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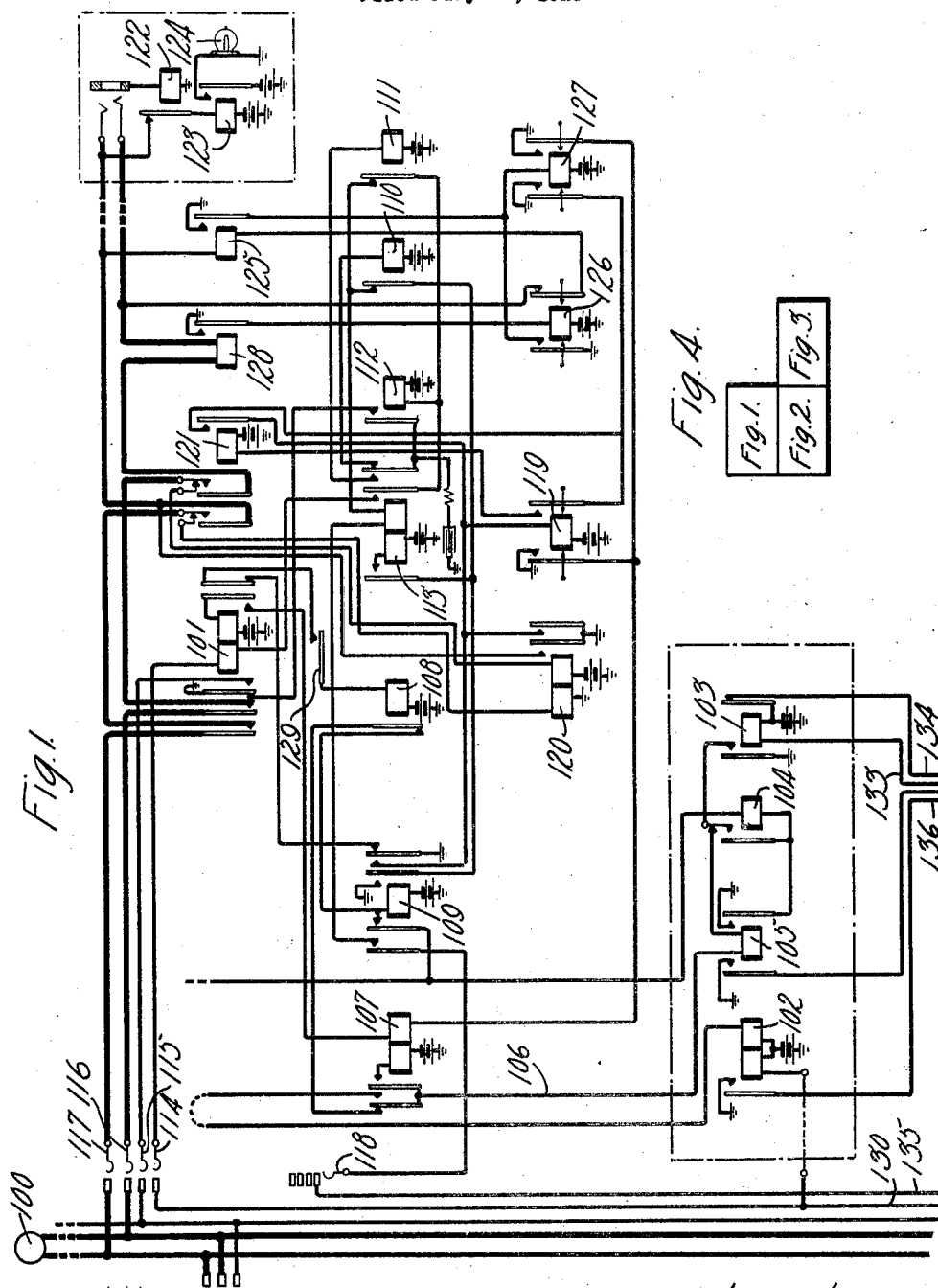
1,563,631

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TELEPHONE SYSTEM

Filed July 25, 1923

3 Sheets-Sheet 1



Inventor:  
Edward E. Hinrichsen,  
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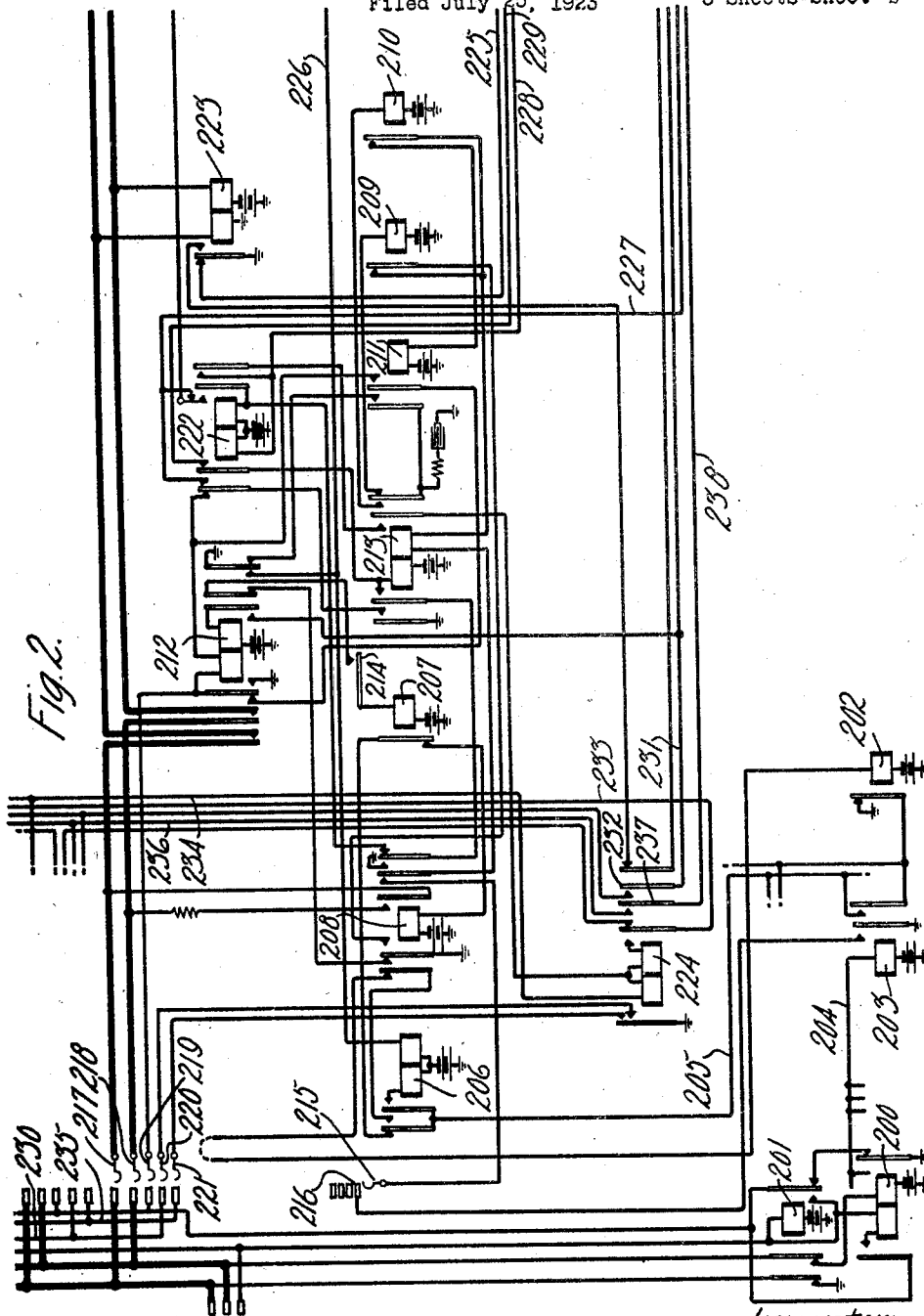
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3 Sheets-Sheet 2



Inventor:  
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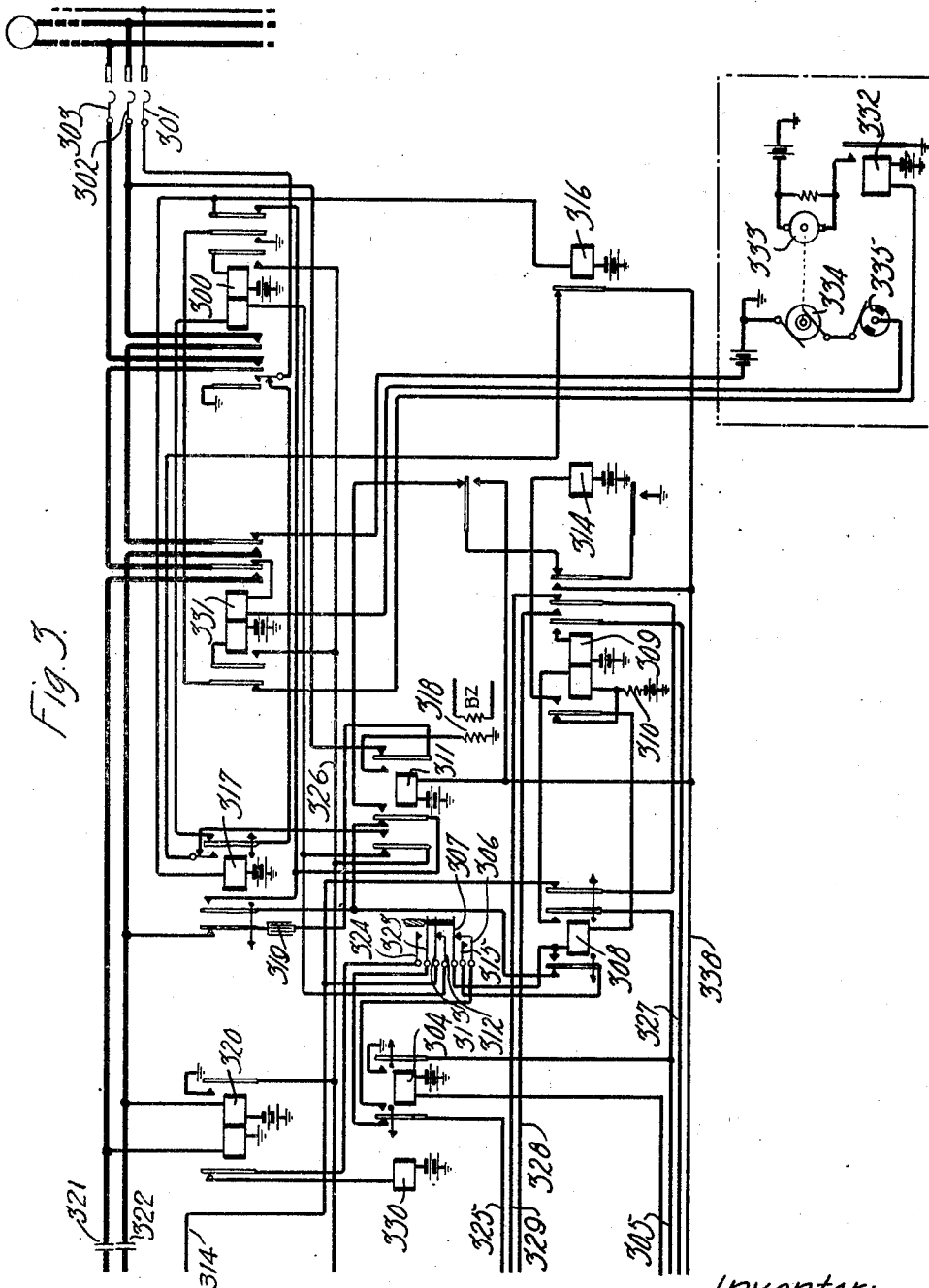
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3 Sheets-Sheet 3



Inventor:  
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## UNITED STATES PATENT OFFICE.

EDWARD E. HINRICHSSEN, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## TELEPHONE SYSTEM.

Application filed July 25, 1923. Serial No. 653,631.

*To all whom it may concern:*

Be it known that I, EDWARD E. HINRICHSSEN, a citizen of the United States of America, residing at New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Telephone Systems, of which the following is a full, clear, concise, and exact description.

This invention relates to telephone systems and particularly to machine switching systems of small capacity such as are used for private branch exchange installations.

The object of the invention is to provide a small capacity machine switching telephone system which shall be economical, simple and reliable in operation. More particularly, the object is to promote economy through the use of certain apparatus to perform an additional function to that heretofore performed by similar apparatus known to the prior art.

A feature of the invention resides in the provision of a circuit arrangement wherein a single impulse is absorbed without operating the selecting switch but is recorded so that a second single impulse will close a circuit to effect the connection of the calling line to the central office, means being provided for wiping out the record in case the first single impulse is followed by a series of impulses greater than one.

The drawings, comprising three sheets designated Fig. 1, Fig. 2 and Fig. 3 respectively, when placed as shown in Fig. 4 diagrammatically represent the circuit arrangement embodying the present invention.

The system in general consists of a number of lines having multiple terminals appearing before connector switches, link line finder switches, trunk line finder switches and trunk connector switches. Link circuits are provided, having at one end a line finder switch for picking up a calling line and at the other end a connector switch for extending the link circuit to a called line. Outgoing trunk circuits are provided having a line finder switch at one end for picking up calling lines and extending their other ends to the central office. In the drawings, the incoming trunk circuits with their connector switches are not shown since they form no part of the present invention.

In operation, a subscriber removes his receiver from its hook and sets up a calling

condition on the terminals of his line, which causes a link line finder switch to hunt for the line and extend it to the link circuit. The subscriber thereupon manipulates his substation sender to send two series of impulses to set the connector switch on the terminals of the called line. The invention herein consists in the circuit arrangement within the link circuit which will absorb a preliminary impulse and render it ineffective to cause a wrong connection, but will record this impulse so that if it is followed by another single impulse the connection will be transferred from the link circuit to a trunk circuit. In order to call the trunk circuit, the calling subscriber dials 11, which, of course, consists of two time-spaced single impulses. The sending of these two trains of one impulse each operates the relay system in the link circuit but does not move the connector switch and results in the starting of the trunk line finder switch and the release of the link line finder switch.

In making a call to a regular subscriber's line either a series of N impulses or a single impulse followed by a series of N impulses will direct the connector switch to the same called line. The preliminary impulse is absorbed without moving the switch and is recorded. When this is followed by a series of impulses the first of this series is absorbed and the switch is moved on the second whereupon the record previously established is wiped out.

It is believed that the invention will be more fully understood from the following detailed description of the operation of the circuits.

The subscriber at substation 100 removes his receiver from its hook and completes a circuit from battery through the right-hand winding of line relay 200, the back contact and inner left-hand armature of cut-off relay 201, over the loop of substation 100 to the outer left-hand armature and back contact of relay 201 to ground. Relay 200 is energized in this circuit and in attracting its armatures establishes a circuit from ground, the right-hand armature and front contact of relay 200, conductor 204 and winding of relay 203 to battery and ground. Relay 203 is energized and thereupon establishes a circuit from ground, back contact and armature of relay 202, outer right-hand armature and

front contact of relay 203, conductor 205, outer left-hand armature and back contact of relay 206, armature and back contact of release relay 207 and winding of relay 208 to battery and ground. Relay 208 is energized in this circuit. A circuit is thereupon established from ground, inner left-hand armature and front contact of relay 208, armature and back contact of magnet 209, armature and back contact of magnet 210, and winding of relay 211 to battery and ground. Relay 211 attracts its armatures and establishes a circuit from ground, outermost right-hand armature and back contact of relay 212, front contact and outer left-hand armature of relay 211, outer right-hand armature and back contact of relay 213 and winding of magnet 209 to battery and ground. Magnet 209 is the vertical magnet of the line finder switch and acts upon its energization to move the brushes of the switch one vertical step. Upon this movement, the off-normal contact 214 is closed, but, due to the energization of relay 208, the circuit of release relay 207 is not at this point closed. The energization of magnet 209 opens the circuit for relay 211 and relay 211 in retracting its armatures, opens the circuit of magnet 209. Thereupon, the circuit for relay 211 is closed and this in turn again closes the circuit of magnet 209 so that a second vertical step is accomplished. In this manner through the interaction of relay 211 and magnet 209, the brushes of the switch are stepped vertically in a hunting movement to find the group of lines containing line 100. When this group is reached, brush 215 will encounter a terminal associated with the wanted group whereupon a circuit will be established from ground, innermost right-hand armature and contact of relay 203, terminal 216, brush 215, front contact and middle right-hand armature of relay 208, right-hand winding of relay 213, armature and back contact of magnet 210, winding of relay 211 so that relay 211 is prevented from becoming deenergized for an instant. It will be understood that this circuit is closed as magnet 209 completes its operation and brings the brushes of the finder switch opposite the wanted group. When this step becomes fully completed the connection through the back contact and armature of magnet 209 will be broken. Prior to this time, the circuit through the right-hand winding of relay 213 is ineffective to cause the energization of such relay because of a ground connection to both sides of this winding. However, when magnet 209 attracts its armature, this short circuit is removed and relay 213 becomes energized in series with relay 211. Relay 213 now locks up through its left-hand winding, its front contact and inner left-hand armature, the outer right hand armature and front con-

tact of relay 208 to ground. The energization of relay 213 also transfers the control from magnet 209 to magnet 210 so that magnet 209 is released and a circuit is now completed from ground, the outer right-hand armature and back contact of relay 212, the front contact and outer left-hand armature of relay 211, the outer right-hand armature and contact of relay 213, magnet 210 to battery and ground. Magnet 210 causes the brushes of the finder switch to move in their secondary direction. Upon such first secondary step, brush 215 is disconnected from terminal 216 so that the energization of relay 211 now depends entirely on a circuit extending from ground, the inner left-hand armature and front contact of relay 208, the armature and back contact of magnet 209, the armature and back contact of magnet 210 and winding of relay 211 to battery and ground. Therefore, upon the energization of magnet 210, the circuit for relay 211 is opened and this relay becomes deenergized with the same effect as before so that through the interaction of relay 211 and magnet 210, the brushes of the finder switch are caused to rotate until the particular calling line is found.

Brush 219 comprises the test brush of the line finder switch. As this brush travels over the terminals of idle lines, a direct connection to ground is found, such connection being from ground, the right-hand armature and back contact of the line relay such as 200, the back contact and right-hand armature of the cut-off relay such as 201 and thence to the terminal corresponding to brush 219. Lines, busy as calling lines, will present also the same characteristic, that is, a direct connection will be extended from ground, the front contact and innermost left-hand armature of the relay, such as, 212, through a brush corresponding to brush 219 in the switch with which the busy line is connected and thence to the terminal corresponding to brush 219 over the multiplied terminal connections to the particular brush 219 of the seeking line finder switch. Lines, busy as called lines, will have a direct connection extending from ground, the outermost left-hand armature and front contact of relay 300, brush 301 and thence to the sleeve conductor of the called line, through the front contact and right-hand armature of the cut-off relay such as 201, to the terminal corresponding to brush 219. Lines, busy on trunk calls, will have a direct connection from ground, innermost left-hand armature and front contact of relay 101, front contact and right-hand armature of cut-off relay 201 to the terminal corresponding to brush 219. Thus, idle lines and busy lines both present a direct connection to ground to brush 219. The line which is calling, however, will present a different characteristic, that is, the

brush 219 will encounter a terminal to which a connection extends through the left-hand armature and front contact of relay 200, the left-hand winding of relay 200, winding of cut-off relay 201 to battery and ground. As the brush 219 engages its terminal, magnet 210 will be completing its stroke and relay 211 will be energized. It will be noted that during the energization of relay 211, the left-hand winding of relay 212 is short-circuited, such connection extending from the right-hand terminal of the left-hand winding of relay 212, the front contact and inner left-hand armature of relay 211, back contact and innermost left-hand armature of relay 212, and thence to the left-hand terminal of the left-hand winding of relay 212. As magnet 210 fully completes its stroke, the energizing circuit of relay 211 is opened and relay 211 therefore retracts its armatures. The short-circuit about the left-hand winding of relay 212 is now opened and a circuit is completed from ground, the outer left-hand armature and front contact of relay 213, the outermost left-hand armature and back contact of relay 222, the left-hand winding of relay 212, brush 219, its corresponding terminal, the left-hand armature, front contact and left-hand winding of relay 200 and winding of relay 201 to battery and ground. Relay 201 is energized in this circuit and through its right-hand armature now completes a direct connection from the terminal corresponding to brush 219 to its winding. At the same time the left-hand winding of relay 200 is short-circuited so that this relay, now being deprived of its original energizing circuit through the left-hand armatures of the cut-off relay and its holding circuit through its own left-hand armatures, becomes deenergized. The deenergization of relay 200 causes the deenergization of group relay 203 so that the ground is removed from conductor 205. Relay 212 also becomes energized in this circuit but not until relay 201 becomes locked, because, due to the resistance of the left-hand winding of relay 200, the operation of relay 212 is delayed. Therefore, the operation of the cut-off relay 201 is followed by the energization of relay 212 which immediately extends a direct connection from ground, the front contact and innermost left-hand armature of relay 212 to brush 219 and thence through the winding of the cut-off relay. Upon the energization of relay 212, the loop of the calling line is extended to the windings of relay 223 whereupon a circuit is completed from ground, armature and front contact of relay 223, back contact and outermost left-hand armature of relay 224, winding of relay 304 to battery and ground. Relay 304 becomes energized and provides a locking circuit for relay 212 extending from ground, front con-

tact and right-hand armature of relay 304, conductor 305, front contact and innermost right-hand armature of relay 212, right-hand winding of relay 212 to battery and ground. The energization of relay 212 also closes a circuit from ground, outermost right-hand armature and front contact of relay 212, right-hand winding of relay 206, to battery and ground whereupon the circuit of relay 208 is opened so that this relay now becomes deenergized. It will be noted that the circuit of release relay 207 is now opened at another point, that is, the middle right-hand armature and back contact of relay 212 so that the closing of the back contact and inner right-hand armature of relay 208 to ground is at this time ineffective. The deenergization of relay 208 opens the holding circuit of relay 213 and this relay becomes deenergized.

It should be noted that the conductor extending from the front contact and outer right-hand armature of relay 203 to the left-hand armatures of relay 206 is now extended through the outermost left-hand armature and back contact of relay 208 and thence through a chain circuit which leads to the winding of relay 202. The conductor leading from the back contact corresponding to the outer left-hand armature and back contact of relay 208 leads to the left-hand armatures of a relay corresponding to relay 206 and associated with another line finder having brushes which will traverse terminals multiplied to the terminals of the line finder switch shown in Fig. 2. Relay 206 is known as the advance relay so that during busy condition of the line finder shown in Fig. 2, any other calls in this same group will be extended over the outer left-hand armature and front contact of relay 206, the outer left-hand armature and back contact of relay 208 and thence to the outer left-hand armature and back contact of the next advance relay whereupon the connection will be extended to the relay corresponding to relay 208. Relay 206 will remain energized throughout the busy condition of the line finder switch of Fig. 2. Should the line finder of Fig. 2 return to normal during the extension of a connection to another line finder switch, relay 206 will be held busy until this operation has been completed by a circuit extending through the inner left-hand armature and front contact of relay 206, left-hand winding of relay 206 to battery and ground.

In case all of the line finders having access to the calling line are busy then the chain circuit to relay 202 will become effective so as to energize relay 202. This removes the ground from the outer right-hand armature of relay 203 and prevents the indefinite extension of ground to conductor 305.

The connection is now in a stable condition awaiting the sending of impulses.

Let us suppose that a single preliminary impulse is sent. This results in the momentary deenergization of relay 223. A circuit will now be established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left-hand armature and front contact of relay 304, off-normal contacts 306 and 307, winding of relay 308, left-hand armature and back contact of relay 309, resistance 310 to battery and ground. Relay 308 becomes energized in this circuit and upon its energization closes a circuit from ground, front contact and right-hand armature of relay 304, inner right-hand armature and front contact of relay 308, left-hand winding of relay 309, resistance 310 to battery and ground. Relay 309 is, however, short-circuited at this time so that it does not become energized. As soon as relay 223 attracts its armature, after the momentary interruption of its circuit, the circuit for relay 308 is opened, whereupon the short-circuit about relay 309 is removed and since relay 308 is slow to release, relay 309 becomes energized, whereupon a holding circuit is established from ground, outermost right-hand armature and front contact of relay 212, conductor 226, conductor 326, outermost left-hand armature and back contact of relay 311, off-normal contacts 312 and 313, conductor 314, the normal contacts of the inner right-hand armature of relay 222, conductor 227, conductor 327, innermost right-hand armature and front contact of relay 309, right-hand winding of relay 309 to battery and ground. In a short interval relay 308 becomes deenergized whereupon a circuit is established from ground, outermost right-hand armature and front contact of relay 212, conductor 226, conductor 326, outermost left-hand armature and back contact of relay 311, off-normal contacts 312 and 313, conductor 314, back contact and outermost right-hand armature of relay 309, middle right-hand armature and front contact of relay 309, conductor 328, conductor 228, left-hand winding of relay 222 to battery and ground, whereupon relay 222 becomes energized. Relay 222 now locks into a circuit extending from ground, outermost right-hand armature and front contact of relay 212, conductor 226, conductor 326, outer left-hand armature and back contact of relay 311, off-normal contacts 312 and 313, conductor 314, alternate contacts of the inner-right-hand armature of relay 222, right-hand winding of relay 222 to battery and ground. The energization of relay 222 also results in the opening of the holding circuit for relay 309 so that this relay now becomes deenergized. Upon the deenergization of relay 309, a new circuit is established from ground, the outermost right-hand ar-

mature and front contact of relay 212, conductor 226, conductor 326, outermost left-hand armature and back contact of relay 311, off-normal contacts 312 and 313, back contact and outer right-hand armature of relay 308, middle right-hand armature and back contact of relay 309, conductor 329, conductor 229, front contact and inner left-hand armature of relay 222, left-hand winding of relay 213 to battery and ground. Relay 213 becomes energized in this circuit and locks up through its front contact and inner left-hand armature, outer right-hand armature and back contact of relay 208, the inner right-hand armature and alternate contact of relay 222 to the ground extended to conductor 314 over a circuit hereinbefore described. The energization of relay 213 extends ground from the outer left-hand armature of relay 213 through its associated front contact, the outer left-hand armature and front contact of relay 222, conductor 227, conductor 327, to the innermost right-hand armature of relay 309 but since relay 309 is now deenergized, this circuit is ineffective.

From the foregoing it will be seen that a single preliminary impulse is absorbed in the relay system of the link circuit and the connector switch represented by brushes 301, 302 and 303 is not moved off normal.

We will now assume the case where after the calling subscriber has inadvertently sent a preliminary impulse, he sends two trains of impulses representing the digits 3 and 4. The first train of impulses consists of three momentary deenergizations of relay 223. Upon the first deenergization of this relay, a circuit will be established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left-hand armature and front contact of relay 304, off-normal contacts 306 and 307, winding of relay 308, left-hand armature and back contact of relay 309, resistance 310, to battery and ground. Relay 308 becomes energized as before and establishes a circuit for relay 309, which, however, is ineffective until relay 223 again attracts its armature. Upon this happening, the short circuit about the left-hand winding of relay 309 is removed and this relay becomes energized, locking up through its right-hand winding over the circuit just described, which extends to the ground at the outer left-hand armature of relay 213. Upon the second deenergization of relay 223, a circuit will be extended from ground, armature and back contact of relay 223, conductor 225, conductor 325, left-hand armature and front contact of relay 304, off-normal contacts 306 and 307, winding of relay 308, left-hand armature and front contact of relay 309, winding of magnet 314 to battery and ground. Magnet 314 becomes energized and steps the brushes 301 to 303 one step in

a primary direction. Upon the succeeding energization of relay 223, magnet 314 becomes deenergized and upon the next deenergization of relay 223, magnet 314 is energized for a second time to advance the brushes 301 to 303. As the brushes 301 to 303 are stepped off normal, the circuit for relay 308 is changed so that it now extends from the front contact of relay 304, through off normal springs 306 and 315, the left-hand armature and front contact of relay 308 and thence over the circuit through the winding of magnet 314. Upon the final energization of relay 223, relay 308 becomes deenergized. Also, as the switch steps off normal, the circuit through off-normal contacts 312 and 313 will be opened so that ground is removed from conductor 314, allowing relays 213 and 222 to become deenergized so that upon the subsequent deenergization of relay 308, the circuit of relay 309 is opened and this relay reattracts its armatures. Thus a series of three impulses moves the brushes 301 to 303 two steps in the primary direction.

The subscriber now sends a series of four impulses to move the brushes 301 to 303 in their secondary direction. During the sending of each impulse a circuit will be established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left-hand armature and front contact of relay 304, off-normal springs 306 and 315, left-hand armature and back contact of relay 308, back contact and inner left-hand armature of relay 311, back contact and outermost right-hand armature of relay 300 to a point where the circuit divides, extending in one direction through the winding of rotary magnet 316 and in the other direction through the winding of relay 317 to battery and ground. Magnet 316 and relay 317 become energized, magnet 316 responding separately to the impulses and relay 317, since it is slow to release, responding to the train of impulses as a whole. At the end of this train of impulses, the brushes 301 to 303 will rest on the terminals of the called line.

If the called line is busy, then the brush 301 will encounter a terminal to which ground is connected and this ground will be extended over the normal contacts of the outermost left-hand armature of relay 300, right-hand armature and front contact of relay 317, back contact and armature of magnet 316, winding of relay 311 to battery and ground. It will be understood that this circuit is established upon the deenergization of magnet 316, but before relay 317 can retract its armatures. As relay 317 retracts its armatures, a substitute circuit for relay 311 is established which may be traced from ground, the outermost right-hand armature and front contact of relay 212, conductor 226, conductor 326, outermost left-hand ar-

mature and front contact of relay 311, normal contacts of the right-hand armature of the relay 317, contact and armature of the magnet 316 to the winding of relay 311 so that upon the encountering of the busy condition, magnet 316 first becomes deenergized, then the busy relay 311 becomes energized, and lastly, the slow-releasing relay 317 becomes deenergized, but in so doing establishes a holding circuit for the busy relay 311. Busy tone is now transmitting to the calling subscriber from the source of busy tone 318, the front contact and right-hand armature of relay 311, condenser 319, outermost left-hand armature and back contact of relay 317, right-hand winding of the called supervisory relay 320 to battery and ground and thence by induction to the other winding of relay 320 so this tone, being connected to both sides of the line, is transmitted through the condensers 321 and 322 to the calling subscriber's substation. When the calling subscriber recognizes this tone he will replace the receiver on its hook so that relay 223 will become deenergized, and after a short interval this will be followed by the deenergization of slow releasing relay 304, whereupon a circuit will be established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left-hand armature and back contact of relay 304, off-normal contacts 323 and 324, left-hand armature and back contact of relay 320, release relay 330 to battery and ground. Release relay 330 becoming energized, returns the switch to normal.

The deenergization of relay 304, which followed the deenergization of relay 323 also removes ground from conductor 305 and thereby opens the holding circuit of relay 212. Relay 212 restoring its armatures to normal, establishes a circuit from ground, inner left-hand armature and back contact of relay 208, back contact and middle right-hand armature of relay 212, off-normal contact 214, winding of release relay 207 to battery from ground. Release relay 207 causes the restoration of the line finder switch of Fig. 2, to normal condition.

Let us suppose that the called line had been found in an idle condition. Then the circuit extending through brush 301 to the winding of relay 311 will be ineffective. Relay 317 becomes deenergized in a short interval, whereupon a circuit is established from ground, the outer right-hand armature and front contact of relay 212, conductor 226, conductor 326, outer left-hand armature and back contact of relay 311, left-hand winding of relay 300, back contact and right-hand armature of relay 317, normal contacts of the outermost left-hand armature of relay 300, brush 301 and thence to the winding of the cut-off relay associated with the called line to battery and ground. In this

circuit, relay 300 will become energized and immediately upon so doing will extend a circuit from ground, outermost left-hand armature and front contact of relay 300, brush 301, and thence to the cut-off relay of the called line, which will thereupon become energized. Relay 300 also locks itself into a circuit extending from ground, the outermost right-hand armature and back contact of relay 212, conductor 226, conductor 326, the front contact and innermost right-hand armature of relay 300, right-hand winding of relay 300 to battery and ground. Relay 300 by attracting its armatures at this time establishes a circuit from ground, front contact and middle right-hand armature of relay 300, outermost right-hand armature and back contact of relay 331 to the ringing start relay 332, and thence to battery and ground so that the relay 332 becomes energized and closes the circuit for the motor 333 which puts into operation the ringing current generating means 334. Ringing current is now caused to flow over a circuit from ground through the source of ringing current 334, the interrupter 335, the left-hand winding of relay 331, the back contact and inner right-hand armature of relay 331, the middle left-hand armature and front contact of relay 300, brush 303 over the loop of the called subscriber's substation, brush 302, front contact and innermost left-hand armature of relay 300, outer right-hand armature and back contact of relay 331 to battery and ground. Current flowing in this circuit is insufficient to cause the energization of relay 331 until the called subscriber removes his receiver from its hook, whereupon the flow of ringing current is increased and relay 331 becomes energized. Upon its energization, relay 331 locks up through its left-hand winding its inner left-hand armature and front contact to the ground on the conductor 326. During the transmission of ringing current, a small amount of this current is extended over a path from brush 302, back contact and right-hand armature of relay 311, condenser 319, the outer left-hand armature and back contact of relay 317, the right-hand winding of relay 320 to battery and ground, whence by induction it is transmitted to the calling subscriber to notify such subscriber that the called line is being rung.

The circuits are now in condition for conversation and while this ensues the calling line supervisory relay 223 and the called line supervisory relay 320 will be energized. Upon the ending of the conversation and when both the calling and called subscribers hang up their receivers, these relays will become deenergized, whereupon the release circuits hereinbefore described will become effective and the connection will be broken down in the manner described.

Let us now describe the operations which take place when the calling subscriber sends a series of three impulses followed by a second series of four impulses without first sending the preliminary impulse hereinbefore described. Upon the first retraction of its armature by relay 223, a circuit will be established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left hand armature and front contact of relay 304, off normal contacts 306 and 307, winding of relay 308, left hand armature and back contact of relay 309, resistance 310 to battery and ground. Relay 308 becomes energized in this circuit and establishes a circuit for relay 309, which at present extends from the upper terminal of the left-hand winding of relay 309, through the front contact and innermost right hand armature of relay 308, right hand armature and front contact of relay 304 to ground and from the lower terminal of the left hand winding of relay 309 through the back contact and left hand armature of relay 309, winding of relay 308, off-normal contacts 307 and 306, front contact and left hand armature of relay 304, conductor 325, conductor 225, back contact and armature of relay 223. Since the left hand winding of relay 309 is short circuited at this time it does not become operated. Upon the subsequent attraction of its armature by relay 223, however, the ground is removed from the lower terminal of the left hand winding of relay 309, and this relay attracts its armatures. Upon the energization of relay 309, a locking circuit is provided extending from ground, the outermost right hand armature and front contact of relay 212, conductor 226, conductor 326, outermost left hand armature and back contact of relay 311, off-normal contacts 312 and 313, conductor 314, normal contacts of the innermost right hand armature of relay 222, conductor 227, conductor 327, innermost right hand armature and front contact of relay 309, right hand winding of relay 309 to battery and ground. Thereafter, when relay 223 retracts its armature on the second deenergization, which comprises the second impulse, a circuit is established from ground, armature and back contact of relay 223, conductor 225, conductor 325, left hand armature and front contact of relay 304, off-normal contacts 306 and 307, winding of relay 308, left hand armature and front contact of relay 309, winding of vertical magnet 314 to battery and ground, whereupon the switch represented by brushes 301 to 303 is moved one step in its primary direction. Upon the first step of the brushes 301 to 303, the off-normal contacts controlled by this switch are moved to their operated position so that the circuit which formerly extended from off-normal contact 306 through off-normal con-

tact 307 to the winding of relay 308 is now transferred to the off-normal contact 306, thence to off-normal contact 315, the left hand armature and front contact of relay 308, and thence to the winding of relay 308 so that this relay will now be maintained energized as long as impulses are transmitted, but will become deenergized thereafter. The third impulse, like the second impulse, will cause the energization of magnet 314 so that the whole train of three impulses will result in the stepping of brushes 301 to 303 two steps in their primary direction.

The result of the next series of impulses will be the same as that hereinbefore described so that it will be apparent that the line designated by the digits 3 and 4 may be reached by sending either two trains of three and four impulses respectively or by sending three trains of one, three and four impulses, respectively.

The last condition to be described will be that where the calling subscriber sends two trains of one impulse each. The result of the first impulse, as hereinbefore described, will be the energization of relays 222 and 213 with relays 308 and 309 deenergized. With this condition established, the calling subscriber sends a single impulse. This results in the establishment of a circuit from ground, armature and back contact of relay 223, conductor 225, conductor 325, left hand armature and front contact of relay 304, off normal contacts 306 and 307, winding of relay 308, left hand armature and back contact of relay 309, resistance 310 to battery and ground. Relay 308 becomes energized and in the manner hereinbefore described establishes a circuit for relay 309, which is at this time ineffective. Upon the end of this impulse relay 309 becomes operated and immediately locks up in a circuit from ground, outermost left hand armature and front contact of relay 213, outermost left hand armature and front contact of relay 222, conductor 227, conductor 327, innermost right hand armature and front contact of relay 309, right hand winding of relay 309, to battery and ground. In a short interval, relay 308 becomes deenergized. A circuit is thereupon established from ground, outermost right hand armature and front contact of relay 212, conductor 226, conductor 326, outermost left hand armature and back contact of relay 311, off normal contacts 312 and 313, conductor 314, back contact and outer right hand armature of relay 308, middle right hand armature and front contact of relay 309, conductor 328, conductor 228, front contact and outermost right hand armature of relay 222, front contact and inner right hand armature of relay 213, left hand winding of relay 224, conductor 234, conductor 134, back contact and right hand ar-

mature of relay 103 to battery and ground. This causes the energization of relay 224, whereupon a circuit is now established from ground through the right hand winding of relay 224, thence over the front contact and innermost right hand armature of relay 224, conductor 233, conductor 133, winding of relay 103 to battery and ground. Relay 103 becomes energized in this circuit and removes the battery connection from the left hand winding of relay 224 but this relay remains energized through its right hand winding in series with the winding of relay 103. The energization of relay 103 results in the establishment of a connection from ground, left hand armature and front contact of relay 103, normal contacts of the armature of relay 104, winding of relay 105, conductor 106, outer left hand armature and back contact of relay 107, armature and back contact of release relay 108, winding of relay 109 to battery and ground. Relays 105 and 109 become energized in this circuit. Relay 105 establishes a circuit from ground, front contact and right hand armature of relay 105, winding of relay 104, inner left hand armature and front contact of relay 109, winding of relay 109 to battery and ground. This circuit is, however, ineffective for the energization of relay 104 at the present time due to the ground extending to the winding of relay 109 over the circuit previously described.

The energization of relay 109 results in the establishment of a connection from ground, front contact and innermost right hand armature of relay 109, armature and back contact of magnet 110, back contact and armature of magnet 111, winding of relay 112 to battery and ground. Relay 112 becomes energized and establishes a circuit from ground, the innermost left hand armature and back contact of relay 101, front contact and armature of relay 112, outermost right hand armature and back contact of relay 113, winding of magnet 110 to battery and ground. Magnet 110 becomes energized and moves the brushes 114 to 117 one step in their primary direction. Upon the energization of magnet 110 the before described circuit of relay 112 is opened and this relay becomes deenergized. This in turn opens the circuit of magnet 110 so that this magnet becomes deenergized whereupon, through the interaction of relay 112 and magnet 110, the trunk finder switch is moved step by step until the group containing the calling line is found.

The energization of relay 224, hereinbefore described, extends a connection from ground, the left hand armature and upper front contact of relay 224, brush 221 and its corresponding terminal, conductor 235, conductor 135 to the terminal representing the group of lines containing the calling

line. When this group of lines is encountered, this ground connection is extended over brush 118, the outermost left hand armature and front contact of relay 109, the right hand winding of relay 113, the back contact and armature of magnet 111, winding of relay 112 so that this relay remains energized. Upon the complete energization of magnet 110 upon its operation to move the brush 118 onto its associated terminal, a short circuit about the right hand winding of relay 113 is removed so that this relay now becomes energized in series with relay 112. Thereupon, a circuit is established from ground, the innermost left hand armature and back contact of relay 101, the front contact and armature of relay 112, the outer right hand armature and front contact of relay 113, magnet 111 to battery and ground. Magnet 111 becomes energized and opens the circuit for relay 112, at the same time moving the brushes 114 to 117 one step in their secondary direction and also moving brush 118 off from its associated terminal. Thereafter, relay 112 and magnet 111 are free to interact in the manner hereinbefore described to move the brushes 114 to 117 until the calling line is encountered. When the calling line is reached a circuit will be extended from ground, the left hand armature and lower front contact of relay 224, brush 220, conductor 230, conductor 130, brush 114, left hand winding of relay 101, front contact and inner right hand armature of relay 113, winding of relay 112 to battery and ground. This will prevent relay 112 from becoming deenergized and the switch will be stopped at this point. As magnet 111 brings its armature to its completely operated position where its armature will break away from its contact, relay 101 will become operated, whereupon a direct ground connection is extended from ground, the innermost left hand armature and front contact of relay 101, brush 115 to the sleeve conductor of the calling line, which extends to the cut-off relay of said line.

Upon the first operation of relay 109, another circuit was established from ground, outer right hand armature and front contact of relay 109, winding of relay 119 to battery and ground. Now, upon the energization of relay 101, a locking circuit is established from ground, front contact and left hand armature of relay 119, right hand winding of relay 107, front contact and innermost right hand armature of relay 101, right hand winding of relay 101 to battery and ground. Relay 107 becomes energized in this circuit and releases the original energizing circuit of relay 109 so that relay 109 now depends for its energization upon the circuit extending through the winding of relay 104. This relay now becomes ener-

gized and establishes a circuit from ground, left hand armature and front contact of relay 103, alternate contacts of the armature of relay 104, winding of relay 104, inner left hand armature and front contact of relay 109, winding of relay 109 to battery and ground.

It will now be noted that upon the energization of relay 224 the circuit extending from ground, the armature and front contact of relay 223 through the back contact and outermost right hand armature of relay 224 to the winding of relay 304 for maintaining relay 304 energized was broken, and after a short interval relay 304 became deenergized. However, the line finder switch was prevented at this particular time from deenergizing due to a circuit extending from ground, the front contact and left hand armature of relay 105, front contact and armature 232 of relay 224, conductor 231, front contact and innermost right hand armature of relay 212, the right hand winding of relay 212 to battery and ground. The continued energization of relay 212 is effective in maintaining the line finder switch of Fig. 2 on the terminals of the called line until relay 105 becomes deenergized. When this occurs, as has been described, relay 212 retracts its armatures, whereupon the release circuit for relay 207 is established from ground, inner left hand armature and back contact of relay 208, back contact and middle right hand armature of relay 212, off normal contact 214, winding of release relay 207 to battery and ground. The energization of this relay returns brushes 217 to 221 to normal position. The release of relay 212 by removing ground from conductor 226 causes the release of relays 213 and 222, and this in turn causes the release of relay 224 so that the connection is now entirely normal in the link circuit.

As the brushes 116 and 117 encounter the terminals of the calling line, a circuit is established from battery, the right hand winding of relay 120, the normal contacts of the inner left hand armature of relay 121, the front contact and middle left hand armature of relay 101, brush 116 over the loop of the calling subscriber's substation, brush 117, outermost left hand armature and front contact of relay 101, normal contacts of the outermost left hand armature of relay 121, left hand winding of relay 120 to ground. Relay 120 becomes energized in this circuit. The release of relay 224, resulting also in the release of relay 103, opens the holding circuit of relay 109, but due to the energization of relay 101 the release relay 108 does not become energized and the ground which was extended by relay 109 to the winding of relay 119 is now replaced by ground extending from the outermost right hand armature and

front contact of relay 120. Relay 120 also extends a ground connection through its innermost right hand armature and front contact of the outermost talking conductor leading over the trunk to the central office, and thence through the back contact and armature of cut-off relay 122, winding of line relay 123 to battery and ground so that line relay 123 is energized and causes the signal lamp 124 to indicate to the operator at that point that a call has been initiated.

When the operator at the central office answers the call, she establishes a condition which will cause current to flow from ground over the tip or top conductor of the trunk line through relay 125, right hand armature and back contact of relay 126, the ring or lower conductor of the trunk line to battery. This will cause the energization of relay 125, whereupon a circuit is established from ground over the contact and armature of relay 125, winding of relay 127 to battery and ground. Relay 127 in turn establishes a circuit from ground, front contact and left hand armature of relay 127, right hand armature and front contact of relay 119, winding of relay 121 to battery and ground, whereupon relay 121 becomes energized and connects the calling line directly to the central office trunk. Relay 120 now becomes deenergized, thus removing the ground connection from the tip conductor leading to the central office. Relay 119, however, is maintained energized over a circuit from ground, front contact and left hand armature of relay 127, front contact and right hand armature of relay 121, winding of relay 119 to battery and ground so that relay 107 in series with the right hand winding of relay 101 is maintained energized. Upon the operation of relay 121, the supervisory relay 128 becomes energized, this relay establishing a circuit from ground, front contact and armature of relay 128, winding of relay 126 to battery and ground. Relay 126 opens the bridge across the trunk circuit so that relay 125 becomes deenergized, and at the same time substitutes a circuit for the energization of relay 127 so that during the conversational period relays 101, 121, 128, 107, 119, 126 and 127 are operated.

At the end of the conversation, when the calling subscriber hangs his receiver on its switchhook, relay 128 becomes deenergized, resulting, first, in the deenergization of relay 126; second, the deenergization of relay 127; third, the deenergization of relay 119; and fourth, the deenergization simultaneously of relays 107 and 101. The deenergization of relay 101 establishes a circuit from ground, the outermost right hand armature and back contact of relay 109, the back contact and outermost right hand armature of relay 101, off-normal contact 129,

release relay 108 to battery and ground, whereupon the release relay is energized and the trunk finder switch is returned to normal.

Those calling lines which are restricted in their service have a connection, which is shown in the dotted line extending from conductor 130 to the left hand winding of relay 102. Therefore, when relay 224 becomes energized, a circuit is established from ground, the left hand armature and lower front contact of relay 224, brush 220, conductor 230, conductor 130, the left hand winding of relay 102 to battery and ground. Relay 102 becomes energized and extends a connection from ground, front contact and armature of relay 102, conductor 136, conductor 236, armature 237 of relay 224, conductor 238, conductor 338, winding of relay 311 to battery and ground.

This causes the energization of relay 311 so that a circuit is now established from ground, outer right-hand armature and front contact of relay 212, conductors 226 and 326, outer left-hand armature and front contact of relay 311, normal contacts of the right-hand armature of relay 317, contact and armature of magnet 316, winding of relay 311, so that relay 311 becomes locked in this circuit. The energization of relay 311 also results in the opening of the holding circuit for relays 213 and 222 so that they become deenergized and open the circuit for relay 224 and this relay releases and stops the action of the trunk finder switch. Relay 311 places busy tone on the calling subscriber's line in the manner hereinbefore described to notify him that service over the central office trunk is denied whereupon the calling subscriber will hang up his receiver and abandon the connection. This causes the deenergization of relay 323 so that the link circuit is returned to normal in the manner hereinbefore described.

It will be understood that for each outgoing trunk circuit represented by Fig. 1, there is a relay 107. Thus, when a connection is extended to a trunk in the manner hereinbefore described, and all of the available trunks are busy, a connection is established from ground, left hand armature and front contact of relay 103, normal contacts of the left hand armature of relay 104, relay 105, conductor 106, left hand armatures and front contacts of relays 107, right hand winding of relay 102 to battery and ground, which will result in the energization of relay 102 with the same result just described in connection with a restricted service line, that is, the busy tone will be returned to the calling subscriber.

What is claimed is:

1. In a telephone system, lines, link circuits and trunks, switches for extending said lines to said links, switches for extend-

ing said links to said lines, other switches for extending said lines to said trunks, means responsive both to a series of N impulses and to a single impulse followed by a series of N impulses for moving said second mentioned switches to a definite point and responsive to a plurality of series of single impulses for causing the actuation of one of said other switches.

10 2. In a telephone system, lines, link circuits and trunks, means for extending said lines to said links, switches for extending said links to a called line, other switches for extending a calling line to said trunks, 15 and means responsive to a series of N impulses and to a single impulse followed by a series of N impulses for moving said first mentioned switches to a definite point for making connection with a particular called 20 line and responsive to a plurality of series of single impulses for causing the operation of one of said second mentioned switches to extend the calling line to one of said trunks.

3. In a telephone system, lines, trunks, a 25 switch for extending a calling line to any called line, a switch for extending a calling line to one of said trunks, means responsive

both to a series of N impulses and to a single impulse followed by a series of N impulses for moving said first mentioned switch to a 30 definite point to make connection with a particular called line and responsive to a plurality of series of single impulses for causing the actuation of said second mentioned switch to extend the calling line to 35 one of said trunks without disturbing said first mentioned switch.

4. In a telephone system, lines, link circuits and trunks, line finder switches for extending said lines to said links, connector 40 switches for extending said links to said lines, other line finder switches for extending said lines to said trunks, means in said links responsive both to a series of N impulses and to a single impulse followed by 45 a series of N impulses for moving said connector switches to a definite point and responsive to a plurality of series of single impulses for causing the actuation of one of said other line finder switches and the re- 50 lease of the line finder switch first involved.

In witness whereof, I hereunto subscribe my name this 19th day of July A. D., 1923.

EDWARD E. HINRICHSSEN.