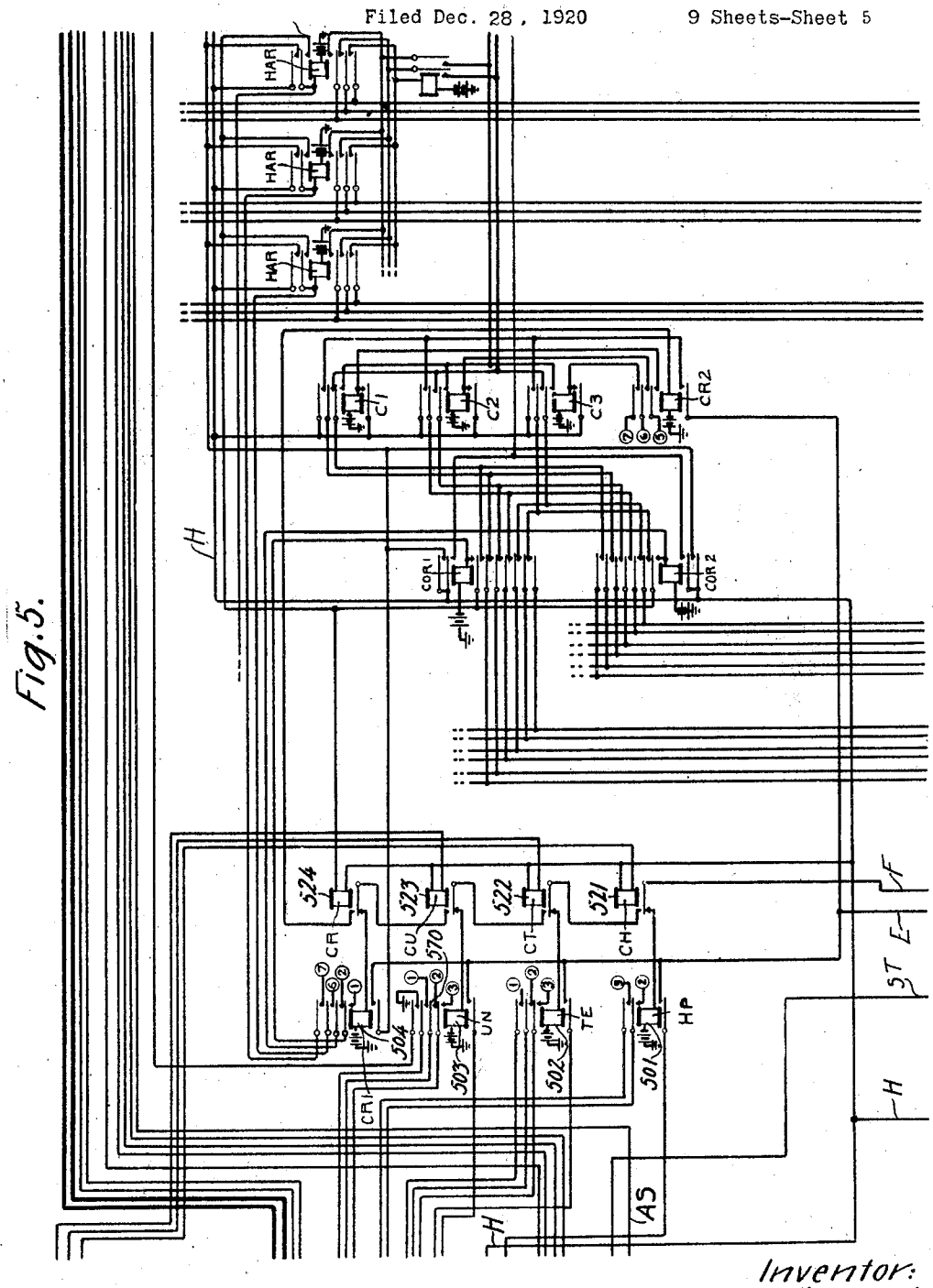


Fig. 5.

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TELEPHONE EXCHANGE SYSTEM

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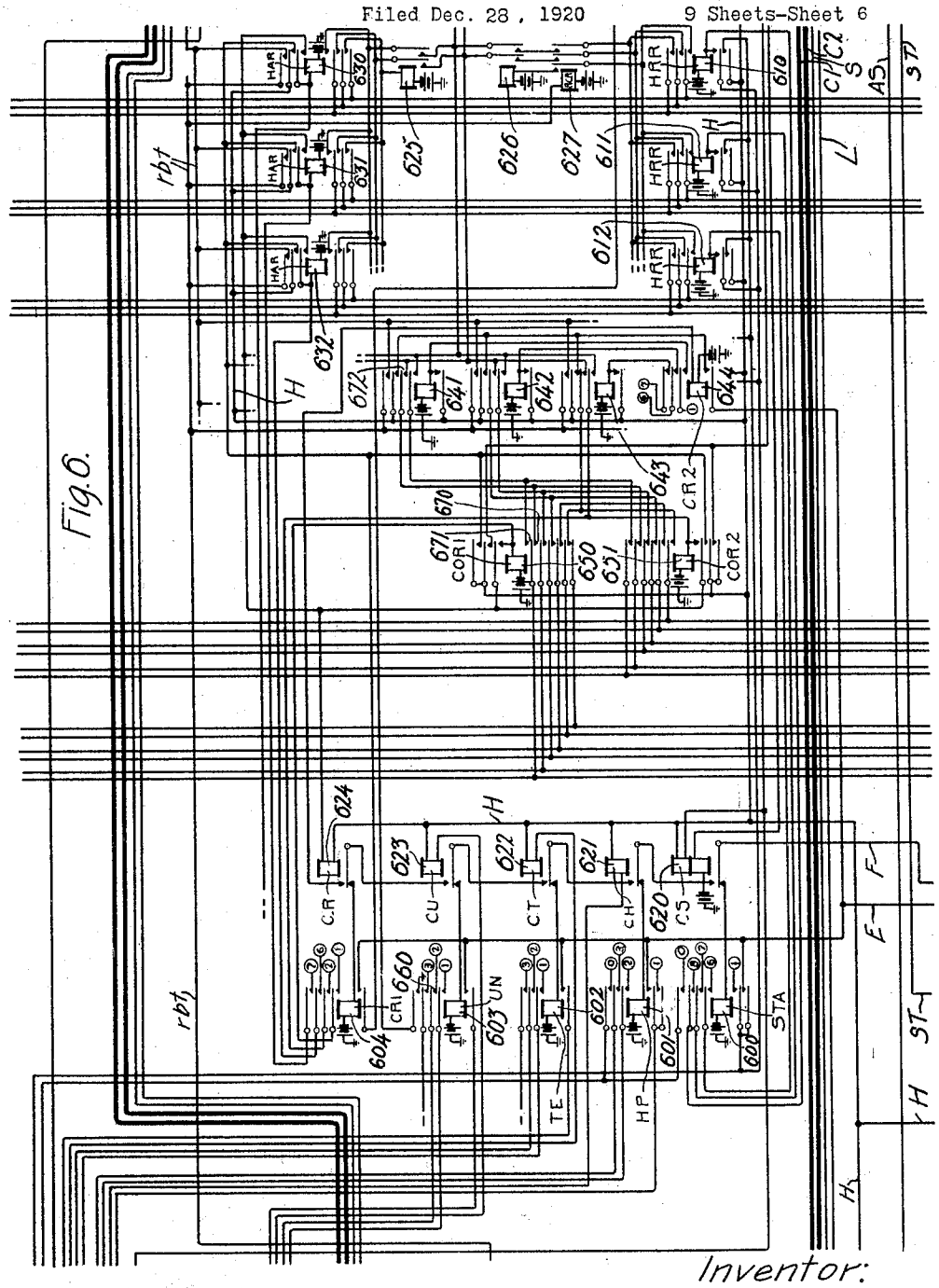


Fig. 6.

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TELEPHONE EXCHANGE SYSTEM

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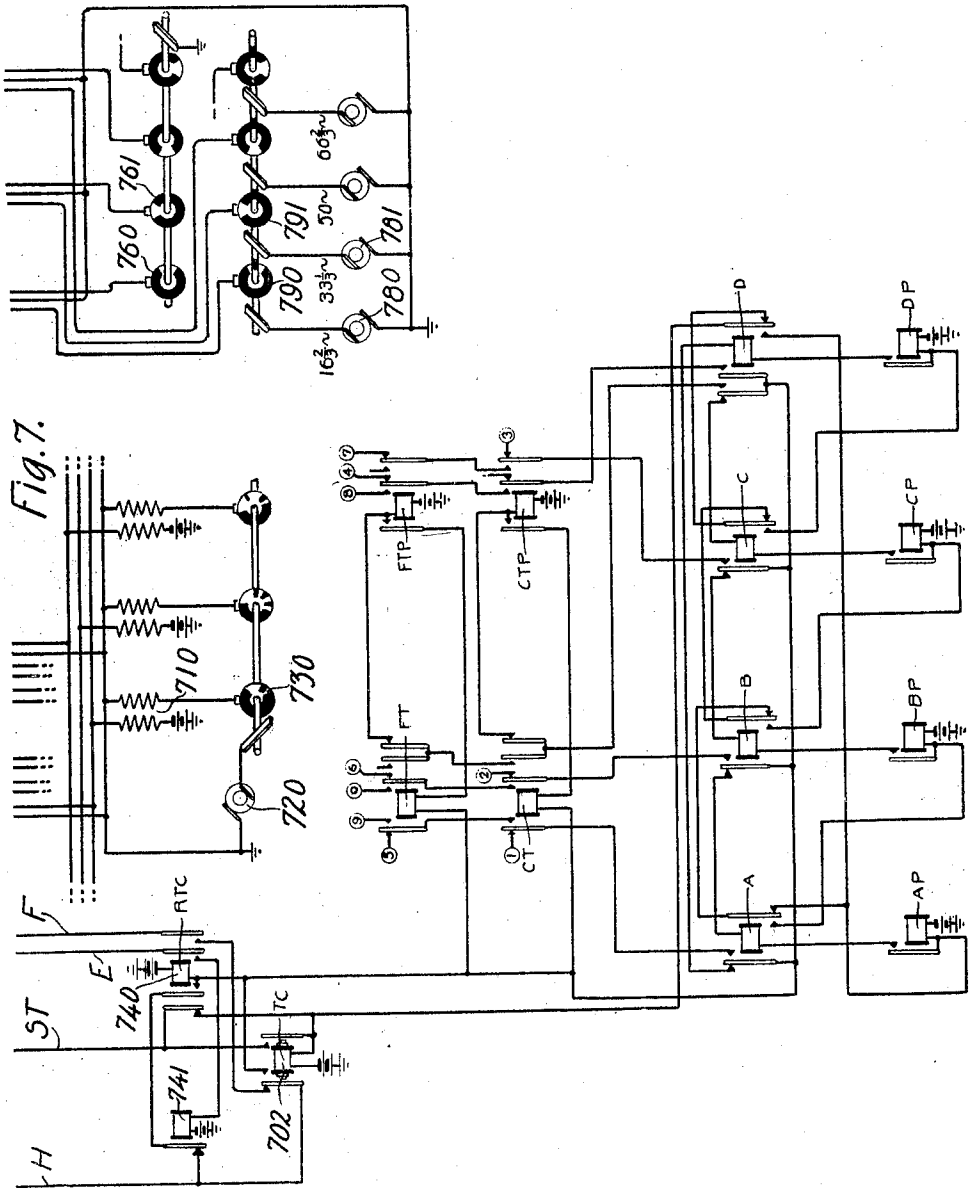


Fig. 7.

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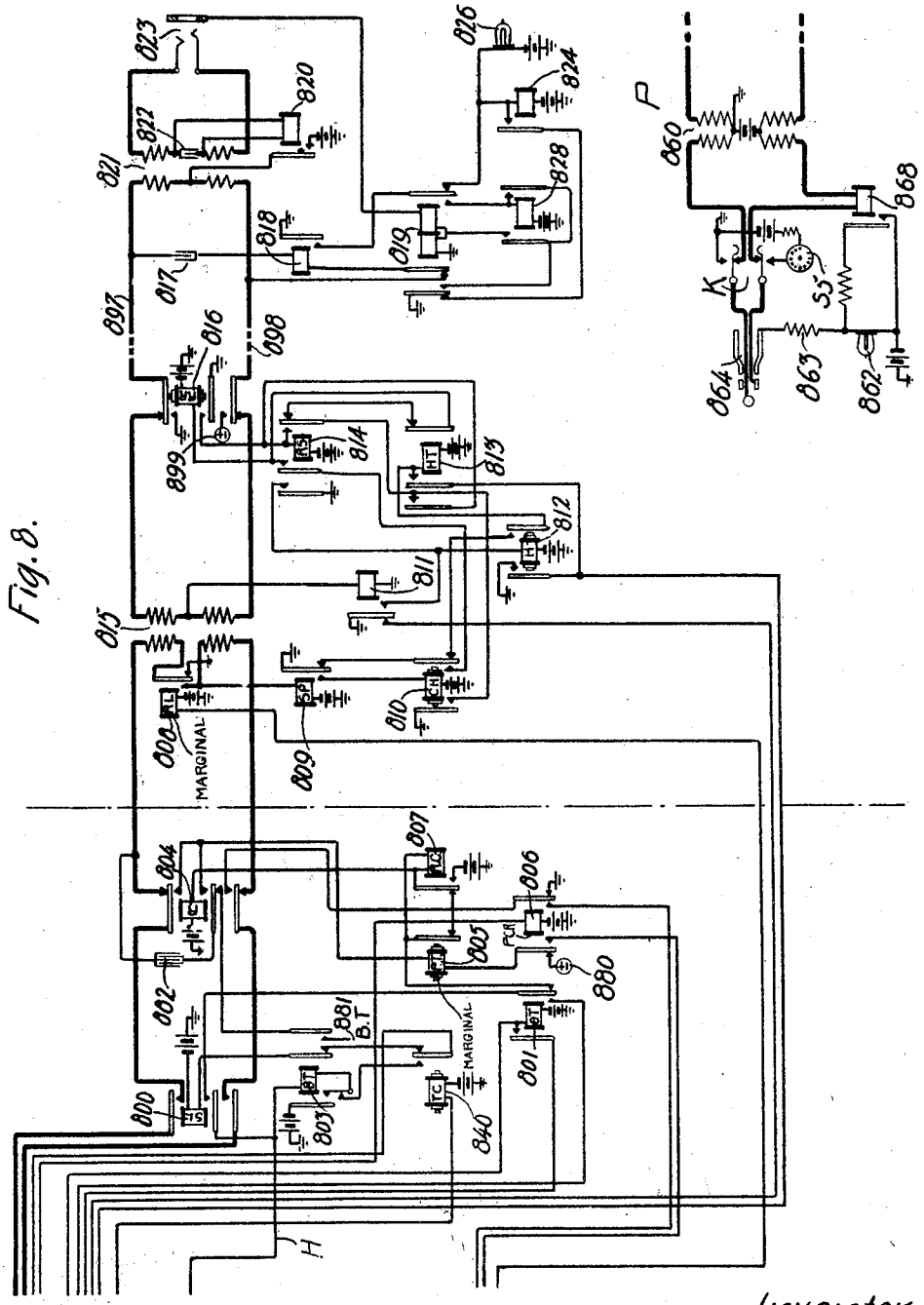


Fig. 8.

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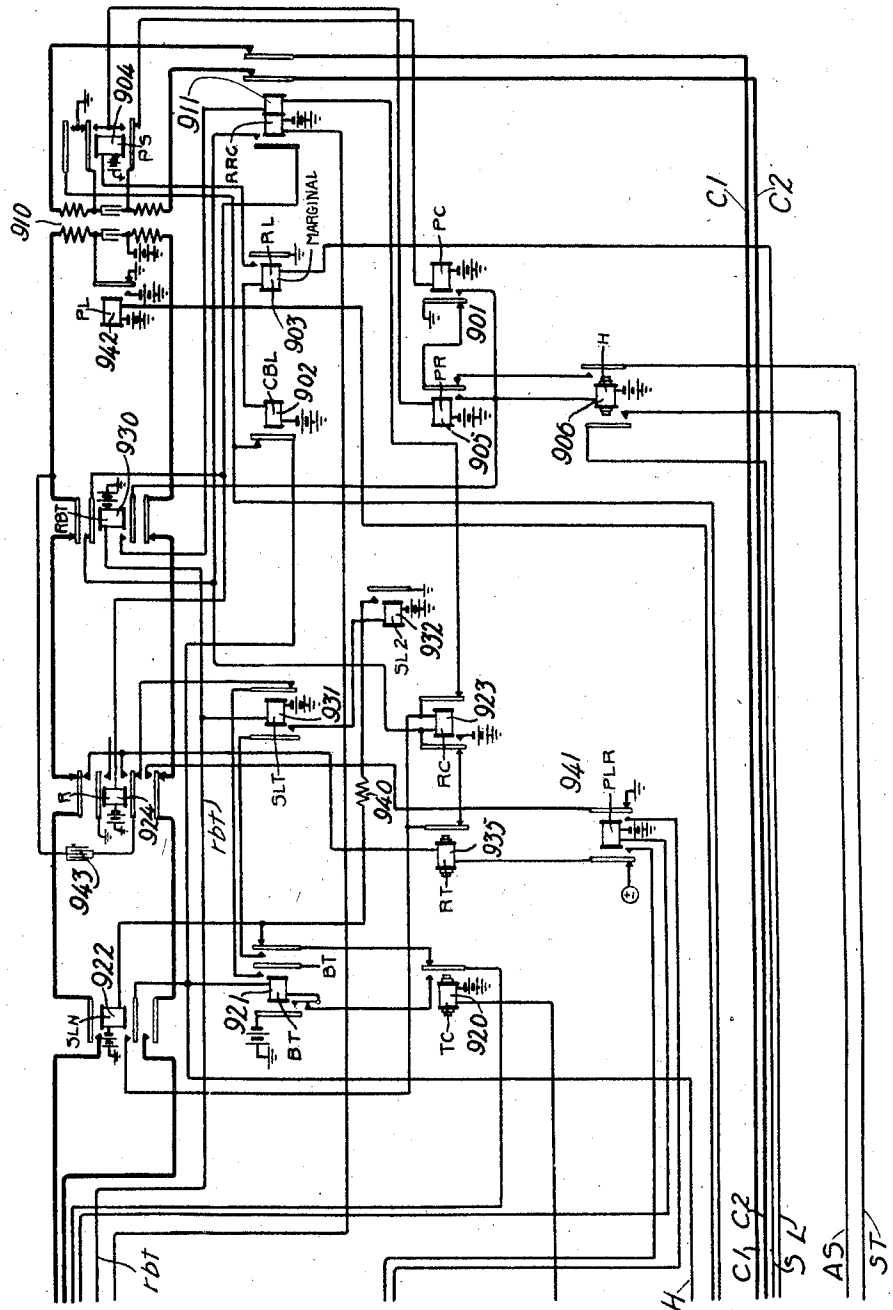
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TELEPHONE EXCHANGE SYSTEM

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Fig. 9.



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Patented Mar. 25, 1924. 1,487,996

UNITED STATES PATENT OFFICE.

SAMUEL B. WILLIAMS, JR., OF BROOKLYN, NEW YORK, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

TELEPHONE-EXCHANGE SYSTEM.

Application filed December 28, 1920. Serial No. 433,665.

To all whom it may concern:

Be it known that I, SAMUEL B. WILLIAMS, Jr., a citizen of the United States, residing at Brooklyn, in the county of Kings, State of New York, have invented certain new and useful Improvements in Telephone-Exchange Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone exchange systems and more particularly to such systems in which connections between lines are established under the control of subscribers.

One of the objects of the invention is to provide an improved automatic telephone system of the relay type.

Another object of the invention is to provide a system of this nature which will accommodate lines of various characters, such as individual lines, party lines, and rural lines.

Still another object of the invention is to provide in a full relay automatic telephone system, involving lines of different characters, a two-way trunk circuit, with means whereby connections may be established between subscribers of the system and an operator at a distant exchange.

To carry out the various objects, the invention contemplates dividing the lines terminating at an exchange into groups, lines of various characters, such as individual lines, party lines, and rural lines being grouped indiscriminately, that is any one group may contain individual lines only, rural lines only, or party lines only, or any number of either two or all three of the lines of different character. For interconnecting lines of the system relay line finders, link circuits, and relay connectors are employed. A subscriber in initiating a call causes a group, subgroup and units controlling relay to be actuated which causes one of the line finders to connect with the calling line and thereafter extend the calling line to the link circuit associated therewith. Associated with the link circuit is a variably operable impulse receiving device which responds to impulses received from the calling station and a variably operable impulse recording device which records the number of impulses transmitted. More specifically, in the present disclosure relays are employed in the impulse receiving and in the impulse recording device.

Another feature of the invention consists in providing a link circuit with switching mechanism for connecting one of a plurality of sources of ringing current thereto, the switching mechanism being controlled in various manners by the calling subscriber and the conditioning of the switching mechanism and the character of the ringing current being automatically determined by the character of the called line.

Another feature of the invention consists in the provision of a link circuit common to a plurality of lines of different character for extending a call from a relay line finder to a relay connector.

Another feature of the invention consists in providing a link circuit for interconnecting lines in an automatic telephone system, with revertive ringing apparatus within the link circuit itself, no special switches being necessary for handling revertive calls.

Another feature of the invention consists of the provision of means in a system of this nature whereby a link circuit adapts itself automatically for operation as a full metallic or simplex circuit, depending upon the character of the calling line.

Other features including other circuit details will be more apparent as the description progresses.

The drawings when placed in the manner indicated in Fig. 11 diagrammatically illustrate means for carrying out the invention. Figs. 1 to 4 inclusive and Figs. 6, 7 and 9 of the drawings when arranged as shown in Fig. 11 illustrate means for interconnecting lines terminating in the exchange and when arranged as shown in Fig. 11 except with a duplicate of Fig. 7 below Fig. 5, illustrate means for connecting lines of the exchange to an operator's position at a distant exchange or vice versa. Fig. 1 includes the circuit arrangement and apparatus for an individual line, a party line, and a rural line subscriber's station. Fig. 2 includes a trunk connector circuit. Fig. 3 includes a subscriber's line finder and a subscriber's connector circuit. Fig. 4 includes line relay equipment for the subscriber's station shown in Fig. 1, group, subgroup, and units controlling relays and an allotter circuit. Fig.

5 includes a trunk link circuit. Fig. 6 includes a portion of a subscriber's link circuit. Fig. 7 includes a set of a counting relays and ringing equipment for rural and party lines. Fig. 8 includes a trunk circuit extending from the relay automatic exchange to an operator's position at a distant exchange and a portion of an operator's cord circuit. Fig. 9 includes a portion of a subscriber's link circuit. Fig. 10 shows a number and lettering arrangement for an impulse sender or a dial which is contemplated for use in this system.

The system herein disclosed contemplates an exchange having a capacity of 200 lines although it is to be understood that the invention is not limited to a system of this capacity. The subscribers' lines in an exchange having a capacity of 200 lines may be divided into groups of twenty lines each, each group being divided into two subgroups of ten lines each. The invention is equally well adaptable for various other capacities, for example an exchange of one hundred lines may be divided into four groups of twenty five lines each, each group being divided into five sub-groups of five lines each or again, an exchange of three hundred and thirty six lines may be divided into twenty one groups of sixteen lines each, each group being divided into four subgroups of four lines each, etc. Lines of different character, such as individual lines, party lines, and rural lines may be arranged separately, in groups, or combined together in any manner desired in groups. As shown in Fig. 4 of the drawings each line has four conductors and the connections for each class of lines at the exchange is identical with the exception of connections of the fourth conductor. For individual lines the fourth conductor will be open at the exchange, for party lines the fourth conductor will have a resistance therein, and for rural lines the fourth conductor will be connected directly to ground. It is thus seen that a slight change in this fourth conductor at the exchange is all that is necessary to change subscriber's line from one class of service to another.

As herein disclosed each party line may have four stations thereon although it will be readily apparent to those skilled in the art that the system is adaptable for a greater number than this. Each rural line may have as many stations on the line as is desired. Although in the present disclosure means for ringing three of such stations only has been shown, it will be apparent that the system is readily adaptable for more than this number. It is thus seen that the system herein disclosed provides for 200 lines and a capacitv for as many stations as use is made of the lines. For interconnecting lines, relay line finders, relay link circuits, and relay connectors are employed, such apparatus being common to the different classes of lines.

In general the system functions as follows in the case of establishing a connection between two lines of the relay system. In response to the initiation of a call from a line, a group, a subgroup, and a units controlling relay are actuated which cause the actuation of a group, subgroup, and units relay in a preselected line finder, which in turn extends the calling line to a link circuit. For each link circuit there is provided a set of counting relays and impulse recording means which receives the impulses transmitted by the calling line and records them so that a group, a subgroup, and a units relay of the connector circuit corresponding to the number of the desired line are operated and connection is made with the desired line.

Associated with each link circuit are a plurality of sources of code ringing for ringing rural lines, a plurality of sources of different frequencies for ringing party lines, and means for ringing individual lines, together with switching mechanism comprising various relays which operate to connect ringing current to the lines. The relays which connect the ringing current to the lines are controlled in various manners by the calling subscriber, and the conditioning of the link circuit for the application of the ringing current to the line is determined by the character of the called line. For example, if an individual line is called alternating current is automatically applied to the individual line; if a party line is called, ringing current of a frequency corresponding to the line of the called station is applied to the line in response to the dialing of a letter corresponding to the particular party desired. It is to be noted, however, that the relay connector is associated with the called line before the ringing current is applied, and that no switch is actuated in response to the transmission of the number of impulses corresponding to the letter of the desired station but simply a relay or a set of relays actuated to connect the proper frequency with the called line.

A two-way trunk circuit is also provided by means of which calls may be made to or from any station of the exchange to a distant exchange. On outgoing calls from a station to a distant exchange the calling subscriber's line relay is actuated, which causes the operation of a particular group, subgroup, and units relay, which in operating cause the operation of relays in a relay line finder and the connection of the calling line with the link circuit. The calling subscriber then dials, causing ten impulses to be sent, in response to which the counting relays and impulse recording means cause

the relay connector to be actuated, whereupon a group, a subgroup, and a units relay therein, actuate to connect with the calling line. The line finder relays are thereupon disconnected from the calling line and the calling line is extended to the trunk circuit. Ringing current is then automatically applied to the trunk circuit extending to this exchange which causes the actuation of a signal at the distant exchange. The trunk circuit is automatically adapted for simplex or full metallic operation depending upon the character of the line at the exchange to or from which the call is extended.

On an incoming call from the distant exchange the operator at said distant exchange inserts the calling plug of one of her cord circuits into the jack of the trunk circuit and then proceeds to actuate her dial a number of times corresponding to the number desired at the relay automatic exchange. In response to the impulses transmitted over the trunk line, the set of counting relays and the impulse recording device shown in Figs. 5 and 7 of the drawings will be actuated to cause the operation of a set of trunk connecting relays, such as shown in Fig. 2, to extend the trunk to the line of the desired subscriber. If the station of an individual line is desired, alternating current will be automatically applied to the line of the desired subscriber. If a rural or a party line subscriber is desired the operator will actuate her impulse sender to send a set of impulses corresponding to the letter of the desired subscriber, whereupon either code ringing current or frequency ringing current will be applied to the line of the desired subscriber in a manner similar to that for a subscriber to subscriber connection. The trunk circuit is conditioned for the application of the proper source of ringing current thereto for signalling the called subscriber by an electromagnetic means which does or does not operate depending on the character of the called line.

Call from a party line station to a station on the same line.

Let it be assumed that station L of a party line 312 desires a connection with the station M on the same line. Upon the removal of the receiver 156 from the switchhook 158, line relay 442 individual to the calling line, is energized over a path extending from grounded battery, upper winding of relay 442, back contact and outer armature of cut-off relay 470, primary winding of induction coil 155, contacts 159, receiver switchhook 158, transmitter 154, contacts 151 of sender S1, inner armature and back contact of relay 470 and lower winding of relay 442 to ground. Subgroup relay 431, units relay U2 and relay AD thereupon energize over a path extending from ground, left-hand armature and back contact of relay 460, winding of relay 431, armature and front contact of relay 442, winding of relay U2 and winding of relay AD to grounded battery. Group relay 464 is thereupon energized over a path extending from ground, left-hand armature and back contact of relay 410, lower armature and back contact of relay 405, right-hand armature and back contact of relay 432, right-hand armature and front contact of relay 431 and right-hand winding of relay 464 to grounded battery. Relay 464 then completes a locking circuit for itself and an energizing circuit for relay 405 over a path extending from grounded battery, left-hand winding, front contact and inner left-hand armature of relay 464, winding of relay 405 and back contact and left-hand armature of relay 410 to ground. Relay 405 thereupon operates and completes a circuit for slow-to-release relay 406 over a path extending from ground, upper armature and front contact of relay 405, left-hand armature and back contact of relay 407 and winding of relay 406 to grounded battery. Relay 406 in operating completes a circuit for operating relay 407 over a path extending from grounded battery, winding of relay 407, front contact and armature of relay 406 and front contact and upper armature of relay 405 to ground. Relay 407, in attracting its left-hand armature, opens the energizing circuit for slow-to-release relay 406 whereupon said relay 406 releases. As soon as relay 406 retracts its armature a circuit is completed for slow-to-release starting relay 408 over a path extending from ground, upper armature and front contact of relay 405, armature and back contact of relay 406, front contact and right-hand armature of relay 407 and winding of relay 408 to grounded battery. The purpose of slow-to-release relay 406 and relay 407 is to delay the operation of the starting relay 408 in the event that two calls come in at the same time, thereby providing a time interval during which the group and sub-group relays, of those group circuits, which have not obtained connections with the starting circuit, can fully release and thus insure that their contacts will be opened, and that but one group circuit is connected to the starting circuit at that time.

When the starting relay 408 operates, ground is extended through the armature and front contact of relay 408, right-hand armature and back contact of relay 410, brush 415 and contact 416 of switch FS, conductor F1, left-hand armature and back contact of relay 303 and winding of allotter relay 310 to grounded battery.

Switch FS is of that type in which no normal position is provided. Hence its brush rests on the contact to which it was last

moved. In the present case it is shown as resting on its second contact leading to line finder LF1 which is the second line finder of the series, the first one being that indicated in connection with the relay 409 corresponding to relay 310 of LF1.

Relay 310 operates after being energized in the above described circuit and locks up in the following circuits; from grounded battery, winding of relay 310, front contact and innermost right-hand armature of relay 310 winding of relay 410, front contact and armature of relay 408 to ground. Relay 410 does not operate at this time as it is short circuited by the original energizing ground connection for relay 310. Allotter relay 310 in operating indicates that line finder LF1 has been allotted and the circuits of the group, sub-group and units relays of this line finder are closed to the starting circuit. Group relay 362 of the line finder LF1 is operated over a path extending from grounded battery, winding of relay 362, contacts 363 of relay 310, and right-hand armature and front contact of group relay 464 to ground. Sub-group relay 300 of the line finder LF1 is operated over a path extending from grounded battery, winding of relay 300, contacts 321 of relay 310, front contact and left-hand armature of sub-group relay 431 to ground. Units relay 302 of the line finder LF1 is operated over a path extending from grounded battery, winding of relay 302, contacts 365 of relay 310, and front contact and armature of relay U2 to ground. Group relay 362, sub-group relay 300 and units relay 302 are thereupon locked up in parallel to ground at the contacts 350 of relay 310.

The line of the calling station is thereby extended through to the link circuit. Relay 901 of the link circuit is then operated over a path extending from grounded battery, winding of relay 901, back contact and lower armature of relay 904, lower right-hand winding of repeating coil 910, back contact and inner right-hand armature of relay 911, conductor C2, contacts 371 of relay 302, contacts 372 of relay 300, contacts 376 of relay 362, contacts 151 of impulse sender S1, transmitter 154, switchhook 158, contacts 159, primary winding of induction coil 155, contacts 377 of relay 362, contacts 378 of relay 300, contacts 370 of relay 302, conductor C1, outer right-hand armature and back contact of relay 911, upper right-hand winding of repeating coil 910, upper inner armature and back contact of relay 904 to ground.

The line of the calling party has a resistance 492 connected in the fourth conductor and relay 903 of the link circuit is therefore not operated, since the resistance is of such a value as to prevent the operation of this relay when the calling line is extended through to the link circuit. Relay 902, however, not being marginal as is relay 903 does operate, being energized in a circuit extending from ground resistance 492 innermost left-hand armature and front contact of relay 362, next to the lowermost armature and contact of relay 300, innermost left-hand armature and front contact of relay 302, conductor L; winding of relay 903, winding of relay 902 to battery and ground. The operation of relay 902 removes a ground connection from the lower winding of relay 620 whereby the first set of impulses is effective to energize the STA relay as will hereinafter appear. Impulse relay 901 in operating completes a circuit for slow-to-release relay 906 over a path extending from ground, armature and front contact of relay 901 and winding of relay 906 to grounded battery. Slow-to-release relay 906 thereupon operates and completes a circuit for the energization of the cut-off relay 470 of the calling line and relay 303 of the line finder LF1 over a path extending from ground, winding of cut-off relay 470, contacts 374 of group relay 362, contacts 383 of sub-group relay 300, contacts 381 of units relay 302, conductor S, left-hand armature and front contact of slow-to-release relay 906, conductor AS, and winding of relay 303 to grounded battery. Cut-off relay 470 in attracting its armatures disconnects the line relay 442 from the calling line thereby releasing the line relay 442, sub-group relay 431, units relay U2 and relay AD. Relay 303 in attracting its left-hand armature opens the starting circuit to the allotter relay 310.

Opening of the starting circuit at the left-hand armature and back contact of relay 303 removes the short-circuit from relay 410 whereupon relay 410 operates, and relay 310 is held energized in series with the winding of relay 410. As soon as relay 303 operates, the starting wire although open at the back contact of relay 410 is extended to the next allotter relay (not shown) thereby preventing two finders from making connection with the calling line and insuring that another finder circuit is ready for selection. As soon as relay 410 operates it opens the holding circuit for relays 405 and 464. Relay 405 in retracting its upper armature opens the circuit for relay 407 causing the release of said relay 407 whereupon the circuit for slow-to-release relay 408 is opened. Relay 408 being of the slow-to-release type does not retract its armature until a short interval after its energizing circuit is interrupted thereby giving sufficient time for the release of all relays of the group and starting circuits, and at the same time holding the allotter relay of the finder circuit busy. When relay 410 operates, a circuit is closed for the operation of the stepping magnet

412 over a path extending from ground, left-hand armature and front contact of relay 410, back contact, armature and winding of magnet 412, resistance 461 to grounded battery. Relay 411 is energized in parallel with stepping magnet 412 and in attracting its right hand armature places ground on the winding of stepping magnet 412 to insure a complete step of the brush 415 controlled by the magnet.

The action of the time-interval relays should be noted at this point. When the line relay first is energized, it causes the energization of relays 431, 464, U2 and AD. Thereupon a circuit is closed from ground, the armature and front contact of relay AD, lowermost armature and back contact of relay 468, winding of relay 413 to battery and ground. Relay 413 closes a circuit through its armature and front contact for the energization of relay 414, which in turn closes a similar circuit through its armature and front contact for the energization of relay 468. Relay 468 locks up through its innermost lower armature and front contact to the ground at the back contact and left-hand armature of relay 411. The movement of the armatures of relay 468 opens the energizing circuit of relay 413. In a short interval, relay 413 becomes deenergized, whereupon the energizing circuit for relay 414 is opened and after another short interval relay 414 deenergizes. In the mean time, however, and under normal operating conditions, relay AD will have become deenergized since immediately upon the energization of relays 431, 464 and U2, the calling line is connected to the link circuit and relay 906 is energized causing, as hereinbefore described the energization of the cut-off relay 470. The energization of the cut-off relay in turn causes the deenergization of those relays controlled by the line relay and therefore relay AD becomes deenergized. Also the original energizing circuit for relay 310 is opened at this time, due to the energization of relay 303 by relay 906, whereupon relay 410 becomes energized as hereinbefore described. Simultaneously with the energization of relay 410, the energizing circuit of relay 408 is opened but relay 408, being slow to release, maintains the circuit for relay 410 closed for a short time-interval. During this time interval, relay 411 is energized, whereupon the magnet 412 is energized so that the brush 415 will be moved onto its next contact and the locking circuit for relay 468 is opened by the movement of the armatures of relay 411.

If there is any delay in the operation of the allotter relay 310 then an automatic operation of the brush 415 will take place. Suppose for instance, there had been a dirty contact between the brush 415 and its contact 416, then upon the energization of relay 408 none of the group, sub-group or units relays such as 362, 300, and 302 would have been energized because relay 310 could not be energized and the line circuit would not have been extended to the link circuit. The relays 413, 414 and 468 would thereupon go through the actions described, but relay 468 would not become deenergized due to the breaking of its locking circuit by relay 411. On the other hand relay AD would have remained energized for much longer period than usual; hence upon the deenergization of relay 414, a circuit is established from the ground on the armature and front contact of relay AD, the armature and back contact of relay 414, the front contact and upper armature of relay 468, the back contact and armature of magnet 412, winding of magnet 412, resistance 461 to battery and ground. The brush 415 will then be moved to its next contact 417. In parallel with the winding of magnet 412, relay 411 will be energized, thereby breaking the locking circuit of relay 468 and opening the circuits of magnet 412 and relay 411. Thereupon relay 413 will become energized again and unless the allotter relay for the next finder is operated as hereinbefore described, this same action will take place resulting in the further movement of brush 415.

Under the control of the impulse sender S1 at the station of the calling subscriber, the impulse relay 901 of the link circuit will be actuated a number of times to cause the extension of the line of the calling subscriber to the line of the called subscriber. As hereinbefore stated, when a station on a party line calls another station on the same line, the calling subscriber first dials the suffix of his station and then dials the number of the desired station. It having been assumed that the party L of the party line desires connection with a party M on the same line, he will, as will be noted by referring to Fig. 10 of the drawings, first dial the letter L, causing six impulses to be transmitted to the impulse relay 901 of the link circuit. The calling party will then dial the digits 3, 1 and 2 and thereafter the letter, M. In dialing the letter M it will be noted, by referring to Fig. 10 of the drawing, that seven impulses will be transmitted to the impulse relay 901.

It should be noted at this point that the impulse senders S, S1 and S2 are arranged to send "impulses" which are, as a matter of fact, interruptions of the circuit rather than impulses. However, those skilled in the art commonly speak of a series of interruptions in this type of circuit as a series of impulses, and since this is now common practice, this terminology will be maintained throughout this specification.

Hereinafter when an impulse or a series or train of impulses is spoken of as being sent from a supstation dial it will be understood that an interruption of the circuit of very short time duration is meant.

In response to the first impulse of the first series transmitted to the impulse relay 901, relay 702 and counting relay AP will be energized over a path extending from ground, armature and back contact of relay 901, armature and back contact of relay 905, front contact and right-hand armature of relay 906, conductor ST, outer left-hand armature and back contact of relay 740, and thence in parallel, one path extending through the winding of relay 702 to grounded battery, and the other path extending through the right-hand armature and back contacts of relays D, C, B, and A and the winding of relay AP to grounded battery. Relay 702 in operating completes a circuit for the energization of relay 740 over a path extending from grounded battery, winding of relay 740, front contact and left-hand armature of relay 702, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 740 in operating locks up through its front contact and inner left-hand armature, the armature and back contact of relay 741 to ground on the holding conductor H. The impulse circuit over the conductor ST is now closed through the front contact and right-hand armature of relay 702 and opened at the outer left-hand armature and back contact of relay 740. Relay AP in operating prepares a circuit for the operation of relay A over a path extending from grounded battery, winding, armature and front contact of relay AP, winding of relay A, back contact and left-hand armature of relay B, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay A will not operate over this circuit, however, until the impulse relay 901 attracts its armature at the end of the first impulse. As soon as the first impulse is completed and relay 901 attracts its armature, relay A operates due to the momentary removal of ground from conductor ST, thereby connecting the counting relay BP in circuit with the conductor ST. In response to the second impulse transmitted to the impulse relay 901, counting relay BP is energized over a path extending from ground, armature and back contact of relay 901, armature and back contact of relay 905, front contact and right-hand armature of relay 906, conductor ST, front contact and right-hand armature of relay 702, right-hand contacts of relays D, C, B, and right-hand armature and front contact of relay A through the winding of relay BP to grounded battery. Relay BP in operating prepares a circuit for the counting relay B over a path extending from grounded battery, winding, armature and front contact of relay BP, winding of relay B, back contact and left-hand armature of relay C, front contact and inner left-hand armature of relay 740, and armature and back contact of relay 741 to ground on conductor H. As soon as relay 901 attracts its armature at the end of the second impulse, relay B operates and relays BP and B lock up over a path extending from grounded battery, winding, armature and front contact of relay BP, winding of relay B, back contact and left-hand armature of relay C, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay B in operating opens the locking circuit for relays AP and A, whereupon they release.

At the third interruption of the line circuit, counting relay CP will be operated over a path extending from ground, armature and back contact of relay 901, armature and back contact of relay 905, front contact and right-hand armature of relay 906, conductor ST, front contact and right-hand armature of relay 702, through the right-hand contacts of relays D and C, right-hand armature and front contact of relay B, and winding of relay CP to grounded battery. Relay CP in operating prepares a circuit for the energization of relay C over a path extending from grounded battery, winding armature and front contact of relay CP, winding of relay C, back contact and outer left-hand armature of relay D, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. As soon as relay 901 attracts its armature at the end of the third impulse, relay C energizes, whereupon relays CP and C lock up over a path extending from grounded battery, winding of relay CP, armature and front contact of relay CP winding of relay C, back contact and outer left-hand armature of relay D, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay C in operating opens the locking circuit for relays B and BP, whereupon said relays release.

At the fourth interruption of the relay 901, counting relay DP is energized over a path extending from ground, armature and back contact of relay 901, armature and back contact of relay 905, front contact and right-hand armature of relay 906, conductor ST, front contact and right-hand armature of relay 702, right-hand armature and back contact of relay D, right-hand armature and front contact of relay C, and winding of relay DP to grounded battery. Relay DP thereupon operates and prepares a cir-

cuit for the energization of relay D over a path extending from grounded battery, winding, armature and front contact of relay DP, winding of relay D, back contact and left-hand armature of relay A, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay D will not operate until relay 901 attracts its armature at the end of the fourth impulse. As soon as relay 901 attracts its armature, relay D operates and relays DP and D lock up over a path extending from grounded battery, winding, armature and front contact of relay DP, winding of relay D, back contact and left-hand armature of relay A, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay D in operating interrupts the locking circuit for relays C and CP, whereupon said relays release. As soon as relay D operates, relay CTP will be operated over a path extending from grounded battery, winding of relay CTP, back contact and outer right-hand armature of relay CT, front contact and outer left-hand armature of relay D, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay CTP in operating locks up in series with relay CT.

In response to the fifth interruption of the line circuit, relay AP will be operated over a path extending from ground, armatures and back contacts of relays 901 and 905, front contact and right-hand armature of relay 906, conductor ST, front contact and right-hand armature of relay 702, right-hand armature and front contact of relay D, and winding of relay AP to grounded battery. Relay AP in operating prepares a circuit for relay A over a path extending from grounded battery, winding, armature and front contact of relay AP, winding of relay A, back contact and left-hand armature of relay B, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. When relay 901 attracts its armature at the end of the fifth interruption of the line circuit, relay A operates. Relays AP and A then lock up over a path previously traced. Relay A in operating interrupts the locking circuit for relays DP and D. When relay D releases, the shunt around the winding of relay CT is removed and this relay becomes energized in the locking circuit of relay CTP.

At the sixth interruption of the line circuit, relay BP is operated over a path extending from ground, armature and back contact of relay 901, armature and back contact of relay 905, front contact and right-hand armature of relay 906, conductor ST front contact and right-hand armature of relay 702, right-hand armature and back contact of relay D, right-hand armature and back contact of relay C, right-hand armature and back contact of relay B, right-hand armature and front contact of relay A, and winding of relay BP to grounded battery. Relay BP in operating prepares a circuit for the operation of relay B over a path previously traced. When the relay 901 attracts its armature at the end of the sixth impulse, relay B operates and relays BP and B thereupon lock up over a path previously traced. Relay B in attracting its armature opens the holding circuit for relays A and AP whereupon said relays release.

A short interval after the end of the sixth interruption of the line circuit, slow-to-release relay 702 retracts its armature, thereby completing a circuit for relay 600 over a path extending from ground, front contact and outer right-hand armature of relay 303, conductor H, left-hand armature and back contact of relay 702, front contact and outer right-hand armature of relay 740, conductor F, lower armature and back contact of relay 620, and winding of relay 600 to grounded battery. The contacts of the counting relays FT, CT, FTP and CTP, shown in Fig. 7 of the drawings, are connected with the relays 600 to 604 inclusive, and 644, shown in Fig. 6 of the drawings, as indicated by the similar numbers.

As soon as relay 600 operates, the ringing relay 612 is energized over a path extending from grounded battery, winding of relay 612, upper inner armature and front contact of relay 600, and thence by a connection, (not shown), to the back contact and inner right-hand armature of counting relay FT, front contact and inner right-hand armature of relay CT, front contact and inner left-hand armature of relay B, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay 612 in operating locks up in series with relay 620, over a path extending from grounded battery, winding and front contact and lower inner armature of relay 612, upper winding of relay 620 to ground on conductor H. Relay 612 in operating completes a circuit for the operation of relay 741 over a path extending from ground on conductor H, lower outer armature and front contact of relay 612, lower outer armature and front contact of relay 600, conductor E, inner right-hand armature and front contact of relay 740, and winding of relay 741 to grounded battery. Relay 741 in operating opens the holding circuit for relay 740 and all of the operated counting relays. Relay 741 releases when relay 740 releases.

The counting relays are now ready for the reception of the next series of impulses. In

response to the dialing of the digit 3 impulse relay 901 will be deenergized three times. At the first deenergization of relay 901 slow-to-release relay 702 and counting relay AP will be energized in a manner herebefore described. Relay 702 in operating causes the operation of relay 740, which locks to ground conductor H. When the relay 901 attracts its armature at the end of the first interruption, counting relay A operates, whereupon relays AP and A lock up to ground on conductor H. At the second interruption of the line circuit, relay 901 in retracting its armature, completes an energizing circuit for relay BP. Relay BP in operating prepares a circuit for the energization of counting relay B. When relay 901 attracts its armature at the end of the second interruption of the line circuit, relay B operates and relays BP and B then lock up in series to ground on conductor H. Relay B in operating opens the locking circuit for relays AP and A, whereupon said relays release. At the third interruption of the line circuit relay 901 in retracting its armature completes a circuit for the operation of relay CP. Relay CP in operating prepares a circuit for the energization of relay C. When relay 901 attracts its armature at the end of the third interruption of the line circuit, relay C operates, whereupon relays CP and C lock up in series to ground on conductor H. Relay C in operating releases relays BP and B.

After the third impulse has been delivered to the impulse relay 901, the line circuit will be closed for a relatively long interval, whereupon slow-to-release relay 702 will release, thereby completing a circuit for the energization of relay 601 over a path extending from ground, front contact and outer right-hand armature of relay 303, conductor H, left-hand armature and back contact of relay 702, front contact and outer right-hand armature of relay 740, conductor F, armature and front contact of relay 620, armature and back contact of relay 621, and winding of relay 601 to grounded battery.

Relay 601 thereupon operates and completes a circuit for the sub-group connecting relay 396 over a path extending from grounded battery, winding of relay 396, upper intermediate armature and front contact of relay 601, and thence by a connection, (not shown), to the like numbered contact of counting relay CTP, front contact and left-hand armature of relay C, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 396 in operating locks up over a path extending from grounded battery, winding, front contact and upper armature of relay 396, winding of relay 621 to ground on conductor H. Relay 621 is energized and locked up in the circuit just traced, thereby transferring the conductor F to the tens relay 602. Relay 396 in operating completes a circuit for reverting busy test relay 358 over a path extending from grounded battery winding of relay 358, contacts 367 of relay 396, upper contacts of relay 300 and contacts 350 of relay 310 to ground. Relay 601 in operating also completes a circuit for the energization of relay 741 over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower inner armature of relay 601, lowermost contacts of relay 396, and outer right-hand armature and front contact of relay 303 to ground. Relay 741 in operating opens the holding circuit for relay 740, which releases thereby opening the holding circuits for the counting relays C and CP, which in turn release. Relay 740 in deenergizing releases relay 741.

In response to the next interruption of the line circuit in dialing the digit 1, relay 901 retracts its armature and completes a circuit for slow-to-release relay 702 and counting relay AP. Relay 702 in operating completes a circuit for the operation of relay 740, which locks up to ground on conductor H. Relay AP in operating prepares a circuit for the operation of relay A. When relay 901 attracts its armature at the end of the impulse, counting relay A operates, whereupon relays AP and A lock up in series to ground on conductor H. At the end of the transmission of this impulse, the line circuit is closed for a relatively long interval of time, whereupon slow-to-release relay 702 releases, thereby completing a circuit for the energization of tens relay 602 over a path extending from grounded battery, winding of relay 602, back contact and lower armature of relay 622, front contacts and armatures of relays 621, and 620, conductor F, outer right-hand armature and front contact of relay 740, back contact and left-hand armature of relay 702, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 602 in operating completes a circuit for the group connecting relay 397 over a path extending from grounded battery, winding of relay 397, upper inner armature and front contact of relay 602, and thence over a connection, not shown, to a like numbered contact of counting relay CT, front contact and left-hand armature of counting relay A, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, conductor H, outer right-hand armature and front contact of relay 303 to ground. Relay 397 in operating locks up over a path extend-

ing from grounded battery, winding, front contact and right-hand armature of relay 397, winding of relay 622 to ground on conductor H. Relay 622 energizes and locks up in series with relay 397 over the circuit just traced. Relay 397 in operating completes a circuit for reverting busy test relay 357 said circuit including contacts of relay 397, 362 and 310. Relay 602 in operating also completes a circuit for the energization of relay 741 over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower armature of relay 602, contacts 399 of relay 397, and outer right-hand armature and front contact of relay 303 to ground. Relay 741 thereupon operates and in attracting its armature opens the locking circuit for relay 740, which thereupon releases. Relay 740 in releasing opens the operating circuit for relay 741 and the holding circuit for counting relays A and AP, whereupon said relays 741, A and AP release and the counting relay circuit is then ready for the reception of the next series of impulses.

At the first interruption of the line circuit in response to the transmission of the units impulse to the impulse relay 901, slow-to-release relay 702 and relay AP are energized. Relay 702 in operating completes a circuit for the energization of relay 740 which operates and locks up to ground on conductor H. Relay AP in operating prepares a circuit for counting relay A. When relay 901 attracts its armature at the end of the first impulse, of this series, relay A operates, whereupon relays AP and A lock up through the front contact and inner left-hand armature of relay 740 and armature and back contact of relay 741 to ground on conductor H. In response to the second impulse of this series of impulses, relay BP operates over a path previously traced and prepares a circuit for the energization of counting relay B. When relay 901 attracts its armature at the end of the second impulse of the units series of impulses, relay B operates whereupon relays BP and B lock up over a path previously traced to ground on conductor H. Relay B in operating opens the locking circuit for relays AP and A whereupon said relays A and AP release.

After the units impulses have been transmitted, the line circuit will be closed, for a relatively long interval of time, whereupon slow-to-release relay 702 releases thereby causing the energization of units relay 603 over a path extending from grounded battery, winding of relay 603, back contact and armature of relay 623, front contacts and armatures of relays 622, 621, and 620, conductor F, outer right-hand armature and front contact of relay 740, back contact and left-hand armature of relay 702, conductor H, and outer right-hand armature and front contact of relay 303 to ground.

Units relay 303 in operating completes a circuit for units connecting relay 398 over a path extending from grounded battery, winding of relay 398, contacts 660 of relay 603, and thence over a connection, not shown, to a like numbered contact of counting relay CT, front contact and left-hand armature of counting relay B, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Units relay 398 in operating locks up over a path extending from grounded battery front contact and armature of relay 398, winding of relay 623 and conductor H to ground at the right-hand armature and front contact of relay 303. Relay 623 energizes and is maintained energized in series with units relay 398 over the circuit just traced.

Units relay 603 in operating also completes a circuit for relay 920 of the link circuit over a path extending from grounded battery winding of relay 920, uppermost armature and front contact of relay 603 to ground. Relay 920 of the link circuit in operating completes a test circuit extending from ground on conductor H, winding and left-hand normal contacts of relay 921, front contact and armature of relay 920, and thence through the sleeve contacts of relays 398, 396 and 397 to the sleeve conductor of line 312. Battery potential being present on the sleeve conductor, since the calling line is being called, relay 921 operates and locks up through its left-hand alternate contacts. When the units connecting relay 398 energized it completed a circuit for the energization of the reverting busy test relay 359 over a path extending from grounded battery winding of relay 359, inner left-hand armature and front contact of relay 398, front contact and right-hand armature of relay 302, and intermediate right-hand armature and front contact of relay 310 to ground.

As soon as the last impulse of the units series of impulses was delivered to the impulse relay 901, and relay 702 released, relay 741 operated over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower most armature of relay 603, contacts 389 of relay 398, and outer right-hand armature and front contact of relay 303 to ground. Relay 741 in operating opens the locking circuit for relay 740, whereupon said relay 740 releases thereby opening the locking circuit for counting relays BP and B. Relay 740 in releasing releases relay 741. The

counting relays are thereupon restored to normal and ready for the next set of impulses.

As soon as relay 623 operated, units relay 603 released, thereby causing the release of slow-to-release relay 920 of the link circuit.

After dialing the units impulses the calling subscriber dials the letter corresponding to the station of the desired subscriber. At the first interruption of the line circuit in response to the dialing of this series of impulses, slow to release relay 702 and counting relay AP are energized. Relay 702 in operating completes a circuit for the energization of relay 740 which in operating locks up to ground on conductor H. Relay AP in operating prepares a circuit for the energization of counting relay A. When the impulse relay 901 attracts its armature at the end of the first impulse of this series, counting relay A operates whereupon relays AP and A lock up to ground on conductor H. In response to the second impulse of the series transmitted to the impulse relay 901, counting relays BP and B will be energized. These relays then lock up to ground on conductor H. Relay B in operating opens the locking circuit for relays AP and A. In response to the third impulse of this series, relays CP and C are operated and then lock up to ground on conductor H. Relay C in operating opens the locking circuit for relays BP and B, which thereupon release. In response to the fourth impulse of this series transmitted to impulse relay 901, relays DP and D operate and lock up to ground on conductor H. Relay D in operating opens the locking circuit for relay CP and C, whereupon said relays release. Relay D in operating completes an energizing circuit for relay CTP, and is held operated through ground on conductor H. In response to the fifth impulse of this series transmitted to the impulse relay 901, counting relays AP and A are again energized and in operating lock up to ground on conductor H. Relay A in operating opens the locking circuits for relays DP and D, whereupon said relays release and the counting relay CT operates and locks up in series with relay CTP. In response to the sixth impulse transmitted to impulse relay 901, counting relays BP and B are energized and in operating lock up to ground on conductor H. Relay B in operating opens the locking circuit for relays AP and A. In response to the seventh impulse transmitted to the relay 901, relays CP and C operate and thereupon lock up to ground on conductor H. Relay C in operating opens the locking circuit for relays BP and B, whereupon said relays release.

At the end of the last series of impulses, impulse relay 901 retains its armature attracted, thereby causing the release of slow-to-release relay 702. Relay 702 in retracting its armature completes a circuit for the energization of relay 604 over a path extending from grounded battery, winding of relay 604, back contact and lower armature of relay 624, front contacts and armatures of relays 623, 622, 621 and 620, conductor F, outer right-hand armature and front contact of relay 740, back contact and left-hand armature of relay 702, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 604 in operating completes a circuit for the energization of relay 631 over a path extending from grounded battery, winding of relay 631, uppermost armature and front contact of relay 604, and thence over a connection, not shown, to a like numbered contact of counting relay FTP, front contact and outer right-hand armature of relay CTP, front contact and left-hand armature of relay C, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 631 in operating completes a locking circuit for itself over a path extending from grounded battery, winding of relay 631, upper inner armature and front contact of relay 631, winding of relay 624, conductor H, outer right-hand armature and front contact of relay 303 to ground. Relay 624 is energized and maintained operated in series with relay 631 over the circuit just traced. Before relay 624 is operated however, relay 741 is operated over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower armature of relay 604, front contact and upper armature of relay 631, conductor H, front contact and outer right-hand armature of relay 303 to ground. Relay 741 in operating opens the locking circuit for relay 740 which thereupon releases. Relay 740 in releasing opens the holding circuit for the operated relays of the counting circuit, and the operating circuit for relay 741, whereupon said relays are restored to normal.

Upon the energization of relay 631, a circuit is closed from ground, front contact and armature of relay 357, armature and front contact of relay 358, armature and front contact of relay 359, uppermost armature and front contact of relay 631 to the windings of relays 930 and 931 in parallel to battery and ground. Relays 930 and 931 are energized in this circuit. Relay 931 closes a circuit for the energization of relay 932 which extends from battery, winding of relay 932, front contact and left-hand armature of relay 931, front contact and outer right-hand armature of relay 921, back con-

tact and armature of relay 920, sleeve conductor of the called line, contact 394 of relay 398, contact 386 of relay 396, contact 373 of relay 397, winding of relay 470 to ground. It should be noted that relay 470 has already been energized in series with relay 303, but relay 932 is sensitive and becomes energized in the circuit just traced.

The energization of relay 932 causes the energization of relay 922 by means of a circuit extending from grounded battery winding of relay 922, resistance 940, front contact and armature of relay 932 to ground. Through the energization of relays 922 and 930, a circuit is closed from ground, armature and front contact of relay 901, inner lower armature and front contact of relay 930, right-hand winding of relay 911, back contact and right-hand armature of relay 923, front contact and innermost lower armature of relay 922 to the ground on conductor H. The energization of relay 930 prevents the energization of the ringing relay 924 at this time so that the calling subscriber will not have ringing current put on the line until he replaces his receiver on its hook.

The subscriber now replaces his receiver on its switchhook for purpose of ringing the calling subscriber. Relay 901 responds by retracting its armature, whereupon a circuit is established from ground on conductor H through the innermost lower armature and front contact of relay 922, the right-hand armature and back contact of relay 923, the right-hand winding of relay 911, the front contact and innermost armature of relay 930, the winding of relay 906 to battery and ground. Relay 911 becomes energized in this circuit and relay 906 remains energized to hold the connection. Relay 911 cuts off the calling end of the link circuit from the repeating coil 910 and thereby removes the relay 901 from the control by the calling subscriber. Through its left-hand armature, relay 911 closes a circuit from ground on conductor H, the innermost lower armature and front contact of relay 922, the armature and back contact of relay 935, the back contact and left-hand armature of relay 923, the front contact and left-hand armature of relay 911, winding of relay 924 to battery and ground.

Ringing current will now be transmitted alternately to the stations of the calling and the called subscriber and will be continued until either the calling or the called subscriber removes the receiver from the switchhook. As soon as the called subscriber removes the receiver from the switchhook, the calling subscriber may do likewise, whereupon conversation may progress. The path of the current for signaling the called subscriber may be traced as follows:—ground, source 781 of 33⅓ cycle ringing current, interrupter 791, inner lower armature and front contact of relay 631, outer armature and front contact of relay 625, front contact and left-hand armature of relay 941, winding of relay 935, front contact and uppermost armature of relay 924, upper armature and front contact of relay 922, contacts 395 of relay 398, contacts 383 of relay 396, contacts 375 of relay 397 through the 33⅓ cycle ringer and condenser (not shown) at the called substation 312 M, contacts 355 of relay 397, contacts 356 of relay 396, contacts 393 of relay 398, front contact and lowermost armature of relay 922, lowermost armature and front contact of relay 924, right-hand armature and front contact of relay 941, front contact and inner armature of relay 625, front contact and lower intermediate armature of relay 631 to source of ringing current 781. The path for signaling the calling station 312 L may be traced as follows:—from source 780 of 16⅔ cycle ringing current, interrupter 790, uppermost armature and front contact of relay 612, outer armature and front contact of relay 627, front contact and outer armature of relay 626 and thence through the front contact and left-hand armature of relay 941 over the path previously traced through the 16⅔ cycle ringer 153 and condenser 170 at the calling substation 312 L, through the right-hand armature and front contact of relay 941, inner armature and front contact of relay 626, front contact and intermediate armature of relay 627, front contact and upper intermediate armature of relay 612 to source of ringing current 780. Relay 626 which controls the application of ringing current to the calling line is intermittently energized over a path extending from grounded battery, winding of relay 626, front contact and inner armature of relay 627, front contact and inner upper armature of relay 612, and interrupter 760 to ground. Relay 625 which controls the application of ringing current to the called line is intermittently energized over a path extending from grounded battery, winding of relay 625, front contact and lowermost armature of relay 631 and interrupter 761 to ground. The interrupters 760 and 761 may be so arranged that the relays 625 and 626 are alternately energized so that only one source of ringing current is applied to the line at the same time.

When the called subscriber removes the receiver from the switchhook, relay 935 will operate due to an increased flow of current therethrough. Relay 935 in operating completes a circuit for the energization of relay 923 over a path extending from ground on conductor H, inner lower armature and front contact of relay 922, winding of relay 923, front contact and left-hand armature of relay 911 and winding of relay 924 to grounded

battery. Relay 923 in operating locks up through its left-hand armature and front contact and short circuits 924, whereupon said relay 924 releases. Relay 923 in operating also opens the circuit for relay 911 which in retracting its armatures renders the talking circuit continuous, and again places the relay 901 under the control of the calling subscriber so that it energizes and insures the continued energization of the holding relay 906. Relay 930 remains operated, however, and holds the called end of the link circuit open from the line.

It should be noted that in such a revertive connection as that being now described that both the calling and called subscribers' stations are supplied with talking current through the primary windings of repeating coil 910, the reverting busy test relay 930 being operated during such a connection.

Upon the completion of the conversation and when both parties hang their receivers on their hooks, the relay 901 will become deenergized and a short interval thereafter, relay 903 will retract its armature since now there is no circuit for holding it energized. Upon the retraction of its armature by relay 901, relay 906 opens the circuit between relay 303 and relay 470 so that both of these relays become deenergized. Relay 303 removes ground from conductor H and allows all of the relays locked thereto to become deenergized resulting in the complete restoration to normal of the connection.

Call from a single station line to a trunk line.

Assume that a single station line such as 322, desires connections with the main central office. The subscriber of station 322 will first remove the receiver from the switch hook, whereupon line relay 422, individual to the calling line, will be energized over a path extending from battery, upper winding of relay 422, back contact and outer armature of cut-off relay 433, through the substation loop, inner armature and back contact of relay 433, and lower winding of relay 422 to ground. Relay 422 thereupon operates and completes a circuit for the energization of subgroup relay 402, units relay U2 and relay AD over a path extending from ground, left-hand armature and back contact of relay 421, winding of relay 402, armature and front contact of relay 422, winding of relay U2, and winding of relay AD to grounded battery. Group relay 404 is energized over a path extending from grounded battery, right-hand winding of relay 404, front contact and right-hand armature of relay 402, back contacts and right-hand armatures of relays 430, 431, 432, back contact and lower armature of relay 405, and back contact and left-hand armature of relay 410 to ground. Group relay 404 in operating completes a locking circuit for itself and an energizing circuit for relay 405 over a path previously traced. Relay 405 in operating causes the operation of relay 406 which in turn causes the operation of relay 407. Relay 407 in operating releases relay 406 and starting relay 408 is thereupon energized as herebefore described. Relay 408 in operating completes a circuit for the energization of allotter relay 310. Relay 310 in operating locks up and completes circuits for group relay 388, subgroup relay 300, and units relay 302. Group relay 388 is operated over a path extending from grounded battery, winding of relay 388, contact 322 of relay 310, and right-hand armature and front contact of relay 404 to ground. Relay 300 operates over a path extending from grounded battery, winding of relay 300, contacts 321 of relay 310, and front contact and left-hand armature of subgroup relay 402 to ground. Units relay 302 is operated over a path extending from grounded battery, winding of relay 302, contacts 365 of relay 310, and front contact and armature of units relay U2 to ground. Group relay 388, subgroup relay 300, and units relay 302 in operating lock up in parallel to ground at the intermediate right-hand armature and front contact of relay 310.

The operation of the group, subgroup, and units relays of the line finder LF1 extends the line of the calling station through to the link circuit, whereupon relay 901 of the link circuit is operated over a path extending from grounded battery, winding of relay 901, back contact and lower armature of relay 904, lower right-hand winding of repeating coil 910, back contact and inner right-hand armature of relay 911, conductor C2, contacts 371 of units relay 302, contacts 372 of the subgroup relay 300, contacts 353 of the group relay 388, through the substation loop, contacts 354 of group relay 388, contacts 378 of relay 300, contacts 370 of relay 302, conductor C1, outer right-hand armature and back contact of relay 911, upper right-hand winding of repeating coil 910, upper inner armature and back contact of relay 904 to ground.

Since lines having single stations thereon have the fourth conductor thereof open, the relays 902 and 903 will not be operated when the line finder relays extend the line of the calling station through to the link circuit. Since it is a single party line which is originating a call it is not necessary that a station designation be dialled before the number of the called line. Hence relay 620 will be energized over a path from grounded battery, lower winding of relay 620, back contact and armature of relay

902, to ground on conductor H and relay 620 will attract its armatures to transfer the lead F from the winding of relay 600 to the winding of relay 601. Relay 901 in operating completes a circuit for the energization of slow to release relay 906. Relay 906 in operating completes a circuit for relay 303 of the line finder switch LF1 and cut-off relay 433 over a path including contacts of group relays 388, sub-group relay 300 and units relay 302, whereupon said relay 303 operates and disconnects the starting lead F1 from the allotter relay 310 and cut-off relay 433 operates and disconnects the line relay 422 from the line thereby releasing relays 402, U2 and AD. The opening of the starting lead F1 by the operation of relay 310 removes the short-circuit from relay 410, which immediately operates. The operation of relay 410, which is in series with relay 310, prevents said relay 310 from releasing and removes ground from the winding of relays 405 and 404, whereupon said relays release. Relay 410 in operating causes the magnet 412 of the switch FS to be operated to step the brush 415 of said switch FS in operative relationship with the next line finder.

To effect a connection with a trunk leading to the main central office, the subscriber at station 322 dials the digit 0, thereby causing ten interruptions in the line circuit. In response to the first interruption of this series of impulses, relay 901 retracts its armature and completes a circuit for the energization of slow to release relay 702 and counting relay AP, in the manner hereinbefore described. Relay 702 in operating completes a circuit for relay 740 which thereupon operates and locks up to ground on conductor H. Relay AP in operating prepares a circuit for the energization of counting relay A and when the armature of relay 901 is attracted at the end of the first impulse, counting relay A operates and locks up in series with counting relay AP to ground on conductor H. In response to the second impulse transmitted to impulse relay 901, counting relays BP and B operate and lock up. Relay B in operating causes the release of counting relays AP and A. In response to the third impulse transmitted to the impulse relay 901, counting relays CP and C operate and lock up. Relay C in operating opens the locking circuit for relays BP and B, whereupon said relays BP and B release. In response to the fourth impulse transmitted to the impulse relay, counting relays DP and D operate and lock up. Relay D in operating causes the release of relays CP and C. Relay D in operating also completes a circuit for the operation of relay CTP. In response to the fifth impulse transmitted to the impulse relay 901, relay CT operates and locks up in series with relay CTP and counting relays AP and A operate and lock up. Relay A causes the release of relays DP and D. In response to the sixth impulse transmitted to the impulse relay 901, counting relays BP and B operate and lock up. Relay B in operating releases relays AP and A. In response to the seventh impulse transmitted to the impulse relay 901, relays CP and C operate and lock up. Relay C in operating releases relays BP and B. In response to the eighth impulse transmitted to the impulse relay 901, counting relays DP and D operate and lock up. Relay D in operating releases relays CP and C. Relay D in operating also completes a circuit for relay FTP over a path extending from grounded battery, winding of relay FTP, back contact and outer right-hand armature of relay FT, front contact and intermediate armature of relay CT, front contact and outer left-hand armature of relay D, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, conductor H, and outer right-hand armature and front contact of relay 303 to ground. In response to the ninth impulse transmitted to the impulse relay 901, counting relays AP and A operate and lock up and relay FT is energized and relays FTP and FT then lock up over a path extending from grounded battery, winding front contact and left-hand armature of relay FTP, winding of relay FT, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay A in operating releases relays DP and D. In response to the tenth impulse transmitted to the impulse relay 901, relays BP and B operate and lock up. Relay B in operating releases relays AP and A.

After the last impulse of the series of ten impulses has been transmitted to the impulse relay 901, slow to release relay 702 retracts its armatures, thereby completing a circuit for the energization of relay 601 over a path extending from grounded battery, winding of relay 601, back contact and lower armature of relay 621, front contact and lower armature of relay 620, conductor F, outer right-hand armature and front contact of relay 740, back contact and left-hand armature of relay 702, conductor H, and outer right-hand armature and front contact of relay 303 to ground. Relay 601 in operating completes a circuit for the energization of the relay 210 of the trunk connecting circuit over a path extending from grounded battery, winding of relay 210, uppermost armature and front contact of relay 601, and thence over a connection, not shown, to the like numbered contact of relay FT, front contact and inner right-hand armature of relay CT, front contact and left-hand armature of relay B, front contact and inner

left-hand armature of relay 740, armature and back contact of relay 741, conductor H, and outer right-hand armature and front contact of relay 303 to ground.

Relay 210 in operating completes a circuit for the energization of allotter relay 211, and it in turn completes circuits for the group relay 220, subgroup relay 240, and units relay 202 of the trunk connecting circuit corresponding to the operated relays of the line finder circuit LF1.

The group, subgroup, and units relays of the trunk connecting circuit in operating associate the calling line with the trunk circuit. The group, subgroup, and units relays of line finder circuit LF1 are then disconnected from the calling line. The circuit for the energization of group relay 220 of the trunk connecting circuit may be traced as follows: grounded battery, winding of relay 220, contact 254 of relay 211, contacts 274 of relay 210, front contact and right-hand armature of group relay 388 of line finder LF1 to ground at the intermediate right-hand armature and front contact of relay 310. Subgroup relay 240 of the trunk connector is energized over a path extending from grounded battery, winding of relay 240, contacts 255 of relay 211, contacts 275 of relay 210, front contact and upper armature of subgroup relay 300 of the line finder LF1 to ground at the intermediate right-hand armature and front contact of relay 310. Units relay 202 on the trunk connector is energized over a path extending from grounded battery, winding of relay 202, contacts 256 of relay 211, contacts 276 of relay 210, front contact and right-hand armature of relay 302 and intermediate right hand armature and front contact of relay 310 to ground. Group relay 220, sub-group relay 240 and units relay 202 of the trunk connector in operating, lock through the windings of relays 522, 521 and 523 respectively, to ground on conductor H, causing the energization of the latter mentioned relays. When the group, sub-group and units relays of the connector circuit operate to extend the calling line to the trunk circuit, relay 800 of the trunk circuit operates in series with the cut-off relay of the calling line.

The operation of relay 800 completes a circuit from ground, back contact and armature of relay 808, upper left hand winding of repeating coil 815, back contact and upper armature of relay 804, front contact and upper armature of relay 800 through the contacts of the units, group and sub-group relays and over the loop of the calling subscriber's line, back to the lowermost armature and front contact of relay 800, the lowermost and back contact of relay 804, the lower left hand winding of repeating coil 815, winding of relay 809 to battery and ground. Relay 809 is energized and causes the energization of relay 810. Relay 810 completes a circuit from ground, left hand armature and front contact, of relay 810, right hand normal contacts of relay 814, right hand normal contacts of relay 813, and winding of relay 816 to grounded battery. Relay 816 operates and connects ringing current from a source 899 through its lowermost and upper contacts to the conductors 898 and 897 of the trunk circuit and completes an obvious circuit through its lower inner contacts for relay 814, which operates and locks under control of relay 810. Relay 814 in operating completes an obvious circuit for relay 812, and opens the energizing circuit for relay 816 which is preferably of the slow-to-release type so as to properly apply ringing current to the trunk. Relay 812 completes a circuit from ground, front contact and left hand armature of relay 812, conductor AS, winding of relay 212 to battery and ground.

The allotter relay 211, in operating, completes a circuit for relay 801 of the trunk circuit over a path extending from ground, battery, winding of relay 801 contacts 258 of relay 211 to ground. Relay 801, in operating, locks up over a path extending from grounded battery winding of relay 801 front contact and left hand armature of relay 801 and front contact and inner right hand armature and relay 212 to ground. Relay 911 of the link circuit is then operated over a path extending from ground, battery, left-hand winding of relay 911, contacts 277 of relay 210, contacts 259 of relay 211, the front contacts and right hand armature of relay 801, front contact and inner lower armature of relay 800 to ground on conductor H. Relay 911, in operating, renders the calling end of the subscriber's link circuit discontinuous, thereby causing the de-energization of impulse relay 901 and slow-to-release relay 906. The release of these relays results in entirely releasing all relays of the line finder circuit and the link circuit.

When ringing current is applied to the trunk conductors 897 and 898, alternating current relay 818 is energized and in operating completes a circuit for relay 824 and lamp 826 over a path extending from ground, armature and front contact of relay 818, inner armature and back contact of relay 819, and thence in parallel through the winding of relay 824 and lamp 826 to grounded battery. Relay 824 thereupon operates and locks up through its front contact and armature to ground at the back contact and armature of relay 819. Lamp 826 is lighted in the circuit just traced and serves an indication to the operator at the main central office that a call has arrived. The calling line has now been extended to

the operator at the distant exchange and the connection may then be further extended by the operator thereat.

The operator noting the signal may insert plug 864 of cord circuit P into jack 823 whereupon relay 820 operates. Relay 820 is of such a high resistance as to prevent the operation of supervisory relay 868. Relay 819 of the trunk circuit operates when plug 864 is inserted into jack 823 over a circuit including lamp 862 and the left and right hand windings of relay 819. The left hand winding of relay 819 is of such a high resistance however, that lamp 862 does not light. Relay 819 in operating opens the locking circuit for relay 824 and the circuit for lamp 826 whereupon relay 824 releases and lamp 826 ceases to glow. Relay 820 in operating completes a circuit for the operation of relay 811. The operator may now actuate her listening key (not shown) for the purpose of ascertaining the wants of the calling subscriber and then complete the connection in the well known manner. At the conclusion of conversation and restoration of the receiver to the switchhook at the calling station the operator receives a disconnect signal whereupon she may remove the plug 864 from jack 823 whereupon all apparatus is restored to normal. A detailed description of this is given hereafter in connection with a description of a call from the operator for a station of the relay exchange.

Call from a single station line to a station of a rural line.

It will be assumed that a single station line such as a station having the No. 322 desires connection with a station of the rural line 321. It will be further assumed that the particular station of the rural line desired is station No. 11. The calling party at station 322 will first remove the receiver from the switchhook and then dial the number of the desired line, namely, 321 and then the suffix, namely, 11 of the desired subscriber. Upon removal of the receiver from the switchhook on station 322, the line relay 422 individual to the calling line will be energized, after which the group relay 404, sub-group relay 402 and units relay U2 will be energized in a manner similar to that described for a call from the station 322 to the trunk line.

Group relay 388, sub-group relay 300 and units relay 302 of a line finder such as LF1 may then be operated in the manner heretofore described to extend the calling line through to the link circuit.

As soon as the calling line is extended through to the link circuit, relay 901 of the link circuit is operated causing in turn the energization of slow-to-release relay 906, which in operating causes the operation of relay 303 of the line finder LF1. Relay 303 in operating extends the starter wire and releases the group, sub-group and controlling relays as heretofore described. Relay 303 operates in series with the cut-off relay 433 of the calling line. Since the calling line is a single station line the fourth conductor thereof will be open and when the line is extended to the link circuit relays 902 and 903 do not operate. Relay 620 operates however over a path extending from grounded battery, lower winding of relay 620, back contact and armature of relay 902 to ground on conductor H.

The subscriber at station 322 may then actuate the sender S2 for the purpose of effecting connection with the desired line. After three impulses corresponding to the first digit of the desired number have been transmitted to the impulse relay 901 of the link circuit counting relays CP and C will be operated as heretofore described. Relay 601 will then operate and cause the energization of sub-group relay 396 of the connector circuit as heretofore described. Relay 396 in operating locks in series with relay 621. As soon as relay 601 operates, it completes a circuit for the energization of relay 741, which in operating opens the locking circuit for relay 740 which thereupon releases. Relay 740 in releasing opens the locking circuit for the operated counting relays and for relay 741. As soon as relay 621 operated, relay 601 released.

After the transmission of the second set of impulses to the impulse relay 901, slow-to-release relay 702 releases thereby causing the operation of relay 602 over a path previously traced. Relay 602 in operating completes a circuit for the energization of group relay 307 over a path similar to that previously traced for group relay 397. Relay 307 in operating locks up in series with relay 622 to ground on conductor H. Relay 602 in operating also completed an operating circuit for relay 741 as heretofore described, which in operating released all the relays of the counting relay circuit.

In response to the next or units series of impulses transmitted to the impulse relay 901, counting relays AP and A are energized and after the cessation of this impulse, slow-to-release relay 702 releases, thereby causing the operation of units relay 603 over a path previously traced. Relay 603 in operating completes an energizing circuit for units relay 325 of the connector. Relay 325 in operating locks up in series with relay 623 to ground on conductor H. Relay 623 in operating also causes the release of the relays of the counting relay circuit as heretofore described.

When the group relay 307, group relay 396 and units relay 325 have become energized a circuit is closed between cut-off relay

420 sleeve conductor of the called line, armature and front contact of relay 920, winding of relay 921, to ground on conductor H. Neither relay 420 nor relay 921 are energized in this circuit. After a short interval relay 920 becomes deenergized and the sleeve conductor of the called line is transferred from the front to the back contact of relay 920 thence through the outermost right hand armature and back contact of relay 921, winding of relay 922 to battery and ground. Both relay 420 and relay 922 become energized in this circuit and the called line is marked as busy. Relay 924 is then energized over a path extending from grounded battery, winding of relay 924, inner upper armature and back contact of relay 930, left hand armature and back contact of relay 923, back contact and armature of relay 935, front contact and inner lower armature of relay 922 to ground on conductor H.

In response to the transmission of the first digit of the suffix, counting relays AP and A operate and during the short closure of the line circuit after the cessation of this impulse, relay 702 releases, thereby causing the energization of relay 604. Relay 604 in operating completes a circuit for the energization of relay 650 over a path extending from grounded battery, winding of relay 650, upper inner armature and front contact of relay 604 and thence over a connection (not shown) to a like numbered contact of relay CT, front contact and left-hand armature of relay A, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay 604, in operating, also completes a circuit for relay 741 over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower armature of relay 604, front contact and uppermost armature of relay 650 to ground on conductor H. Relay 741 in operating causes the release of all relays of the counting relay circuit as heretofore described. Relay 650 in operating locks up over a path extending from grounded battery, front contact and upper inner armature of relay 650, winding of relay 624 to ground on conductor H, and completes a circuit from ground on conductor H through its upper intermediate contacts for the energization of relay 942. Relay 624 is energized and maintained operated in circuit just traced. Relay 942 in operating prepares the simplexed circuit for the rural line 321.

In response to the next impulse transmitted to the impulse relay 901, counting relays A and AP are again energized as heretofore described. After this impulse has been transmitted to relay 901, the line circuit remains closed, whereupon slow-to-release relay 702 retracts its armatures completing thereby a circuit for relay 644 over a path extending from grounded battery, winding of relay 644, front contacts and armatures of relays 624, 623, 622, 621 and 620, conductor F, outer right-hand armature and front contact of relay 740, back contact and armature of relay 702 to ground on conductor H. Relay 644, in operating, completes a circuit for the energization of relay 641 over a path extending from grounded battery, winding of relay 641, front contact and upper inner armature of relay 644 and thence over a connection (not shown) to a like numbered contact of counting relay CT, front contact and left-hand armature of counting relay A, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay 644 in operating completes a circuit for the energization of relay 741 over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, lower armature and front contact of relay 644, front contact and uppermost armature of relay 641 to ground on conductor H. Relay 741 in operating releases all relays of the counting relay circuit as heretofore described. Relay 641, in operating, locks over a path extending from grounded battery, winding, front contact and lower armature of relay 641 to ground on conductor H. Relay 644 released when relay 740 of the counting relay circuit released.

Ringing current for signaling the desired subscriber is supplied automatically over a path extending from grounded battery, left-hand winding of coil 710, contact 670 of relay 650, contacts 672 of relay 641, front contact and right-hand armature of relay 941, front contact and lowermost armatures of relays 924 and 922 and thence over the heavily marked ring conductor of the link and connector circuits, through ringer 104 and condenser 110, secondary winding of induction coil 102 at the called substation 321—11 and thence over the heavily marked tip conductors of the connector and link circuits front contact and upper armature of relay 922, through the uppermost armature and front contact of relay 924, winding of relay 935, left-hand armature and front contact of relay 941, front contact and upper inner armature of relay 641, contacts 671 of relay 650, through the right-hand winding of coil 710, interrupter 730 and source of current 720 to ground. By means of the interrupter such as 730, any desired code may be projected over the called line.

When the called subscriber responds, relay

935 energizes due to an increased flow of current through its winding causing thereby the energization of relay 923 over a path previously described. Relay 923 in operating locks over a path extending from grounded battery, front contact and left-hand armature and winding of relay 923, front contact and inner lower armature of relay 922 to ground on conductor H. Relay 923 in attracting its left-hand armature short circuits relay 924, thereby releasing said relay 924. Relay 924 in retracting its armatures renders the talking conductors of the link circuit continuous.

At the conclusion of conversation and restoration of the receiver to the switch-hook, relay 901 retracts its armature thereby releasing slow-to-release relay 906, which in retracting its armatures opens the holding circuit for the relays of the line finder and connector circuit causing thereby the restoration of all apparatus to normal.

Call from a main central office to a single party line of the relay exchange system.

Assuming that a subscriber at the main central office desires a connection with a single party line of the relay exchange system such as, for example, the subscriber having station No. 322, the operator at the main central office will insert the calling plug 864 of a cord circuit P (a portion only of which is shown) into the jack 823 of the trunk circuit at her position extending to the branch exchange. The insertion of the plug 864 into the jack 823 completes a circuit for the energization of relay 820, over a path extending from ground, upper left hand winding of repeating coil 860, upper normal contacts of key K, tips of plug 864 and jack 823, upper right hand winding of repeating coil 821, winding of relay 820, lower right-hand winding of repeating coil 821, rings of jack 823 and plug 864, lower normal contacts of key K, winding of supervisory relay 868 and lower left-hand winding of repeating coil 860 to grounded battery. Relay 820 is of such a high resistance as to prevent the energization of supervisory relay 868 in the circuit just traced. Relay 819 of the trunk circuit is operated, when the cord circuit P is inserted into the jack 823 of the trunk circuit over a path extending from grounded battery, lamp 862, resistance 863, sleeves of plug 864, jack 823, and windings of relay 819 in series to ground. The left-hand winding of relay 819 is of high resistance and of such a value as to prevent lamp 862 from lighting when said lamp is connected in series with said high resistance winding. Relay 820, in operating, completes a circuit for the operation of relay 811 over a path extending from grounded battery, front contact and armature of relay 820, and thence in parallel through the secondary windings of repeating coil 821 through the upper and lowermost normal contacts of of relay 816, upper and lower right-hand windings of repeating coil 815 and winding of relay 811 to ground. Relay 811, in operating, completes an obvious circuit through its armature and front contact for the slow-to-release relay 812. Relay 812, in operating, completes a circuit through its right-hand armature for relay 813, said circuit including the normal contacts of relays 809 and 810. Relay 813, in operating locks to ground at the contacts of relay 812 and in opening its right-hand contacts prevents relay 816 from energizing and thus ringing the operator when the called subscriber answers and relay 810 operates. The operation of relay 812 completes a circuit for relay 212 which in turn connects the back contact of relay 811 to conductor ST.

The operator then actuates the dialing key K to connect the impulse sender S5 in operative relationship with the relay 820 of the trunk circuit. The operator will then actuate the sender S5 for the purpose of transmitting impulses in accordance with the number of the desired station. When the first impulse is transmitted to the relay 820, relay 811 will deenergize thereby completing a circuit for the energization of relay 702 and counting relay AP of a counting relay circuit individual to the trunk circuit and identical with that shown in Fig. 7, over a path extending from ground, back contact and left-hand armature of relay 811, conductor ST and front contact and outer armature of relay 212, conductor ST, outer left-hand armature and back contact of relay 740, and thence in parallel, one path extending through the winding of relay 702 to grounded battery and the other path extending through the right hand armatures and back contacts of relays D, C, B, and A, and through the winding of relay AP to grounded battery. Relay 702 thereupon operates and completes a circuit for the energization of relay 740 over a path extending from grounded battery, winding of relay 740, front contact and left-hand armature of relay 702, and conductor H, to ground. Relay 740 thereupon operates and locks up to ground on conductor H. Relay AP, in operating, prepares a circuit for relay A. When relay 811 attracts its armature at the end of the first impulse, counting relay A operates whereupon counting relays AP and A lock up to ground on conductor H. In response to the second and third impulse of the first series transmitted to the relay 811, counting relays BP, B, CP, and C will be successively energized. Relays AP and A and BP and B release as heretofore described.

At the end of the transmission of the first set of impulses to the impulse relay 820, the

line circuit will be closed for a relatively long interval of time whereupon slow-to-release relay 702 will retract its armature thereby opening the original circuit for relay 740.

Relay 702 in retracting its armatures completes a circuit for the energization of relay 501 over a path extending from ground, inner left-hand armature and front contact of relay 212, conductor H, left-hand armature and back contact of relay 702, front contact and outer right-hand armature of relay 740, conductor F, lower normal contacts of relay 521, and winding of relay 501 to grounded battery. Relay 501 in operating, completes a circuit for the energization of sub-group relay 240 over a path extending from grounded battery, winding of relay 240, upper outer contacts of relay 501 and thence over a connection, (not shown), to a like numbered contact of relay CTP, front contact and left-hand armature of relay C, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741, and thence to ground on conductor H. Relay 240, in operating, locks in series with relay 521 over conductor H to ground at the front contact and inner left-hand armature of relay 212, and completes a circuit through its lowermost contacts for relay 261. Relay 741 operates over a path from grounded battery, winding of relay 741, front contact and inner left-hand armature of relay 740, conductor E, front contact and lowermost armature of relay 501, front contact and left-hand armature of relay 261 to ground on conductor H. Relay 741 in operating opens the locking circuit for relay 740, which in releasing, restores the counting relays to normal.

In response to the first impulse of the second series of impulses transmitted to the the relay 820, slow-to-release relay 702 and counting relay AP will again be energized. Relay 702 in operating again completes an operating circuit for relay 740 which thereafter locks up. Relay AP, in operating, prepares an energizing circuit for counting relay A which operates as soon as the relay 811 attracts its armature at the end of the first impulse. Counting relays BP and B are successively operated in response to the transmission of the remaining impulse of the series. At the end of the second series of impulses, slow-to-release relay 702 retracts its armatures whereupon a circuit is completed for relay 502 over a path extending from grounded battery, winding of relay 502, back contact and lower armature of relay 522, front contact and lower armature of relay 521, conductor F, outer right-hand armature and front contact of relay 740 and back contact and left-hand armature of relay 702 to ground on conductor H. Relay 502 in operating completes a circuit for group relay 220 of the trunk connector over a path extending from grounded battery, winding of relay 220, upper intermediate armature of relay 502, and thence over a connection (not shown) to a like numbered contact of counting relay CT, front contact and left-hand armature of relay B, front contact and inner left-hand armature of relay 740, armature and back contact of relay 741 to ground on conductor H. Relay 220 in operating locks up over a path extending from grounded battery, winding front contact and right-hand armature of relay 220, winding of relay 522 to ground on conductor H. Relay 522 operates and is maintained energized in series with relay 220 over the circuit just traced. Relay 220, on operating completes a circuit through its innermost left-hand contacts for relay 260. Relay 502 in operating also completes a circuit for relay 741 over a path extending from grounded battery, winding of relay 741, front contact and inner right-hand armature of relay 740, conductor E, front contact and lower armature of relay 502, front contact and left-hand armature of relay 260 and front contact, and inner left-hand armature of relay 212 to ground. Relay 741 in operating releases relay 740 which in turn releases the counting relays. Relay 740, in releasing, releases relay 741.

In response to the transmission of the third set of impulses to the relay 820, slow-to-release relay 702 and counting relays AP, A, BP and B are successively energized. Relay 740 also operates and locks up when relay 702 operates. After the last impulse of the third series of impulses has been transmitted to the relay 811, slow-to-release relay 702 retracts its armatures thereby completing a circuit for the energization of units relay 503 over a path extending from grounded battery, winding of relay 503 lower back contact of relay 523, lower alternate contacts of relays 522 and 521, conductor F, outer right-hand armature and front contact of relay 740, back contact and left-hand armature of relay 702 to ground on conductor H. Relay 503, in operating, completes a circuit for the energization of units relay 202 of the trunk connector, over a path extending from grounded battery, winding of relay 202, contacts 570 of relay 503, and thence over a connection, (not shown), to the like numbered contact of counting relay CT, and thence over a path previously traced to ground. Relay 503 also completes a circuit through its uppermost contacts for relay 840.

Units relay 202 of the connector locks up over a path extending from ground battery, front contact of relay 202, winding of relay 523 to ground on conductor H. Relay 202, in operating, also completes a circuit for relay 263 over a path extending from

grounded battery, winding of relay 263, inner left-hand armature and front contact of relay 202, front contact and inner left-hand armature of relay 212 to ground. In attracting its lowermost armature, units relay 503 completes a circuit for the energization of relay 741 over a path extending from ground, inner left-hand armature and front contact of relay 212, right-hand armature and front contact of relay 263, lowermost contacts of relay 503, conductor E, inner right-hand armature and front contact of relay 740, and winding of relay 741 to battery and ground. Relay 741, in operating, releases relay 740 which in turn releases the operated counting relays. Relay 741 then releases.

Due to the operation of group relay 220, subgroup 240 and units relay 202, the trunk circuit is now extended through to the line of the desired subscriber and ringing current may be applied to the line of the desired subscriber for the purpose of signaling. When units relay 503 of the link circuit completed a circuit through its uppermost armature for relay 840 of the trunk circuit, said relay 840, in operating completed a test circuit as follows: ground, winding of cutoff relay 433 of the station 322, contact 221 of relay 220, contact 241 of relay 240, contact 290 of relay 202, armature and front contact of relay 840, left-hand normal contacts of test relay 803 to ground on conductor H. If the called line is busy battery potential will be present on the sleeve conductor thereof and if idle, ground potential.

If the called line is idle, test relay 803 does not operate and relay 800 will be operated when relay 840 retracts its armature over a path extending from grounded battery, winding of relay 800, inner right-hand armature and back contact of relay 803, back contact and armature of relay 840, contact 290 of relay 202, contact 241 of relay 240, contact 221 of relay 220 and winding of cut-off relay 433 to ground. Relay 800, in operating renders the tip and ring conductors of the trunk circuit, extending to the trunk connector, continuous and completes a circuit for the energization of relay 804, over a path extending from grounded battery, winding of relay 804, armature and back contact of relay 807, back contact and armature of relay 805, back contact and right-hand armature of relay 801, front contact and lower inner armature of relay 800 to ground on conductor H.

Relay 804, in operating, connects the ringing current from the source 880 to the tip and ring conductors extending to the desired station, said ringing current passing through the normally closed contacts of relay 806, the winding of relay 805, the lowermost and upper alternate contacts of relay 804 and the lowermost and upper make contacts of relay 800, over the tip and ring conductors, through the contacts of the operated group, subgroup and units relays through the desired station 322, to actuate the ringer thereat.

It will be noted that relay 806 does not operate due to the fourth conductor of the called line being open. If the operator had called a line of a different character, for example, a rural or a party line relay 806 would have operated due to ground being present on the fourth conductor of such a line and the trunk circuit would have been automatically conditioned for the application of party or rural line ringing.

Upon the response of the called subscriber at station 322, relay 805 operates due to an increased flow of current therethrough. Relay 805, in operating, removes the short circuit from relay 807 whereupon said relay 807 operates and locks, and in attracting its armature short-circuits relay 804, which thereupon releases. Relay 804, in retracting its armature, connects the station of the called line through to the relay 809 of the trunk circuit whereupon said relay 809 operates. Relay 809 in operating completes a circuit for the slow-to-release relay 810. Relay 810 in operating completes an obvious circuit, through the outer left-hand contacts of relay 813, for relay 814. Relay 814 then locks to ground at relay 810.

The called substation is now supplied with talking current from grounded battery, through the winding of relay 809, lower left-hand winding of repeating coil 815 and thence over the heavily marked ring conductors through the substation and thence over the heavily marked tip conductors, upper left-hand winding of repeating coil 815, and armature and back contact of relay 808 to ground.

Upon the completion of the conversation, and restoration of the receiver to the switch-hook at the station 322, relay 809 releases thereby releasing, in turn, relay 810. Relay 810 being slow to release does not de-energize for an interval after relay 809. During this interval a circuit is established for 816 which connects ringing current to the trunk to operate relay 818. Relay 818 causes the operation of relay 828, which locks to the ground on the armature of relay 819. Relay 828, in operating short circuits the high resistance winding of relay 819, which increases the current flow through lamp 862 and causes it to glow, thereby indicating to the operator the fact that the station 322 has hung up.

As heretofore stated relay 810 being of the slow-to-release type remains energized an interval after relay 809 releases thereby completing a circuit for ringing relay 816, which in turn completes an obvious hold-

ing circuit through its inner lower contacts for relay 814. A circuit for slow-to-release relay 812 exists through the outer left hand contacts of relay 814 so that said relay 812 does not deenergize due to the opening of its circuit at the alternate contacts of relay 811, when relay 816 is operated to give the disconnect signal. A short interval after the release of relay 810, relay 816 releases again energizing the relay 811 which maintains relay 812 operated until the operator disconnects.

The operator noting the glowing of signal 862 may remove plug 864 from jack 823 whereupon relay 820 deenergizes causing the deenergization of relay 811 and in turn of relay 812. Relay 812 in releasing removes ground from the winding of relay 212 of the trunk connector circuit whereupon all operated relays of the trunk connector circuit and trunk circuit are restored to normal position.

If the line of the desired subscriber is busy, test relay 803 will be energized due to the presence of battery potential on the sleeve of said line. Relay 803 will then be operated over a path extending from battery on the sleeve conductor of line 322, contact 221 of relay 220, contacts 241 of relay 240, contacts 290 of relay 202, armature and front contact of relay 840, left-hand normal contacts of relay 803, winding of relay 803 to ground on conductor H. Relay 803 in operating locks up through its left-hand alternate contacts to ground on conductor H and through its outer right-hand contacts connects busy tone from a source 881, to the back contact and lower inner armature of relay 804, condenser 882, through the upper left-hand winding of repeating coil 815, armature and back contact of relay 808 to ground. Tone passing through the left-hand winding of relay 815 induces a corresponding tone in the right-hand winding thereof, said tone being then transmitted over the trunk conductors 897 and 898 to the operator at the main central office. The operator at the central office, noting the tone withdraws the plug 864 from the jack 823 whereupon all apparatus is restored to normal.

Calls from and to rural lines.

When a rural line subscriber makes a call, by removing his receiver from the hook, he establishes a circuit from ground, contact 105 of the impulse sender S, contact 112, controlled by the switchhook 113, and thence over a parallel path, one side of which comprises the lower winding of the ringer 104 and the right hand line conductor, and the other side of which comprises the upper winding of the ringer 104, contact 101, switchhook 113, secondary winding of induction coil 102 and the left hand line conductor, to the upper winding of line relay 401 and thence to battery and ground. Closure of this circuit causes the energization of line relay 401, whereupon the rural line is connected through the contacts of the group, subgroup and units relays to the link circuit in the manner heretofore described.

As the fourth conductor of the rural line is connected directly to ground, both relays 902 and 903 will become energized and the calling end of the link circuit will be adapted to simplex operation. This is accomplished through the energization of relay 904 in a circuit from ground, the armature and contact of relay 903, winding of relay 904 to battery and ground. Through the energization of relay 904, relay 901 is rendered ineffective and relay 905 is placed in a circuit leading from battery, winding of relay 905, and thence over a parallel path, one side of which comprises the front contact and inner upper armature of relay 904, the upper right hand winding of repeating coil 910, the back contact and right hand armature of relay 911, conductor C1 and thence to the ground connected to contact 105 of the subscriber's sender S over a path heretofore described, and the other side of which parallel path comprises the front contact and lower armature of relay 904, lower right hand winding of repeating coil 910, back contact and right hand armature of relay 911, conductor C2, and thence to the ground connected to contact 105 of the subscriber's sender S. In this manner relay 905 is placed under control of the subscriber's sender S and will respond thereto in the same manner that relay 901 responds to the other subscriber senders such as S1 and S2.

The contacts controlled by relay 905 perform the same functions as those controlled by the relay 901 so that interruption of the circuit of relay 905 produces the same result as interruption of the circuit of relay 901 and through similar trains of impulses the relay connectors are set to connect the calling line to any other desired line.

On incoming calls from the central office to a rural line, relay 808 will become energized upon the energization of the COR1 or the COR2 relay (Fig. 5), which relays become energized in response to the dialing of a suffix indicating a particular station of a rural line in a manner similar to that heretofore described in connection with relay 650. The circuit for relay 808 in one case may be from battery, winding of relay 808, front contact and inner upper armature of relay COR1 (Fig. 5), conductor H, front contact and inner left hand armature of relay 212, to ground. The energization of relay 808 cuts off the ground connection to the upper left hand winding of repeating

coil 815 and connects it directly to the lower left hand winding of the same coil, so that now current will flow from battery through the winding of relay 809, and thence in parallel through the upper and lower left hand windings of repeating coil 815 in parallel to the subscriber's line whereby signaling and supervision may take place over the two line conductors in parallel, and conversation may be directed over the metallic circuit using the two line conductors in series.

In the case of a call directed from a link circuit to a rural line the direct ground connected to the fourth conductor results in the energization of relay 941 whereby the ringing current is now taken from the contacts of the COR1 or the COR2 relays (Fig. 6). It will also be noticed that upon the energization of either of these two last-mentioned relays that relay 942 will become energized in a circuit from battery, winding of relay 942, lowermost contact of relay 651, to ground on conductor H whereby the simplex condition is again established to the called line, both the upper and lower left hand windings of repeating coil 910 being now connected to battery.

So far certain representative types of connections in this system have been described in detail and it is beleived that other types of connections need not be further described on account of needless repetition. Suffice it to say that the link circuit of Fig. 9 will automatically adapt itself both on its incoming and outgoing ends to the particular type of line calling or called. The connection of a direct ground, ground through a resistance or the disconnection of ground from the fourth conductor determines the action of the two relays 902 and 903, which in turn determine the type of circuit that will be presented to the calling line. The called end of the link circuit is conditioned in response to the dialing of a suffix representing a code of the rural line, and the type of ringing current is determined through the action of relay 941, which responds to either a rural line or a party line.

In the case of a call over the trunk circuit to the central office on an outgoing call, since there is no need for the use of a simplex circuit none will be set up, but on an incoming call a simplex circuit will be established through the operation of one of the code ringing relays COR1 or COR2.

What is claimed is:

1. In a telephone exchange system, a plurality of subscribers' lines of different character, a link circuit common to said lines, a relay line finder responsive to the initiation of a call from a station on one of said lines to extend the line of the calling station to said link circuit, a relay connector, means controlled by the calling subscriber for extending the link circuit over said relay connector to a called station, a plurality of sources of ringing current associated with said link circuit, and means determined by the character of the called line for conditioning the link circuit for the application of the proper source of ringing current thereto.

2. In a telephone exchange system, a plurality of subscribers' lines of different character, a link circuit common to said lines, a relay line finder responsive to the initiation of a call from a station on one of said lines to extend the line of the calling station to said link circuit, a relay connector, means controlled by the calling subscriber for extending the link circuit over said relay connector to a called station, a plurality of sources of ringing current associated with said link circuit, means determined by the character of the called line for conditioning the link circuit for the application of the proper source of ringing current thereto, and subscriber controlled means for applying current to the called line.

3. In a telephone exchange system, a plurality of subscribers' lines of different character, said lines being divided into groups irrespective of their character, the lines of said groups being divided in a plurality of subgroups, a link circuit, means comprising a plurality of groups, subgroup, and units relays for extending the connection from a calling one of said lines to said link circuit, subscriber controlled means for extending the calling line over said link circuit to a called line, a plurality of sources of ringing current associated with said link circuit, and means determined by the character of the called line for conditioning the link circuit for the application of the proper source of ringing current to the called line.

4. In a telephone exchange system, a plurality of subscribers' lines of different character, said lines being divided into groups irrespective of their character, the lines of said groups being divided in a plurality of subgroups, a link circuit, means comprising a plurality of group, subgroup, and units relays for extending the connection from a calling one of said lines to said link circuit, subscriber controlled means for extending the calling line over said link circuit to a called line, a plurality of sources of ringing current associated with said link circuit, means determined by the character of the called line for conditioning the link circuit for the application of the proper source of ringing current to the called line, and subscriber controlled means for applying the proper source of ringing current to the called line.

5. In a telephone exchange system, a plurality of subscribers' lines, said lines in-

cluding lines having single stations thereon and lines having a plurality of stations thereon, the latter named lines including party lines and rural lines, means including a line finder, a link circuit, and a connector in serial relationship for establishing a connection between a calling and a called station of said lines, a plurality of sources of ringing current for signaling, said sources including code, harmonic and alternating current ringing currents, means associated with the link circuit for automatically conditioning the link circuit for the application of code or harmonic ringing current to the line if the call is revertive, and means controlled by the calling station for applying alternately two of the sources of ringing current to the line if the revertive call is on a party line and for applying one of the sources of ringing current if the revertive call is on a rural line.

6. In a telephone exchange system, a plurality of subscribers' lines, said lines including rural lines, individual lines, and party lines, relay switching mechanism for establishing connections between lines, said mechanism including directively controlled relays, a full metallic dialing circuit for extending a connection from an individual or a party line, a simplex circuit for extending connections from a rural line, and means operative to automatically adapt the link circuit for full metallic or simplex operation.

7. In a telephone system, a first exchange, subscribers' lines of different characters terminating therein, a second exchange, an operator's position thereat, means including an impulse sender and automatic switching mechanism for interconnecting one of said lines and said position, a simplex signalling circuit for lines of one character, a full metallic signalling circuit for lines of another character, and means automatically operative depending upon the character of the subscriber's line to render the simplex or the full metallic circuit operative.

8. In a telephone system, a central office, lines of different characters terminating therein, non-numerical switches and connector switching mechanism at said office, link circuits for extending said non-numerical switches to said connector switching mechanism, simplex controlling circuits for lines of one character, full metallic controlling circuits for lines of another character, and means associated with said link circuits for differentiating between the lines of different character in order to supply each with its respective talking and controlling circuit.

9. In a telephone system, a first exchange, subscribers' lines of different characters terminating therein, a second exchange, a trunk line extending between said exchanges, a signal for said trunk line, a cord circuit, a supervisory signal therein, means including an impulse sender and automatic switching mechanism for extending said subscribers' lines to said trunk circuit, a simplex controlling and signaling circuit for lines of one character, a full metallic controlling and signaling circuit for lines of another character, means associated with said trunk circuit for differentiating between the lines of different characters in order to supply each with its respective circuit, means automatically operative to actuate said trunk signal when said trunk line is seized by the calling subscriber, and means under the control of the calling subscriber for controlling said supervisory signal when said cord circuit is connected to said trunk circuit.

10. In a telephone system, lines of different character, a link circuit for interconnecting said lines, automatic switches for connecting said lines to said link and for connecting said link to said lines, means individual to each of said lines for denoting the character thereof, and means in said link circuit responsive to said first means for changing the character of said link circuit.

11. In a telephone system according to claim 10, the provision of a series of steering relays, and means in said link circuit controlled by said responsive means for rendering one of said relays ineffective when lines of certain character appropriate said link circuit.

12. In a telephone system according to claim 10, the provision of one steering relay for each digit in the designation of a called number.

13. In a telephone system according to claim 12, the provision of one steering relay for the station suffix of a calling party line in combination with means controlled by said responsive means for rendering said last relay effective only when party lines appropriate said link circuit.

14. In a telephone system according to claims 10 to 13, inclusive, the provision of switching devices having permanently paired primary and secondary contacts for extending said lines to said link circuit, and said link circuit to said lines.

15. In a telephone system according to claim 10, the provision of a plurality of sources of ringing current common to said link circuit and a plurality of relays individual to said link circuit for connecting said sources of ringing current to said link circuit whereby suitable ringing current may be transmitted to a called telephone line.

16. In a telephone system according to

claim 15, the provision of means to selectively control said ringing current connecting relays.

17. In a telephone system according to claim 16, the provision of means responsive to the establishment of a revertive call by a party line to selectively control a plurality of said ringing current connecting relays.

18. In a telephone system according to claim 17, the provision of means for alternately rendering said selected ringing current connecting relays effective.

19. In a telephone system, telephone lines, a link circuit for interconnecting said lines, switching devices for connecting said lines to said link circuit and switching devices for connecting said link circuit to said lines, a relay common to said switching devices, and a circuit for said relay which is closed only upon the actuation of a switching device for extending said link circuit to said lines corresponding to an actuated switching device for extending said lines to said link circuit, said relay controlling means in said link circuit to establish a revertive connection.

20. In a telephone system according to claim 19, the provision of a plurality of groups of switching devices and a plurality of said revertive connection relays, one individual to each of said groups of switching devices, and a series circuit controlled by said relays for controlling said link circuit whereby the condition for a revertive connection can be established only when all of said relays are energized thus indicating the actuation of corresponding switching devices in each of said groups.

In witness whereof, I hereunto subscribe my name this 23rd day of December A. D., 1920.

SAMUEL B. WILLIAMS, JR.