

April 29, 1924.

1,492,092

R. S. WILBUR  
TELEPHONE SYSTEM

Filed Sept. 16, 1920

4 Sheets-Sheet 1

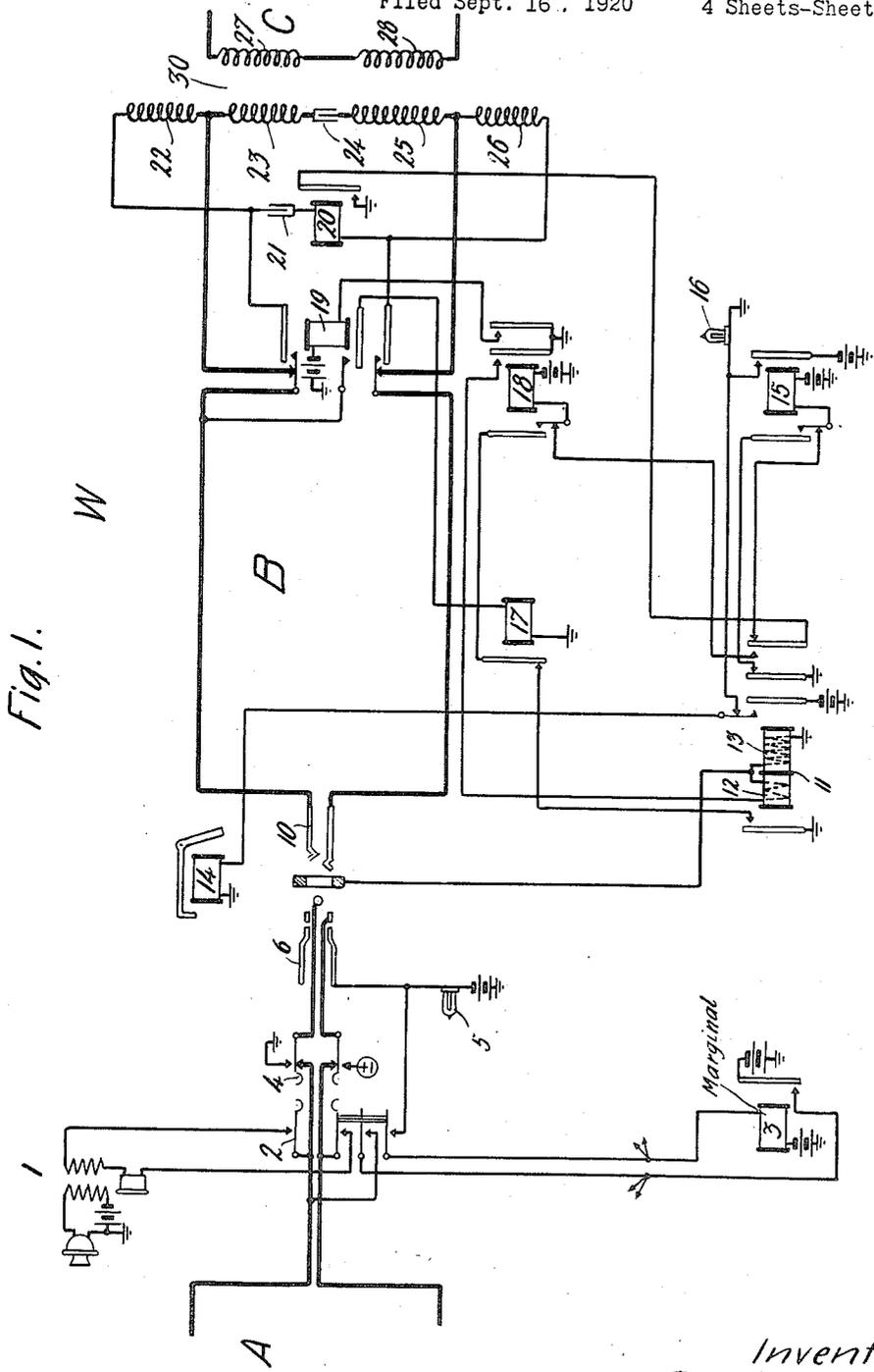


Fig. 1.

W

Inventor:  
Ray S. Wilbur

by

*J. Roberts*

Att'y.



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4 Sheets-Sheet 3

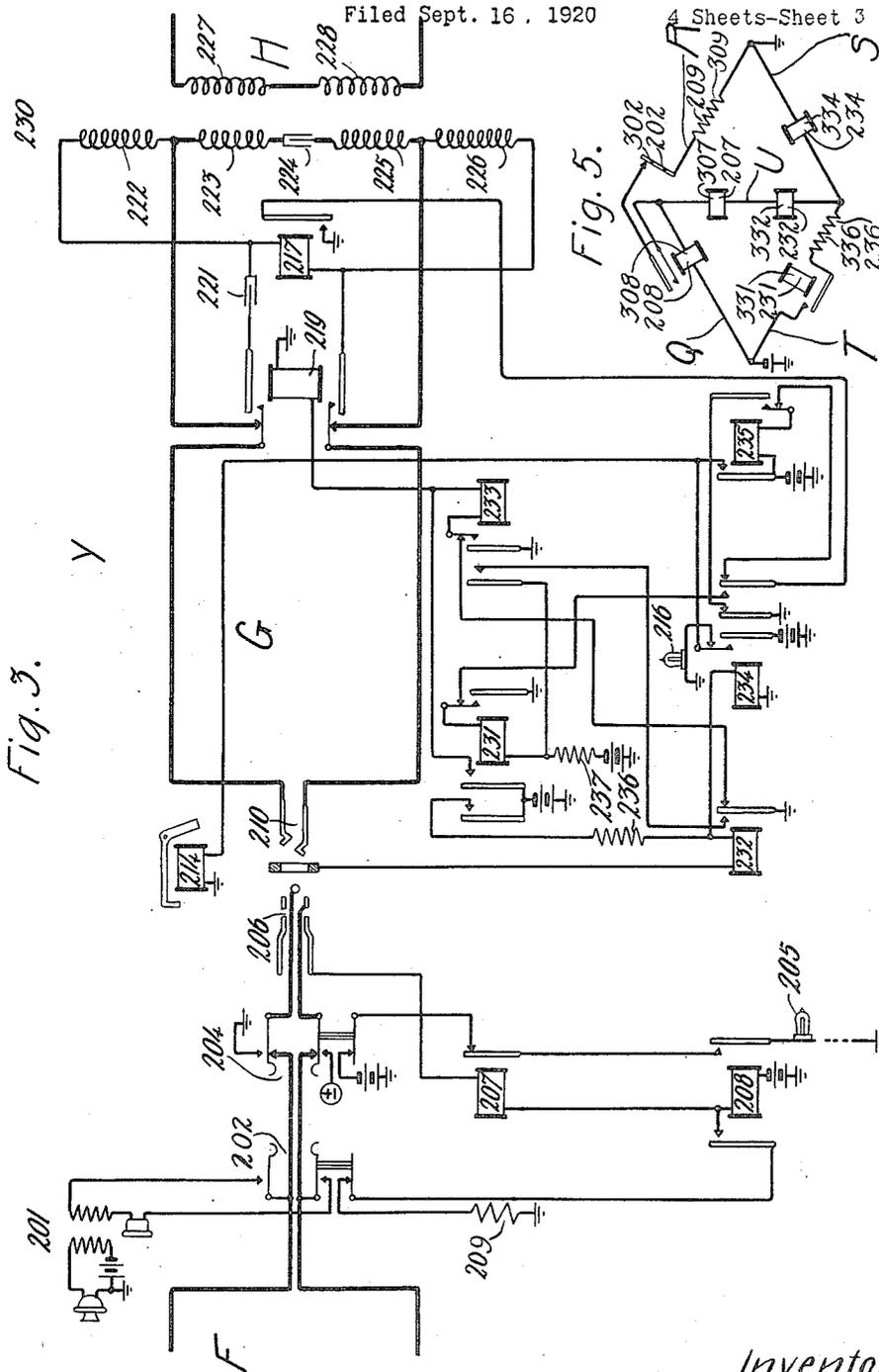
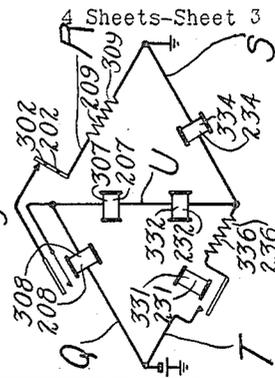


Fig. 5.



Inventor:  
Ray S. Wilbur

by *J. E. Roberts* Att'y.

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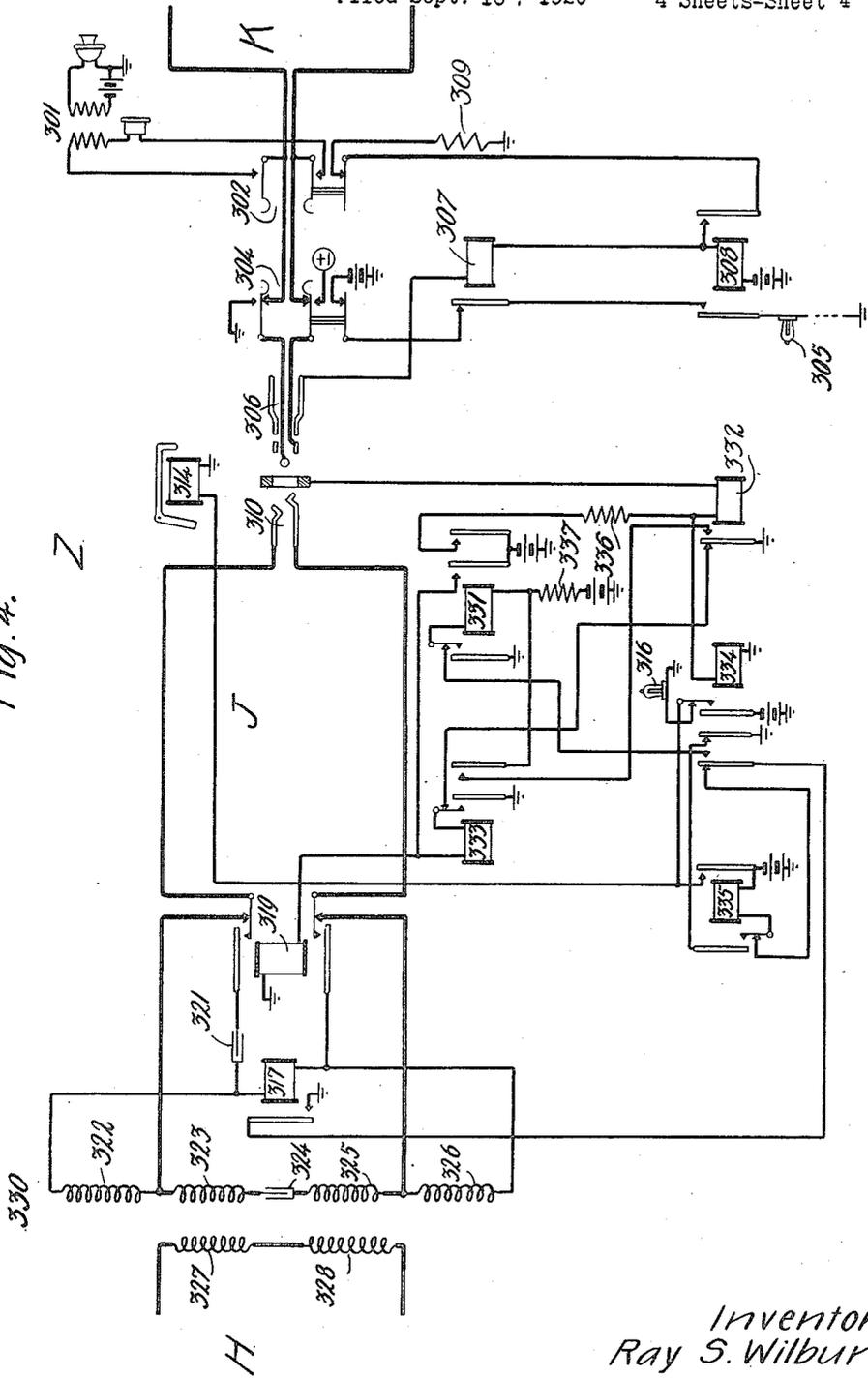
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4 Sheets-Sheet 4

Fig. 4.



Inventor:  
Ray S. Wilbur  
by J. E. Roberts Att'y

# UNITED STATES PATENT OFFICE.

RAY S. WILBUR, OF LYNDHURST, NEW JERSEY, ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

## TELEPHONE SYSTEM.

Application filed September 16, 1920. Serial No. 410,839.

*To all whom it may concern:*

Be it known that I, RAY SETH WILBUR, a citizen of the United States, residing at Lyndhurst, in the county of Bergen and State of New Jersey, 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 more particularly to such systems employing long transmission trunk lines over which both telephonic and signaling currents may be transmitted.

When long transmission lines interconnect widely separated offices or exchanges, it has been the practice to introduce at either end a so-called inequality type repeating coil to inductively join the line proper with the terminating apparatus at each station. These coils are designed to compensate for the difference at voice range frequencies between the impedance of the internal or terminating section of the line circuit and the apparatus associated therewith during conversation, as compared with the impedance of the external section of the line circuit. By thus equalizing the impedances of these portions of the talking circuit, the voice currents are most efficiently transmitted from one office to the other.

In one system of this nature, it has been proposed to provide means associated with the inequality type coils, which will also efficiently transmit therethrough signaling currents of infra voice frequencies, such as are ordinarily employed in signaling over the usual local subscriber's line circuits.

The object of this invention is to provide an improved signaling means for a system of this character.

One feature of the invention is the provision of means in a trunk line circuit of this character, for controlling the incoming calling and supervisory signals independently of the conversational circuits of the terminating sections of the line and of the associated operators' link circuits.

A further feature of the invention resides in the provision of means for converting the apparatus of the terminating sections of the line circuit from its normal condition, adapted to most efficiently transmit voice currents to a condition adapted to most

efficiently transmit signaling currents when it is desired to signal the distant office.

These and other features of the invention not specifically mentioned above, will be apparent from the following description and the embodiments thereof shown in the accompanying drawings, Figures 1 and 2 of which show a telephone trunk line interconnecting two stations or offices, in which the invention is embodied; Figures 3 and 4 show another embodiment applied to a similar trunk line circuit; while Figure 5 illustrates diagrammatically the Wheatstone bridge arrangement of a portion of the signal controlling apparatus shown in Figures 3 and 4.

Referring to the drawing, Figures 1 and 2 when placed end to end with Figure 1 at the left, show a long telephone trunk line circuit C interconnecting two telephone offices or exchanges W and X, and inductively coupled with internal or terminating sections B and D respectively, by means of repeating coils 30 and 130. Windings 27, 28 and 127, 128, respectively, cooperate during conversation with the associated windings 23, 25 and 123, 125, respectively, such windings being proportioned so as to provide the most efficient transmission of voice currents. Additional windings 22, 26, and 122, 126, associated respectively with windings 23, 25 and 123, 125 are so proportioned and associated with the other windings so as to provide the most efficient transmission of the relatively low frequency signaling currents into circuits containing responsive relays 20 and 120, respectively. These circuits are tuned for the low frequency signaling current, while they present very high impedances to the higher or voice frequency currents.

The terminating sections B and D are provided with jacks 10 and 110 respectively for cooperation with plugs 6 and 106 of operator's cord or link circuits A and E at offices W and X respectively. Only such portions of link circuits A and E are shown as are essential to a proper understanding of the invention. Usual line lamps 16 and 116, busy signaling devices 14 and 114, and cord circuit supervisory lamps 5 and 105 are provided at offices W and X respectively. These lamps and devices are controlled by relays which are associated with the

sleeve conductors of the line and cord circuits, and are dependent upon the responsive relays 20 and 120. Relays 19 and 119 are also controlled by ringing keys of the

5 associated cord circuits A and E to provide a more efficient path for the transmission of the outgoing signaling currents.

Figures 3 and 4 when placed end to end with Figure 3' at the left show a similar line  
10 circuit H, interconnecting offices Y and Z, and terminating thereat in internal or terminating sections G and J for association with operator's cord or link-circuits F and K. Usual line lamps 216 and 316, busy  
15 signal devices 214 and 314, and link circuit supervisory signal lamps 205 and 305 are controlled by responsive relays 217 and 317, independently of the talking circuit conductors, as in the case of the system illustrated in Figures 1 and 2. However, the various operating features are obtained by varying the connections of relays and resistances at each office which are placed in the form of the well known Wheatstone  
20 bridge, having arms Q, R, S, T and a galvanometer connection or portion U, as diagrammatically illustrated in Figure 5. The reference characters of the elements at each office are shown in Figure 5 so that the same  
25 figure clearly shows the arrangement at both offices.

It is thought that the invention may be more fully comprehended from the following description of the operation of the systems shown on the drawings.

Referring to Figures 1 and 2 and assuming that the operator at office W wishes to converse with the operator at office X, plug 6 of the cord circuit A is inserted into the  
40 jack 10 of the terminating section B. Relay 11 is operated over a circuit extending from battery through the lamp 5, sleeve contacts of plug 6 and jack 10, and high resistance winding 13 of relay 11 to ground. However,  
45 due to the high resistance of winding 13, lamp 5 does not receive sufficient current to cause its illumination. The operation of relay 11 causes the operation of busy signaling device 14 over an obvious circuit and disconnects the line lamp 16.

The operator at office W thereupon actuates the ringing key 4, establishing a circuit extending from the source of low frequency signaling current through the lower alternate contact of key 4, the ring contacts of  
55 plug 6 and jack 10, the lower normal contact of relay 19, the winding 26 of repeating coil 30, the winding of alternating current relay 20, the condenser 21, the winding 22 of repeating coil 30, the upper normal contact of relay 19, the tip contacts of jack 10 and  
60 plug 6, and the upper alternate contact of key 4 to ground. The circuit path including the winding of relay 20 and the condenser 21, being tuned to the frequency of

the signaling current being applied to the circuit just traced, ordinarily of 16 cycles per second, relay 20 operates. A circuit is completed by the operation of relay 20, which extends from battery through the  
70 winding and the left-hand normal contact of relay 18, the right-hand alternate contact of relay 11, and the contact of relay 20 to ground. Relay 18 thereupon locks over a circuit extending from battery through the  
75 winding and left-hand alternate contact of relay 18, the contact of relay 17, and the left-hand alternate contact of relay 11, to ground. The closure of the middle alternate contact of relay 18 supplies ground to the low resistance winding 12 of relay 11, thereby shunting the high resistance winding 13 of such relay by the low resistance  
80 winding 12, to increase the current flow through the lamp 5 sufficiently to permit it to glow. The closure of the right-hand alternate contact of relay 18 causes the operation of relay 19 over an obvious circuit, so that the ringing current thereafter traverses a circuit traced from the source of  
85 signaling current, through the lower alternate contact of key 4, the ring contacts of plug 6 and jack 10, the lower alternate contact of relay 19, the windings 26 and 25 of the repeating coil 30, the condenser 24, the  
90 windings 23 and 22 of the repeating coil 30 in series, the upper alternate contact of relay 19, the tip contacts of jack 10 and plug 6, and the upper alternate contact of key 4 to ground.

Thus ringing current is efficiently induced into the secondary windings 27 and 28 of the repeating coil 30 and traverses the external section of the trunk line circuit C to the office X, and flows through the windings 127 and 128 of the repeating coil 130  
105 thereat. By the medium of the coil 130, these signaling currents are induced into the secondary windings 122, 123, 125, and 126 thereof, and flow through the circuit tuned for such signaling currents, which includes the winding of relay 120 and the condenser 121. Relay 120 thereupon responds to such signaling current and completes a circuit which may be traced from battery through  
110 the winding and normal contact of relay 115, the left-hand normal contact of relay 111, and the contact of relay 120 to ground. Relay 115 thereupon operates and is locked in an operated condition over a circuit traceable from battery through the winding and right-hand alternate contact of relay 115 and the middle normal contact of relay 111 to ground. The lamp 116 is illuminated and busy signaling device 114 is operated  
115 over obvious circuits controlled by the closure of the left-hand alternate contact of relay 115. After maintaining the ringing key 4 actuated for the usual period, the operator at office W releases such key, where-  
120  
125  
130

upon relay 20 releases, but relays 18 and 19 remain operated since they are controlled by the sleeve relay 11. In like manner, due to the discontinuance of the ringing current by the release of key 4, relay 120 releases, but relay 115 remains operated since it is controlled by the sleeve relay 111.

In response to the illumination of the lamp 116, the operator at office X inserts plug 106 of cord circuit E into jack 110, thereupon completing a circuit from battery through lamp 105, the sleeve contacts of plug 106 and jack 110 and the high resistance winding 112 of relay 111 to ground. Relay 111 operates due to the current flowing through such circuit, but due to the high resistance of winding 112, such current is insufficient to cause the illumination of lamp 105. The opening of the middle normal contact of relay 111 causes relay 115 to release, thereby extinguishing lamp 116; but the closure of the middle alternate contact of relay 111 before the opening of its right-hand normal contact maintains the operations of busy signaling device 114 over an obvious circuit. The closure of the left-hand alternate contact of relay 111 shifts the connection of the armature of relay 120 to the normal contact of relay 118, while the closure of the right-hand alternate contact of relay 111 connects ground to the contact of relay 117.

The operator at office W, upon releasing the ringing key 4, actuates the listening key 2, thereby connecting the operator's telephone set 1 to the talking conductors of the link circuit A and the associated terminating section B of the trunk line extending to the office X. The closure of the lower local contact of key 2 causes the operation of a common marginal relay 3 over a circuit extending from battery through the winding of relay 3, the lower local contact of key 2, the sleeve contacts of plug 6 and jack 10, the low resistance winding 12 and the high resistance winding 13 of the relay 11 in parallel and the middle alternate contact of relay 18 to ground. Relay 3 is made marginal and operates only when, following the actuation of the listening key 2, the two windings 12 and 13 of relay 11 are in parallel relation as in the case where the operator at office W had previously actuated the ringing key 2 or an incoming ringing signal had been received prior thereto. The operation of relay 3 completes a circuit extending from battery through the contact of relay 3, the lower middle contact of key 2, the upper normal contact of key 4, the tip contacts of plug 6 and jack 10, the middle alternate contact of relay 19 and the winding of relay 17 to ground. Relay 17 thereupon operates and opens the locking circuit of relay 18 which, in releasing, causes the release of relay 19 to reestablish the original talking condition of the terminating circuit through

the normal contacts of such relay, as well as to open the branch circuit including the low resistance winding 12 of relay 11, so that the high resistance winding 13 of relay 11 is placed directly in circuit with the lamp 5 in multiple with the winding of relay 3, and the reduced current flow extinguishes such lamp but does not cause the release of relay 3.

The operator at office X, after inserting the plug 106 into the jack 110, actuates listening key 102 to connect the operator's set with the tip and ring conductors of the link circuit E and the associated terminating section D of the trunk circuit, for conversational purposes. The closure of the lower local contact of listening key 102 completes a circuit extending from battery through the winding of the marginal, common or positional relay 103, the lower local contact of key 102, the sleeve contacts of plug 106 and jack 110, and the high resistance winding 112 of relay 111 to ground. However relay 103 is marginal as in the case of relay 3 and does not operate when placed in series with the high resistance winding 112 of relay 111, therefore battery is not connected to the tip conductor of the cord circuit E and the terminating section D of the trunk circuit. The operators may thereupon converse, the voice currents flowing through the windings 123, 125, 127 and 128 of repeating coil 130 and the windings 27, 28, 23 and 25 of the repeating coil 30, such windings being properly proportioned to efficiently transmit currents within the voice range of frequencies.

Upon the completion of the conversation the operators release the listening keys 2 and 102, the release of key 2 causing the release of relay 3. The operator at office W thereafter actuates ringing key 4 to send a disconnect signal to the office X. The actuation of such ringing key completes a circuit similar to that originally traced upon the first actuation of such key, and causes the operation of ringing response relay 20 which again causes the operation and locking of relay 18 and the consequent operation of relay 19. As in the previous case, the operation of relay 19 changes the terminating section B of the trunk circuit to a condition suitable for the transmission of the signaling currents through the proper windings of repeating coil 30 into the external section of trunk circuit C, extending to the office X. These currents are received at the latter office through the proper windings of repeating coil 130 and, as previously mentioned, cause the operation of relay 120 and thereafter the operation of relay 118 over a circuit traceable from battery through the winding and right-hand normal contact of relay 118, the left-hand alternate contact of relay 111 and the contact of relay 120 to ground. Relay 118 closes an obvious circuit for relay 119,

which thereupon operates and interrupts the talking conductors of the terminating section D. The closure of the right-hand contact of relay 118 completes a locking circuit therefor, extending from battery through the winding and right-hand alternate contact of relay 118, the contact of relay 117 and the right-hand alternate contact of relay 111 to ground. The closure of the middle alternate contact of relay 118 connects ground to the low resistance winding 113 of relay 111, thereby placing such winding in parallel relation with the high resistance winding 112 of such relay permitting sufficient current to flow through the circuit including lamp 105 to cause its illumination to serve as a disconnect signal to the operator at office X.

The operator at office X may thereupon challenge by actuating the listening key 102 connecting the operator's set 101 to the conductors of the link circuit E, to ascertain whether it is desired to discontinue the conversation. Due to the parallel relation of the high and low resistance windings 112 and 113 of relay 111, relay 103 receives sufficient current to cause its operation. A circuit is thereby completed from battery through the contact of relay 103, the middle lower contact of key 102, the upper normal contact of key 104, the tip contacts of plug 106 and jack 110, the middle alternate contact of relay 119 and the winding of relay 117 to ground. In operating, relay 117 interrupts the locking circuit for relay 118, which releases to cause the release of relay 119 to restore the conductors of the terminating section D to talking condition. The ground is also removed from the low resistance winding 113 of the relay 111 so that lamp 105 is extinguished due to the reduced current flow through its circuit including the high resistance winding 112 of relay 111. Upon finding that the operator's telephone set at office W is disconnected, the operator at office X removes the plug 106 from the jack 110, thereupon restoring all apparatus to its normal condition.

Should the operator at office X fail to actuate listening key 102 to challenge the disconnection, the apparatus at office X is restored to normal upon the removal of the plug 106 from jack 110, since by this act relay 111 will release, thereby opening the locking circuit of relay 118, which releases and causes the release of relay 119.

Referring more particularly to Figures 3, 4 and 5 and assuming that the operator at office Y desires to converse with the operator at office Z, the plug 206 of the link circuit F is inserted into the jack 210 of the internal section G of the trunk circuit extending to office Z. By referring to Fig. 5, it will be noted that various relay windings resistances and contacts of keys and relays are included in the well-known form of

a Wheatstone bridge, composed of the arms Q, R, S and T, with the galvanometer portion U including the windings of two of the relays. The insertion of the plug 206 into the jack 210 completes the arms Q and S of the bridge including the galvanometer portion U, but leaves uncompleted the arms R and T. Relays 208, 207, 232 and 234 operate. The operation of relay 207 prevents the illumination of supervisory lamp 205, the circuit for which would otherwise be completed by the closure of the right-hand contact of relay 208. The closure of the left-hand contact of relay 208 includes the resistance 209 in the arm R of the bridge. The operation of relay 232 produces no material effect upon the system, at this time, other than to extend a ground connection to the left-hand alternate contact of relay 233. Relay 234 in operating, causes the operation of a busy signaling device 214 over a circuit extending from battery through the left-hand alternate contact of relay 234 and the winding of electromagnetic signaling device 214 to ground. The opening of the middle normal contact of relay 234 opens the locking circuit normally prepared for relay 235, and the opening of the right-hand normal contact of relay 234 followed by the closure of the right-hand alternate contact thereof transfers the connection leading to the contact of relay 217 from relay 235 to relay 231.

The operator at office Y thereupon actuates the ringing key 204, to complete a circuit for ringing or other signaling current extending from the source of such current through the lower alternate contact of key 204, the ring contacts of plug 206 and jack 210, the lower normal contact of relay 219, the winding 226 of the repeating coil 230, the winding of ringing response relay 217, the winding 222 of the repeating coil 230, the upper normal contact of relay 219, the tip contacts of jack 210 and plug 206, and the upper alternate contact of key 204 to ground. The opening of the local contact of key 204 prevents the illumination of the supervisory lamp 205 during the ringing period. Relay 217 operates and causes the operation of relay 231 over a circuit extending from battery through resistance 237, the winding and normal contact of relay 231, the right-hand alternate contact of relay 234, and the contact of relay 217 to ground. Relay 231 operating over this circuit, closes its left-hand alternate contact to complete the arm T of the Wheatstone bridge by including resistance 236 therein. Due to the balancing of the bridge relays 207 and 232 release. Lamp 205 is not illuminated due to the local contact of key 204 being open. The closure of the middle alternate contact of relay 231 causes the operation of relay 219 over an obvious circuit

and the operation of relay 233 over a circuit including the normal contact of relay 232. Relay 233 locks under control of relay 231. The closure of the right-hand alternate contact of relay 231, causes a locking circuit to be completed therefor, extending from battery through the resistance 237, and the winding and right-hand alternate contact of relay 231 to ground. The operation of relay 219 changes the path for the ringing current and such signaling current is thereupon passed over a circuit extending from the source of signaling current through the lower alternate contact of key 204, the ring contacts of plug 206 and jack 210, the lower alternate contact of relay 219, the windings 226, 225, 223 and 222 of repeating coil 230 in series, with the condenser 224, interposed between windings 225 and 223, the condenser 221, the upper alternate contact of relay 219, the tip contacts of jack 210 and plug 206 and the upper alternate contact of key 204 to ground.

This current is induced into the external section H of the trunk circuit extending to the office Z by means of the cooperating windings 227 and 228 of the repeating coil 230. The current, upon arriving at office Z, flows through the windings 327 and 328 of the repeating coil 330, and is induced into the circuit including the ringing response relay 317 by means of the serially interconnected windings 322, 323, 325 and 326 of repeating coil 330. The circuit including the winding of relay 317 and the latter-mentioned windings of repeating coil 330, is resonant to the frequency of the signaling current impressed upon the line circuit by the ringing key 204. Therefore, relay 317 operates and causes the operation of relay 335 over a circuit extending from battery through the winding and normal contact of relay 335, the left-hand normal contact of relay 334 and the contact of relay 317 to ground. Relay 335, in closing its left-hand alternate contact, completes a locking circuit therefor, extending from battery through the winding and left-hand alternate contact of relay 335 and the middle normal contact of relay 334 to ground. The closure of the right-hand alternate contact of relay 335 completes obvious circuits for busy signaling device 314 and line lamp 316.

The operator at office Z, observing the illumination of lamp 316, inserts plug 306 of link circuit K into the jack 310 of the terminating section J of the trunk line circuit extending to the office Y. As in the case of the equipment at office Y, certain of the apparatus at office Z cooperates to form a Wheatstone bridge, as shown in Fig. 5. Following the insertion of the plug 306, the arms Q and S of the bridge including the galvanometer portion U are completed, while the arms R and T are uncompleted.

Relays 308, 307, 332 and 334 which are serially included in the completed portions of the bridge operate in response to the current flowing therethrough. The operation of relay 307 prevents the illumination of the supervisory lamp 305, the circuit for which would otherwise be completed by the operation of relay 308. The closure of the right-hand contact of relay 308 includes the resistance 309 in the arm R of the bridge, but produces no other material effect at this time. The operation of relay 332 produces no material effect at this time, except to extend a ground connection to the right-hand alternate contact of relay 333, the purpose of which will be evident from the further description of the operation. The operation of relay 334 causes the extinguishment of the lamp 316 by the opening of the right-hand normal contact of such relay, and by the closure of its right-hand alternate contact relay 334 provides a substitute circuit to maintain the busy signaling device 314 in an operated condition, after the relay 335 is released by the opening of the middle normal contact of relay 334. By the opening of the left-hand normal contact and the closure of the left-hand alternate contact, the conductor leading to the contact of relay 317 is transferred from its normal connection with the winding of relay 335, to a connection with the winding of relay 331.

Assuming that the operator at office Y has restored the ringing key 204 prior to the insertion of the plug 306 into the jack 310, the operator at office Y actuates the listening key 202, thereby opening the arm R of the Wheatstone bridge at such office, and, as a result of this circuit change, relays 207 and 232 again operate, relay 207, as before, preventing the illumination of lamp 205; but the operation of relay 232 at this time completes a short circuit around the winding of relay 231, such circuit including the left-hand alternate contact of relay 233 and the alternate contact of relay 232. Relay 231 thereupon releases the opening of its middle alternate contact causing the release of relay 219, which restores the terminating section Y of the trunk circuit to its normal talking condition, in which the conductors leading from the tip and ring contacts of the jack 210 are bridged by the windings 223 and 225 of the repeating coil 230 interconnected by condenser 224. The opening of the left-hand alternate contact of relay 231 also opens the arm T of the bridge, but produces no other material effect at the present time. Relay 233 also releases, due to the opening of the middle alternate contact of relay 231, but no other effect is produced thereby, except to remove the short circuit established around the winding of relay 231.

After inserting the plug 306 into the jack

310, the operator at office Z actuates listening key 302, thereby opening the arm R of the bridge at such office. Such action, however, produces no other material effect upon the system. The closure of the alternate contacts of key 302, places the operator's telephone set 301 in direct connection with the tip and ring conductors of the cord circuit K and the terminating section J of the trunk circuit. The operators at office Y and Z may thereupon converse over a circuit which is designed for the most efficient transmission of currents of talking frequencies, such circuit including the normal contacts of the relays 319 and 219 and the windings 323, 325, 327 and 328 of the repeating coil 330 at office Z, and the corresponding windings 227, 228, 223 and 225 of repeating coil 230 at office Y. The branch circuit including the ringing response relay 217 and the windings 222 and 226 of repeating coil 230, and the corresponding branch circuit including the ringing response relay 317 and the windings 322 and 326 of the repeating coil 330 at office Z, being adapted to receive the low frequency signaling current to the best advantage, and to present a very high impedance to the higher frequencies used in the transmission of the voice currents, do not materially interfere with the conversation.

At the termination of the conversation, or whenever the operator at office Z wishes to signal the operator at office Y the actuation of the ringing key 304, transmits current from the source of signaling current through the lower alternate contact of the ringing key 304, the ring contacts of plug 306 and jack 310, the lower normal contact of relay 319, the winding 326 of repeating coil 330, the winding of relay 317, the winding 322 of repeating coil 330, the upper normal contact of relay 319, the tip contacts of jack 310 and plug 306 and the upper alternate contact of ringing key 304 to ground. Ringing response relay 317 operates, causing the operation of relay 331 over a circuit extending from battery through the resistance 337, the winding and normal contact of relay 331, the left-hand alternate contact of relay 334, and the contact of relay 317 to ground. Relay 331 thereupon locks over a circuit extending from battery through the resistance 337 and the winding and left-hand alternate contact of relay 331 to ground. The closure of the right-hand alternate contact of relay 331 completes the arm T including resistance 336, of the Wheatstone bridge at office Z, and since the arm R has also been connected in circuit the bridge is thereby completed. The bridge is so designed that a balance now exists and relays 332 and 307 release since no current flows through portion U of the bridge. However, the lamp 305 is not lighted during the actuation of key 304 since the continuity of the circuit therefor is interrupted at the local contact of the ringing key 304. The closure of the middle alternate contact of relay 331 causes the operation of relays 319 and 333. The circuit for relay 319 is obvious, while the circuit for relay 333 extends from battery through the middle alternate contact of relay 331, the winding and normal contact of relay 333, and the normal contact of relay 332 to ground. While relay 319 is operated, the ringing current applied to the conductors of the cord circuit flows through the alternate contacts of relay 319 and the windings 326, 325, 323 and 322 of the repeating coil 330, the condenser 324, interposed between the windings 325 and 323, and the condenser 321. These windings, when cooperating with the windings 327 and 328 of the repeating coil 330, are particularly adapted for the transmission of signaling current of the character being applied to the cord circuit, and such signaling current is projected over the external section H of the trunk circuit to the office Y, where it is induced through the windings 227 and 228 into the windings 222, 223, 225, and 226 of the repeating coil 230, the windings 223 and 225 being separated by the condenser 224, and then flows through the winding of ringing response relay 217, causing its operation. The operation of relay 217 causes the operation of relay 231 over a circuit extending from battery through the resistance 237, the winding and normal contact of relay 231, the right-hand alternate contact of relay 234 and the contact of relay 217 to ground. The closure of the middle alternate contact of relay 231 causes the operation of relay 219, while the closure of the left-hand alternate contact of relay 231 completes the arm T of the Wheatstone bridge at office Y by including the resistance 236 therein. The bridge circuit is now completed and is so designed that it is now balanced, accordingly relays 207 and 232 receive no current and consequently release. Relay 207, in releasing, completes a circuit extending from battery through the local contact of key 204, the contact of relay 207 and the right-hand alternate contact of relay 208 and the lamp 205 to ground. The illumination of the lamp 205 serves as a signal to the operator at office Y. The release of relay 232 causes the operation of relay 233 over a circuit extending from battery through the middle alternate contact of relay 231, the winding and normal contact of relay 233 and the normal contact of relay 232 to ground. Relay 231 thereupon locks over a circuit extending from battery through resistance 237, and the winding and right-hand alternate contact of relay 231 to ground. Relay 233 also

locks over a circuit extending from battery through the middle alternate contact of relay 231, and the winding and right-hand alternate contact of relay 233 to ground.

5 In response to the illumination of the lamp 205, the operator at office Y may challenge by the actuation of the listening key 202 and finding that the signal is intended to serve as a disconnect signal, plug 206 is  
10 removed from jack 210. The opening of the local contact of the listening key 202 opens arm R of the bridge whereupon relays 207 and 232 reoperate. Relay 232 in operating completes a short circuit around  
15 the winding of relay 231, which includes the alternate contact of relay 232 and the left-hand alternate contact of relay 233. Relay 231 thereupon releases, causing the subsequent release of relays 233 and 219. Re-  
20 lays 232 and 234 also release when the plug 206 is removed from the jack 210, thereby restoring the busy signaling device 214 to normal. Relay 217 is restored to normal upon the restoration of ringing key 304.  
25 After the plug 206 is removed, or while removing such plug, the operator at office Y maintains the listening key 202, actuated, thereby opening the locking circuit of relay 208, which would extend from battery  
30 through the winding of relay 208, the local contact of key 202, the left-hand alternate contact of relay 208 and the resistance 209 to ground. Thus the release of relay 208 is insured.

35 In a like manner, the operator at office Z, after restoring the ringing key 304, removes the plug 306 from the jack 310, causing similar operations of the similar relays as described in connection with the discon-  
40 nnection of the plug 206 from the jack 210. Similarly the operator at office Z also maintains the listening key 302 actuated during the removal of the plug in order to prevent the locking of the relay 308. All apparatus  
45 at each office is thereby restored to normal.

What is claimed is:

1. In a telephone system, in combination, a transmission line having an external and a terminating section, a repeating coil hav-  
50 ing primary and secondary windings, said primary and said secondary windings efficiently transmitting currents within the voice range of frequencies, additional wind-  
55 ings for the repeating coil for cooperation with said windings for efficiently transmitting low frequency currents, a source of low frequency current, and switching means associated with the terminating section respon-  
60 sive to said low frequency current for converting said coil from a condition for transmitting one of said currents to a condition for transmitting the other of said currents.

2. In a telephone exchange system, two  
65 offices, a trunk circuit extending between the

a repeating coil at each office having pri-  
mary and secondary windings for giving a  
certain ratio of transformation, additional  
windings associated with each of said coils  
for giving a different ratio of transforma-  
tion, and switching means at each terminat-  
ing section responsive to the transmission of  
signaling current over the trunk circuit for  
changing the ratio of transformation. 70

3. In a telephone exchange system, two  
75 offices, a trunk circuit interconnecting the offices, a terminating section associated therewith at each office, normally continuous conductors included therein, a source of sig-  
80 naling current at one office, switching means for associating the source with the terminat-  
ing section thereat, means responsive thereto to interrupt the conductors of both ter-  
minating sections, an operator's telephone  
set at the first-mentioned office, additional  
85 switching means for connecting the tele-  
phone set with the associated terminating  
section, and means responsive thereto for  
restoring the continuity of the conductors  
of the associated terminating section. 90

4. In a telephone exchange system, two  
offices, a trunk circuit interconnecting the  
offices, a source of signaling current at one  
office, switching means thereat for associat-  
ing the source with the trunk circuit, means  
95 at the other office responsive to the current  
from the source, a trunk signaling device  
controlled thereby, means for maintaining  
the trunk signaling device operated after the  
release of the switching means, a link cir-  
100 cuit including a signaling conductor, a sig-  
naling conductor for the trunk circuit at  
said other office, a supervisory signaling de-  
vice associated with the link circuit and  
controlled over the signaling conductor  
105 thereof, means responsive to the connection  
of the link circuit with the trunk circuit to  
remove the trunk signaling device from and  
to transfer the supervisory signaling de-  
vice to the control of the responsive means,  
110 a double wound relay included in the sig-  
naling conductor of the trunk circuit, and  
means associated with the trunk circuit to  
shunt one of the windings of the relay upon  
the actuation of the switching means during  
115 the interconnection of the link and trunk  
circuits thereby operating the supervisory  
signaling device and maintaining the super-  
visory signaling device operated after the  
release of the switching means. 120

5. In a telephone exchange system, two  
offices, a trunk circuit interconnecting the  
offices, a source of signaling current at one  
office, switching means thereat for associat-  
ing the source with the trunk circuit, means  
125 at the other office responsive to current from  
the source, a trunk signaling device con-  
trolled thereby, means for maintaining the  
trunk signaling device operated after the re-  
lease of the switching means, talking and 130

- signaling terminating conductors for the trunk circuit at the other office, a link circuit thereat including talking and signaling conductors for connection with the trunk circuit, a supervisory signaling device associated with the link circuit, means responsive to the connection of the link circuit with the trunk circuit to remove the trunk signaling device from and to transfer the supervisory signaling device to the control of the responsive means, means associated with the trunk circuit to operate the supervisory signaling device upon the actuation of the switching means during the interconnection of the link and the trunk circuits and to maintain the supervisory signaling device operated after the release of the switching means, said means including the signaling conductors of the trunk and link circuits, means associated with the link circuit to connect a source of current to one of the interconnected talking conductors, and means controlled thereby to restore the supervisory signaling device.
6. In a telephone exchange system, two offices, a trunk circuit interconnecting the offices, a source of signaling current at one office, switching means thereat for associating the source with the trunk circuit, means at the other office responsive to the current from the source, a trunk signaling device controlled thereby, means for maintaining the signaling device operated after the release of the switching means, a link circuit at the other office for connection with the trunk circuit, a supervisory signaling device associated therewith, means responsive to the connection of the link circuit with the trunk circuit to remove the trunk signaling device from and to transfer the supervisory signaling device to the control of the responsive means, means associated with the trunk circuit to operate the supervisory signaling device upon the actuation of the switching means during interconnection of the link and trunk circuits and to maintain the device operated after the release of the switching means, an operator's telephone set at the other office, switching means for associating the set with the link circuit, and means controlled over the interconnected talking conductors of the link and trunk circuits and responsive to the association of the operator's set with the link circuit to release the supervisory signaling device.
7. In a telephone exchange system, two offices, a trunk circuit interconnecting the offices, a source of signaling current at one office switching means thereat to associate the source with the trunk, means associated with the trunk responsive to the signaling current, a terminal for the trunk circuit thereat including talking and signaling conductors, a link circuit including talking and signaling conductors connected therewith, a supervisory signaling device associated with the link circuit, means controlled by the responsive means and including interconnected signaling conductors of the link and trunk to operate the supervisory signaling device, and means associated with the trunk circuit and controlled over one of the interconnected talking conductors of the link and trunk to restore the signaling device to normal.
8. In a telephone exchange system, a trunk circuit interconnecting a first and a second office, terminating sections therefor at each office including talking and signaling conductors, a source of ringing current at the first office, means for connecting the source to the associated terminating section, a link circuit connected with the trunk circuit at the second office including talking and signaling conductors, a supervisory signaling device thereat, a relay at the second office responsive to the ringing current received from the first office to operate the supervisory signaling device by means of current flowing over the interconnected signaling conductors of the link and trunk circuits and to connect a second relay to one talking conductor of the trunk circuit, and operator-controlled means included in the link circuit to operate the second relay by current flowing over one of the interconnected talking conductors, thereby restoring the supervisory signaling device.
9. In a telephone system, line sections of different impedances for the transmission of currents of different ranges of frequencies, means inductively coupling said sections, said means compensating for differences in the impedances of the sections for the said ranges of frequencies, means operative incident to the establishment of a connection over said sections for altering the inductive coupling of said sections, a link circuit for connection with one of the line sections, a supervisory signal therein, and means associated with another of the line sections for controlling said signal by the current of one of the ranges over said line sections.
10. In a telephone exchange system, two offices, a trunk line extending between said offices divided into inductively coupled sections for the transmission of currents of different frequencies, said sections having different impedances, means associated with said sections operative incident to the establishment of a connection over said sections for compensating for the differences in impedances of the sections by altering the inductive coupling thereof, a link circuit at one of the offices connected to the trunk line, a supervisory signal therein, and means at the other office for controlling said signal by one of said frequencies over said trunk line.

11. In a signaling system, a transmission line divided into sections, means for applying currents of various frequencies to said line, a repeating coil joining said sections, and means selectively responsive to currents of different frequencies applied to said line to vary the ratio of transformation of said inductive repeating coil. 15

12. In a signaling system, a signal transmission path divided into sections, means for applying currents of various frequencies

to said path, inductive repeating means joining said sections, and means selectively responsive to currents of different frequencies applied to said path to vary the ratio of transformation of said inductive repeating means.

In witness whereof, I hereunto subscribe my name this 11th day of September, A. D., 1920.

RAY S. WILBUR.