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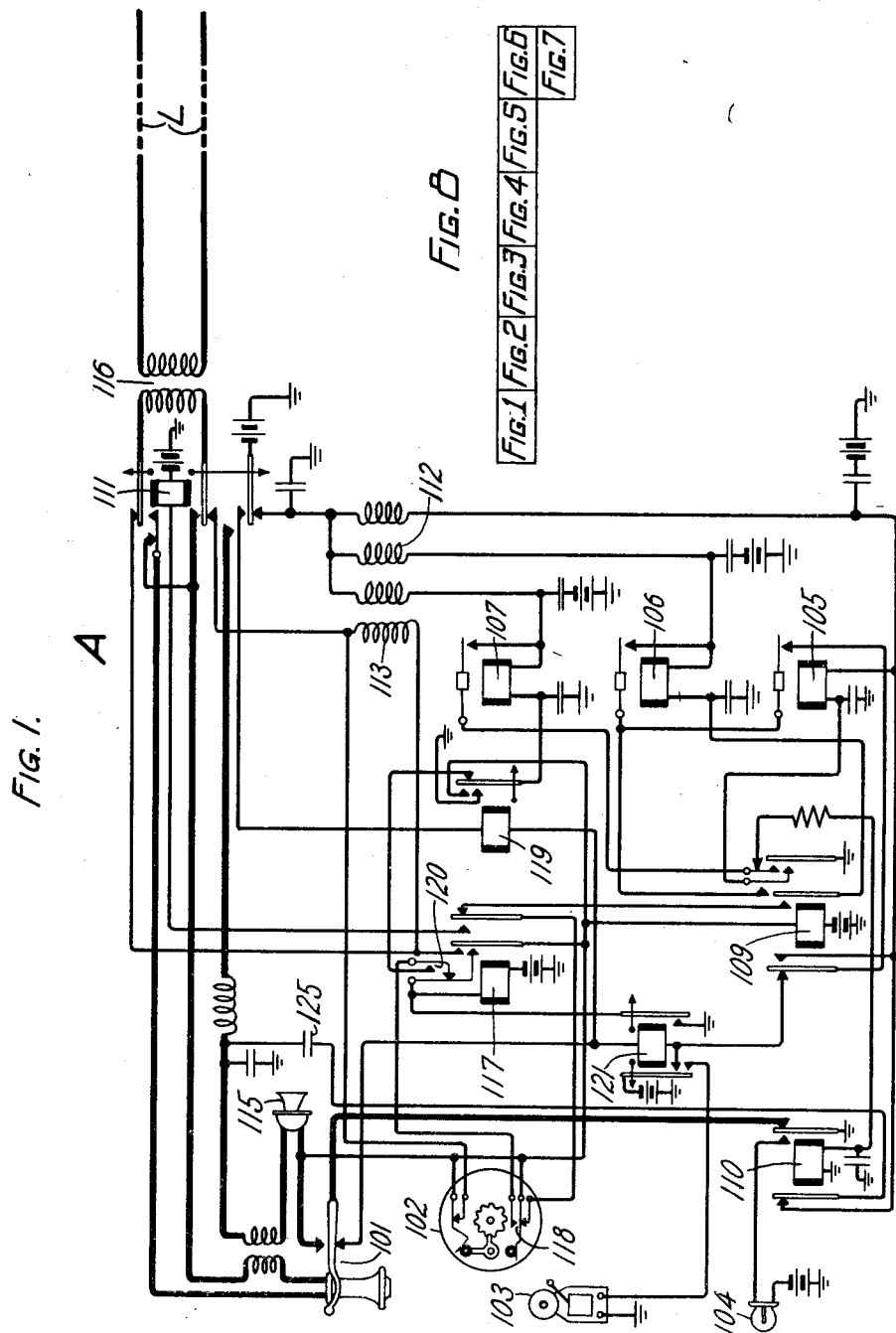
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1,823,120

SIGNALING AND COMMUNICATION SYSTEM

Filed Dec. 23, 1927

7 Sheets-Sheet 1



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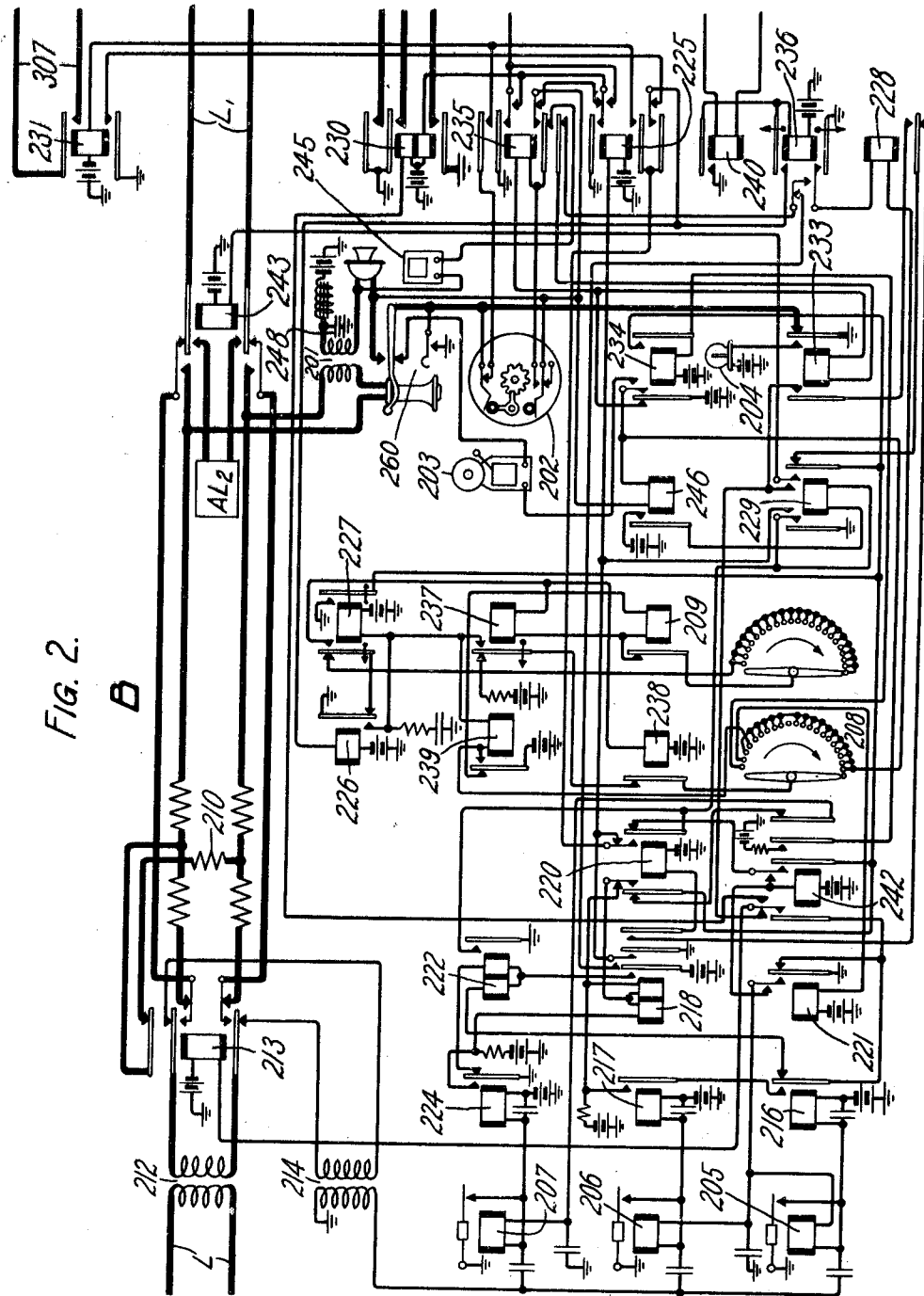
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SIGNALING AND COMMUNICATION SYSTEM

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7 Sheets-Sheet 2



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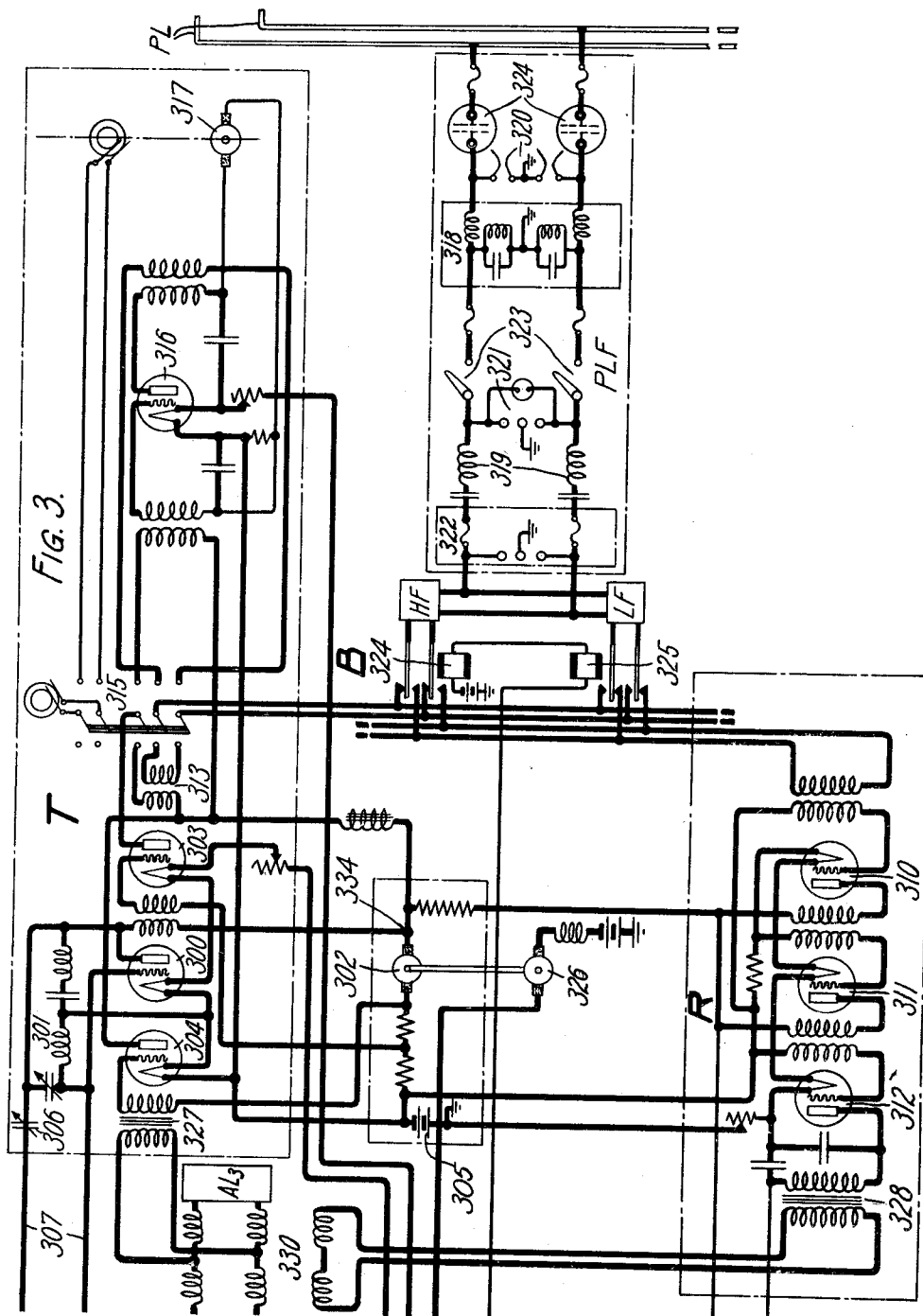
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7 Sheets-Sheet 3



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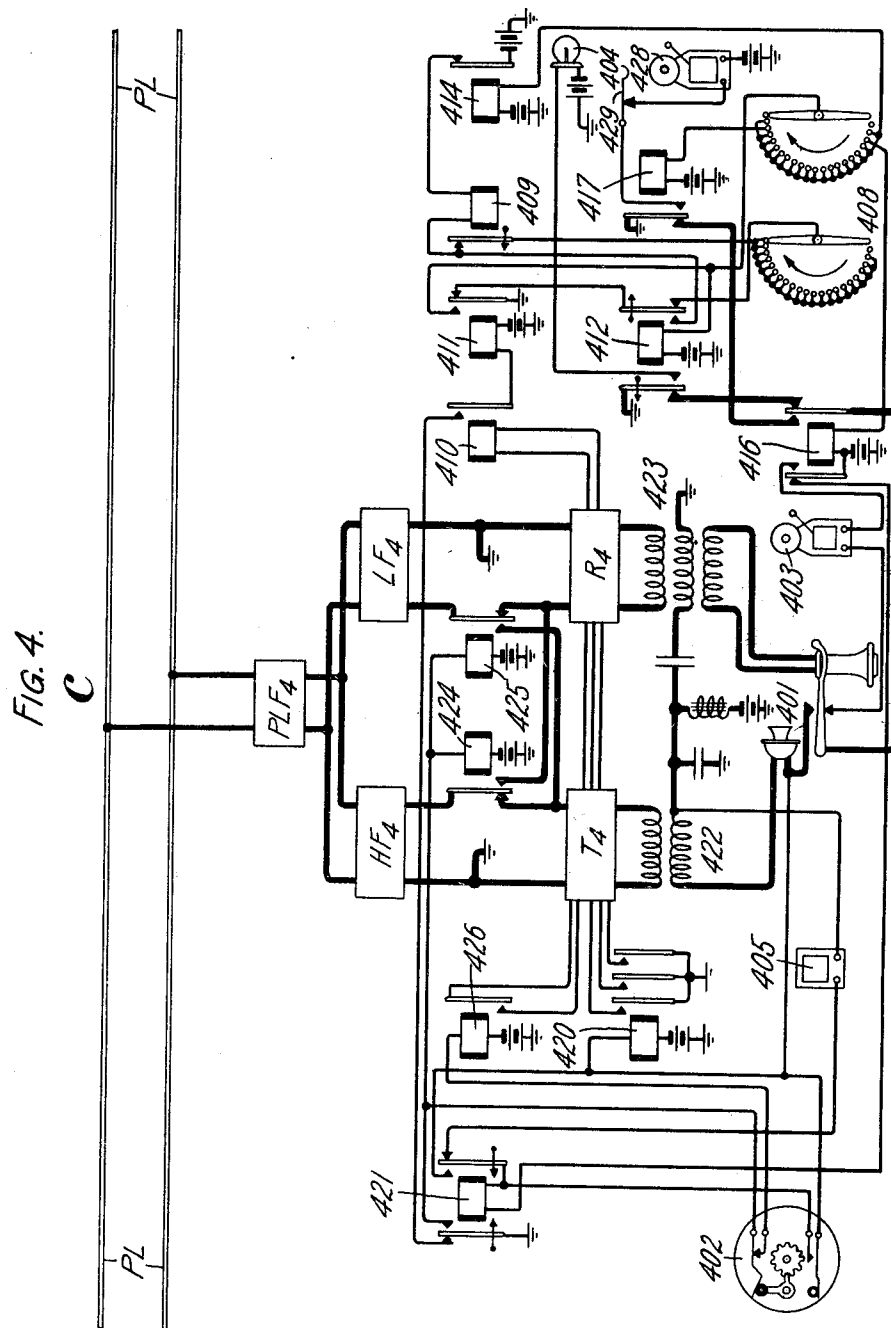
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SIGNALING AND COMMUNICATION SYSTEM

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7 Sheets-Sheet 4



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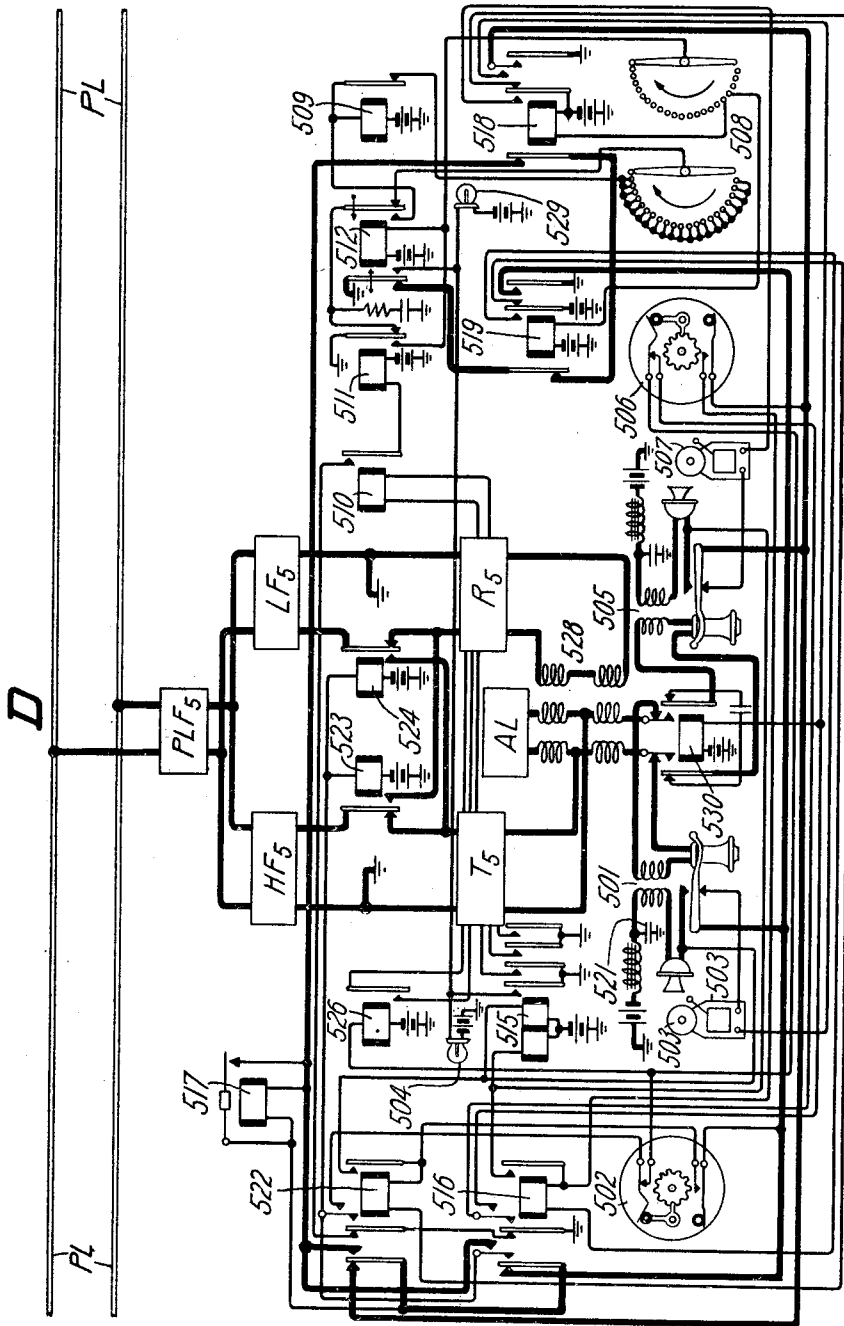
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SIGNALING AND COMMUNICATION SYSTEM

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FIG. 5.



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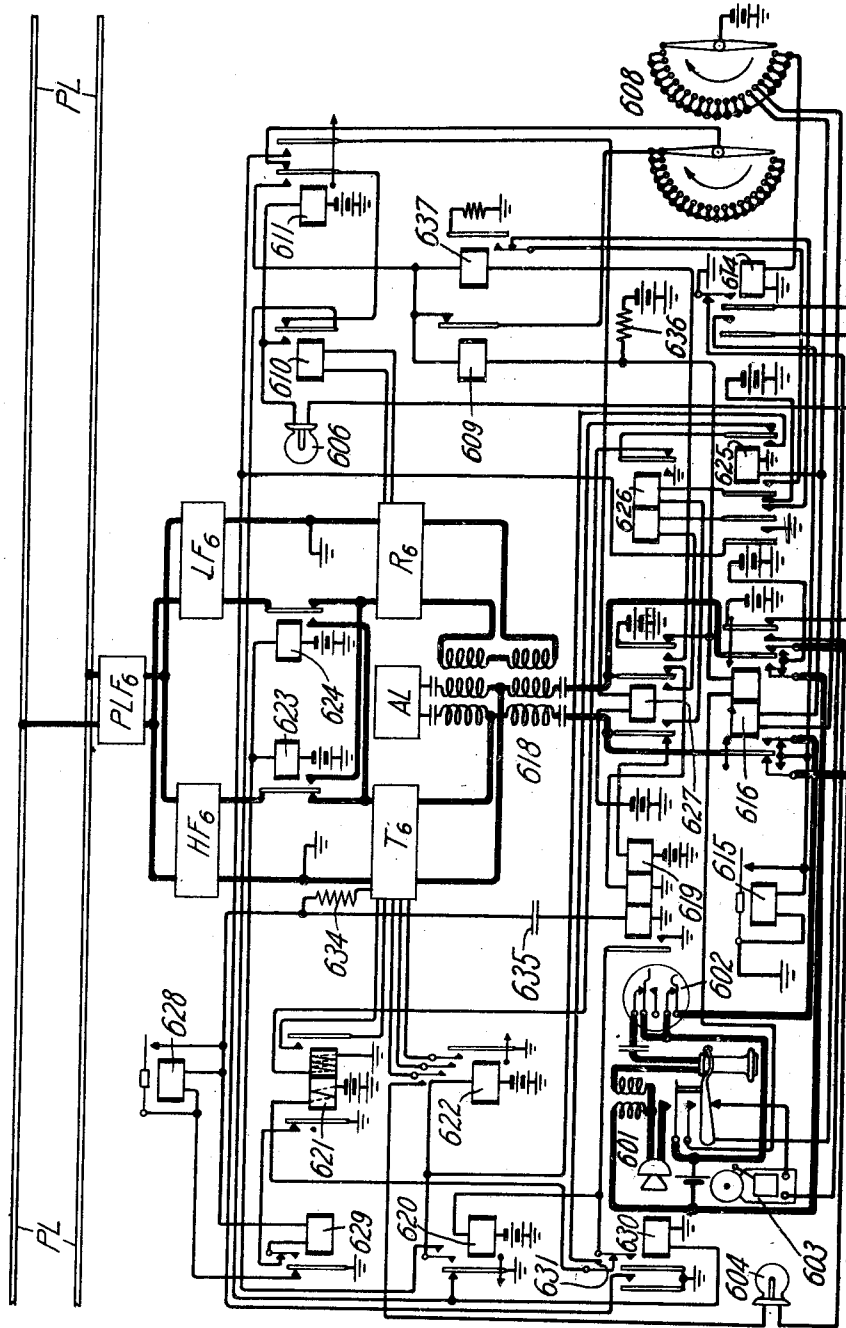
SIGNALING AND COMMUNICATION SYSTEM

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Fig. 6.

E



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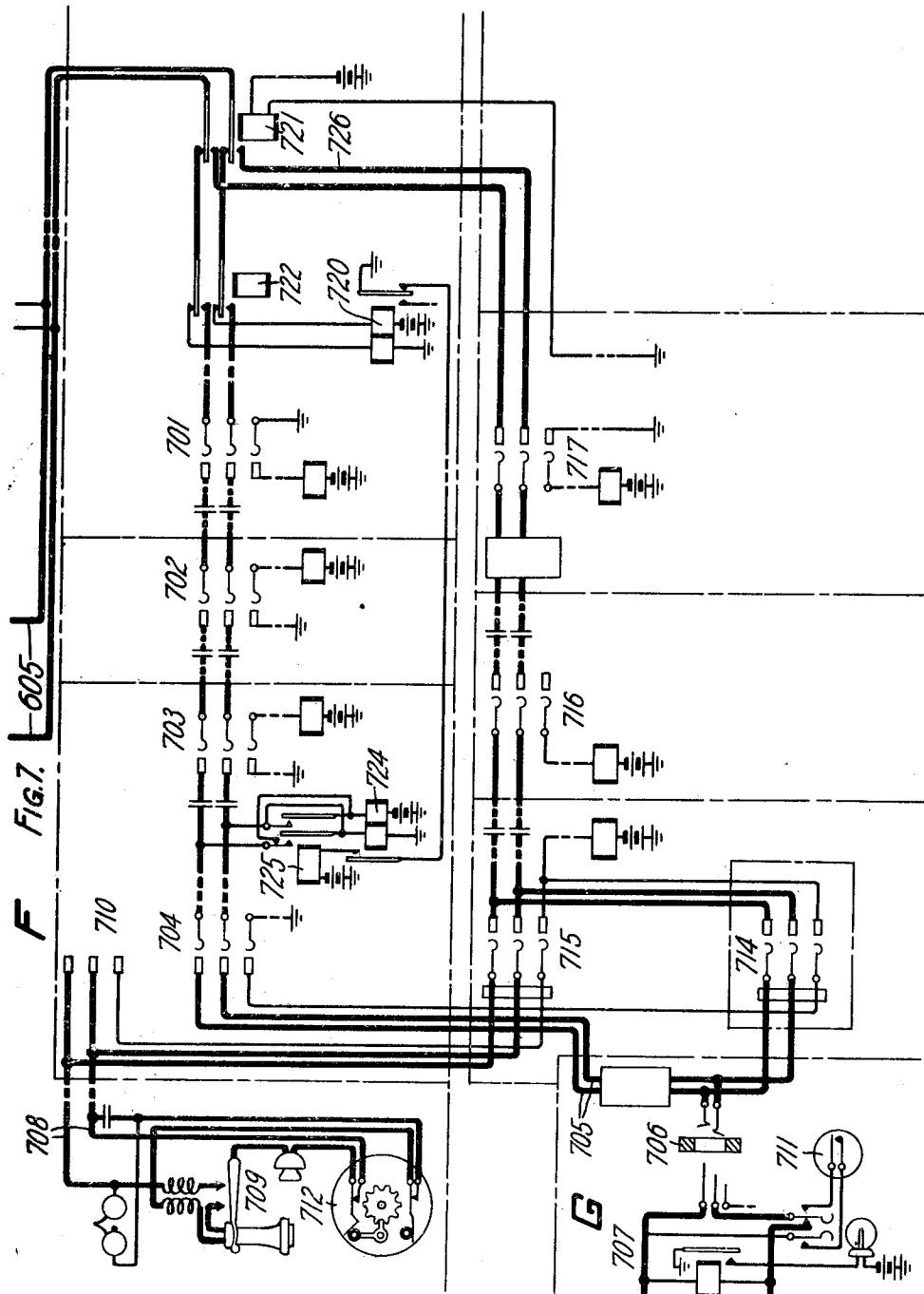
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SIGNALING AND COMMUNICATION SYSTEM

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7 Sheets-Sheet 7



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SIGNALING AND COMMUNICATION SYSTEM

Application filed December 23, 1927. Serial No. 242,023.

This invention relates to telephone systems and particularly to improvements in signaling and telephonic communication over power lines.

5 According to this invention means are provided whereby high frequency currents superimposed on the power currents of such lines are employed as the signaling media and the speech current carriers between connectively
10 associated points with the circuits and apparatus arranged so that the procedure in calling from any point may correspond with established methods of switching control from subscriber stations in automatic telephone exchange working and also to afford supervisory
15 effects of the same character as those commonly employed and well understood in the handling of manual telephone exchange traffic.

20 Certain of the features of the invention reside in means; whereby initiation of a call will result in a dialing signal when the circuits are available for use; whereby dialing operations set up "busy" indications at all
25 other points or stations on the power line system, while the other stations will also be disabled against interfering with the calling operations; whereby when the dialing is completed a call signal at the selected station is
30 operated and the devices conditioned to permit the called station only to answer the call. The establishing of a connection is therefore completely controlled by the usual manipulation of an ordinary subscriber telephone set
35 at a calling station.

Other features reside in arrangements; whereby certain connections are retained under control of a "called" station only, that
40 is, after response at a called station disconnection at that point only may release the connection; whereby, after a connection has been released by a called station and the calling station fails to disconnect, any other station
45 may in initiating a call, disable the former calling station and establish the busy signal and an interference bar against that station; whereby provision is made to permit certain stations to take precedence over other stations and appropriate the circuits irrespective of
50 the busy signal and bar or "lock out" condi-

tion, as may be desirable in certain emergencies; and whereby if a called station fails to answer the circuits will be restored when the calling station abandons the call and disconnects.

Other features of the invention provide that signaling and dialing impulses be formed from the high frequency currents which are also used as the carrier agent for speech
55 currents from a calling station, while a current of different frequency may serve as the carrier for speech currents from a called station.

Another feature of the invention resides in means for extending the same simplified order
60 of operating procedure to lines tributary to a main power circuit system. The tributary line may terminate at the remote end in a subscriber station or in a telephone exchange, while certain equipment is provided intermediate such line and the power line equip-
65 ment. Connections may be established between the tributary line station and any station associated with the power line.

Other features relating to the tributary
70 lines reside in means; whereby impulses formed of various combinations of currents of different frequencies are employed over the tributary lines for dialing and signal control in each direction, in establishing and
75 controlling connections; whereby tributary lines may be opaque to direct currents; whereby the talking current from a tributary line is arranged to modulate the carrier
80 current supplied at the junction point of the tributary line and the power line; whereby the carrier current for transmission from a power line station to a tributary line is suppressed so that the speech frequency or modulated effects only are transmitted from the
85 junction point over the tributary line; whereby the currents of different frequencies employed as signaling and dialing impulses over the tributary line are produced by differently tuned electromagnetic vibrators associated with the tributary line; and where-
90 by certain of said electromagnets serve dually as vibrators and as relays.

Other features relating to the tributary line connections reside in means; whereby,
100

when a connection has been established and has been responded to at a power line station proper, control over the connection is automatically released from the tributary line and will rest entirely with the connected power line station; whereby after connection has been completed over a tributary line and the circuits have come to the "talking" position the signaling and dialing equipments are automatically disconnected from the tributary line; and whereby various network and automatic switching controls therefor are provided at certain points for insuring proper transmission levels over different circuits, which may be connected and for maintaining balance of circuits to insure against so-called circulating currents in the terminating circuits of the carrier current system proper.

Other features relating to the power line system in general reside in provisions; whereby connections may be established between stations of the power line over trunk circuits to an automatic telephone exchange; whereby a power line station connected to the trunk may actuate the automatic exchange system to select any subscriber station or other automatic or manual exchange which may be accessible thereto; and whereby any automatic or manual station associated with said exchange system may call any station on the power line over said trunk.

Other features of the invention reside in means whereby the communicative connection between a subscriber at a power line station and the power line may be arranged on the so-called two-wire basis or on the so-called four-wire basis. For the two-wire arrangement a hybrid coil with an associated artificial line serves for branching the carrier circuits into a single metallic circuit which serves for both transmitting and receiving currents, while in the four-wire arrangement one pair of wires is routed to the telephone receiver while a second pair is routed to the transmitter of a telephone set. In the latter arrangement provision is made, however, for deflecting a certain amount of speech energy from the transmitter to the receiver to set up so-called "side tone" effects.

Another feature of the invention resides in means to permit any designated power line stations to carry out a "group" connection in simultaneously calling and transmitting to any desired number of other stations, irrespective of the normally maintained bar against entrance of other than a single called station.

The invention has been illustrated in the accompanying drawings as applied to a telephone system which includes a plurality of stations associated directly with a power line, a station associated by means of a tributary line with the power line and a trunk circuit which joins an automatic exchange which

serves subscriber stations and also a manual exchange.

In the accompanying drawings Fig. 1 illustrates the equipment at the tributary station. Figs. 2 and 3 illustrate the equipments of a station at a point where the tributary line of Fig. 1 joins the power line. Fig. 4 illustrates a station at which the telephone set is connected on the four-wire basis. Fig. 5 illustrates a plurality of telephone stations connected on the two-wire basis. Fig. 6 illustrates a plurality of telephone stations with a trunk circuit extending to the equipment of Fig. 7. Fig. 7 illustrates an automatic exchange equipment with a subscriber station and also manual exchange equipment. Fig. 8 shows the arrangement of the drawings.

Referring to the drawings, the equipment employed to illustrate the invention is arranged in general as follows: At the tributary station A, Fig. 1, is shown a telephone set 101, dial 102, call signal 103, busy signal 104 and combined vibrator and relay units 105, 106 and 107. These relays may be of the general type disclosed in Patent No. 1,579,237 of April 6, 1926, to H. W. O'Neill. Each of these devices is used both as a tuned vibrator for converting direct current into alternating current for signal transmission and as a frequency selective relay for reception of signals. Each relay produces and responds to one frequency a different frequency for each device. In this manner impulses formed of permutations of the three frequencies may be transmitted or received in setting up and controlling different switching effects by way of the telephone line L which leads from this station A to station B.

At station B, Figs. 2 and 3, is shown a telephone set 201, dial 202, call signal 203, busy signal 204 and combined vibrator relay units 205, 206 and 207. These units may be of the same construction as the vibrator relays shown in Fig. 1 and arranged to transmit and respond to frequencies corresponding with the frequencies of the relays 105, 106 and 107 respectively. The selector 208 is of the usual rotary type, has two sectors of terminals and a stepping magnet 209 for rotating the associated brushes over the terminals in clockwise direction. This switch is for selecting either the telephone set 201 at this point, the tributary line L or other telephone sets or lines, not shown but which may be connected from this selector.

As signaling over the power line PL is accomplished by means of a high frequency current superimposed on the power line and the telephonic communication is by using this high frequency as a carrier and modulating it with the speech current, there is provided at the station B, as well as at the other stations, associated directly with the power line, a source of high frequency current with

suitable transmitting devices as shown at T, while a receiving system as the one shown at R serves for reception of the transmitted currents. The transmitter T consists of an oscillator having a vacuum tube 300, a feedback circuit 301 and direct current sources 302 and 312. The output current of this oscillator may be amplified through the tube 303 for transmission to the power line while the tube 304 in this circuit serves as an amplifier for speech currents from over the line L1 which then modulate the carrier current produced by the oscillator.

Leads 307 under control of a relay 231 connect a condenser 306 of the feedback circuit 301 to change the period of the oscillator to a lower frequency as when a call may originate at the stations of Fig. 1 or Fig. 2. Under calls from over the line P1 the relay 231 remains inert and the oscillator operates at its normal or higher frequency. The difference in frequency of the two currents must be sufficient to permit one frequency to be employed by a calling station and the other frequency by a called station for two-way transmission without interference between the two frequency channels of the common power line. These frequencies may be in the order of 80,000 and 100,000 cycles respectively and hereinafter will be indicated as the low and the high frequency carriers, respectively.

The receiver circuit R (Fig. 3) consists of amplifier tubes 310 and 311 and a detector or demodulator tube 312 with their proper circuit arrangements including the usual coupling transformers, and sources of direct currents 302 and 305. It should be understood that the transmitter T and the receiver R may be of any well-known construction and that the forms shown are merely illustrative of arrangements that may be employed in this circuit for transmitting and receiving the high frequency carrier currents.

Rectangles AL2 and AL3 represent artificial lines which may be of types well-known in the telephone art so that AL2 may simulate the characteristics of the line L for which it substitutes, while the artificial line AL3 should also balance the characteristics of line L to prevent circulation of energy from the transmitter T through the receiver R. A hybrid coil 330 is employed to merge the two frequency channels of the line PL into the two wire circuit L1.

The switch 315 when operated towards the left connects the power line PL with the transmitter T through the transformer 313 and when operated towards the right connects an auxiliary amplifier circuit, including the tube 316, the B battery supply 317 and associated transformers, between the power line PL and the transmitter to increase the energy of the carrier current produced by the transmitter T. This auxiliary amplifier

is to meet adverse line conditions or for use in calling over longer lines where more carrier current energy may be required.

An assembly PLF for coupling to the power line PL consists of condensers 324, "gap-space" arresters 320, protectors 321, 322, filters 318, 319 and a disconnecting switch 323, in affording protection and also excluding the low frequency currents of the power line system. At HF and LF filters may be assumed as present for passing the respectively high and low frequency carrier currents. For calls originating over the line PL to the line L1 low frequency carrier current from line PL will be excluded from the circuits of T by the filter HF and passed by filter LF to the receiving circuits R, while high frequency carrier current from the transmitter T may traverse filter HF to the line PL, the low pass filter LF will exclude this current from the circuits of the receiver R. For a call in the opposite direction from over line L to line PL relays 324 and 325 transpose these filters so that the low frequency carrier current from the transmitter T (now tuned as already described) may pass to line while being excluded from the receiver R.

The equipment at station C comprises a telephone set 401, dial 402, call signal 403 and busy signal 404. The transmitter T4 is identical with the transmitter T and the receiver R4 is identical with the receiver R, while the selector 408 and the stepping magnet 409 therefor are arranged in a manner similar to selector 208 and magnet 209, of Fig. 2. A high frequency filter HF4 and a low frequency filter LF4 as well as a power line filter protective arrangement PLF4 are identical with the corresponding equipments described for station B.

The equipment at station D is arranged for the selection of either one of two telephone station equipments. One of these equipments comprises a telephone set 501, dial 502, call signal 503 and busy signal 504, while the other equipment comprises a telephone set 505, dial 506, call signal 507, and busy signal 529. The selector 508 and the stepping magnet 509 therefore are arranged to select either one of these stations for talking with any other station over power line PL. The transmitter T5 and receiver R5 and the filters HF5 and LF5 and the filter and protective arrangement PLF5 are all identical with the corresponding equipment at station B.

The equipment at station E is arranged for selecting equipment comprising the subscriber's set 601, dial 602, call signal 603 and busy signal 604 or for selecting a trunk 605 leading to an automatic exchange. A busy signal 606 is arranged to indicate the association of the power line PL through this station with the trunk 605. The selector 608 with the stepping magnet 609, similar to the corre-

sponding selectors at the other stations, is used for the selections at this point, while the transmitter T6, receiver R6, high frequency filters HF6 and LF6 and the filter and protective arrangement PLF6 are identical with the corresponding equipments at the other station.

Trunk 605 terminates at the automatic exchange F, shown in Fig. 7, where a series of selectors 701, 702 and 703 and the connector 704 are illustrative of the equipment for selecting trunks, for example, a trunk 705 leading to a manual exchange G where this trunk terminates in a jack 706. At this distant exchange is shown part of an operator's cord circuit 707 which may be of well known type. A subscriber's station 709 and a subscriber's line 708 are shown that may also be selected by the connector 704. The operator at station G and the subscriber 709 may, by means of their respective dials 711 and 712, select, through the selectors 714 and 715, respectively, and the selector 716 and connector 717, the trunk 605 for establishing connections from the point G or from the station subscriber 709 with any other station connected to the power line PL.

From the above general description it will be evident that telephone connections may be established over the power line PL; between any two stations directly associated with the power line; between any one of these stations and the station A connected through the tributary line; or between any one of the above mentioned stations and a subscriber at a distant manual exchange or a subscriber associated with the automatic exchange. It should also be clear that the signaling over the line L is accomplished by means of combinations of three currents of different frequencies and that currents of two different frequencies are used for signaling purposes and as carriers for the speech currents in connection where the power line is involved.

The various supervisory signals required in establishing connections over the line L are composed of combinations of the above mentioned three frequencies as delivered by the vibrating relays 105, 106 and 107 and the dialing impulses from station A to call station B or any other station are formed by the dial at station A, and consist of a certain combination of these high frequencies. On the other hand, the dialing impulses over the power line from any of the stations are provided by interrupting the "lower frequency" carrier current. It should also be clear that when a power line station is calling, the "lower frequency" current is used for supervisory signal control as well as for the speech carrier from the calling station, while from a called station the "higher frequency" carrier current serves for supervisory signal control and for the speech carrier from the called

station. This use of "lower" and "higher" frequency carrier currents is to separate the oppositely directed signaling and transmission effects into two distinct channels, and to distinguish between the signals and speech currents.

The following is a description of the operation of the system in setting up and controlling a connection between stations shown in the drawings, and a call from station A to station C will first be assumed. In this case, the receiver will be removed from its switchhook at the telephone set 101. This closes a circuit from battery, winding of relay 109, upper contact and switchhook of telephone set 101, right-hand armature and back contact of relay 110 to ground. Response of the relay 109 closes circuits to vibrate the relays 105 and 106. The circuit for relay 105 is from battery, lowermost normal contacts of relay 111, right-hand winding of transformer 112, winding of relay 105, outer right-hand alternate contacts of relay 109 to ground while the circuit of vibratory relay 106 is from battery over the lowermost normal contacts of relay 111, next right-hand winding of transformer 112, winding of relay 106, inner right-hand armature and front contact of relay 109, outer right-hand armature and back contact of relay 117 through the closed lowermost contact of dial 102, upper contact and switchhook of set 101 to ground at the right-hand contacts of relay 110. The relays 105 and 106 vibrate on a short-circuiting basis which is as follows: Relay 105 closes a short-circuit for itself from its right-hand winding terminal, left-hand armature and front contact of relay 109, contacts of relay 105, the next right-hand alternate contacts of the relay 109, to the left-hand winding terminal of this relay 105, while for the relay 106 the short-circuit is from its right-hand winding terminal, contacts of relay 106 to ground at the outer armature and front contacts of relay 109, the left-hand winding terminal of the relay 106 being grounded at this time as already traced. These relays will thus be alternately energized and deenergized and thus continue to vibrate at the respective frequencies to which their armatures have been tuned. The resulting changes of current strengths in the windings of the transformer 112 induce corresponding alternating currents, in the winding 113 of this transformer, and these currents will be of frequencies corresponding to the frequency of the vibrating relays, respectively.

At station A a tone will now be produced in the telephone receiver due to the vibration of relay 105. It will be noted that one terminal of the primary winding of the repeating coil of the set 101 is connected through a condenser 125 to ground while the other terminal connects through the transmitter, up-

per switchhook contacts and the right-hand contacts of relay 110 to ground. A derived path from the right-hand terminal of vibrator 105 is through the left-hand normal contacts of relay 110 and a condenser 125 to the non-grounded terminal of the primary winding of the repeating coil of the telephone set 101. Current changes set up by the vibrator 105 in this derived circuit will produce a tone in the receiver which is in a normally closed loop through the secondary winding of the induction coil and the next upper normal contacts of the relay 111. This tone will indicate that the power line PL is idle and therefore that dialing may proceed. It will later appear how relay 109 cannot operate in case the power line may be in use and therefore no "dialing tone" would then be produced.

The frequencies set up by the relays 105 and 106 in the winding 113 of the transformer 112 may reach the line L over the upper and next lower sets of contacts of relay 111, and an insulating transformer 116, thence through a second insulating transformer 212 and the lower and next upper sets of normal contacts of a relay 213 to energize a transformer 214. Relays 205 and 206, connected to the secondary winding of the transformer 214, are tuned to respond to the frequencies produced by relays 105 and 106 respectively. Relays 205 and 206 now close obvious circuits for the operation of relays 216 and 217 respectively. The latter relays in operating close a circuit for the operation of relay 218 as follows: Battery, left-hand winding of relay 218, next left-hand normal contacts of relay 220, and the front contacts of relays 217 and 216 to ground at the normal contacts of relay 221. Response of relay 218 results in energization of relays 222, 225, 226, 227, 220, 230, 231, 324, 325 and 233, as follows: The circuit for relay 222 is from battery, the inner right-hand front contacts of relay 218, right-hand winding of relay 222, and the normal contacts of relay 224 to ground; for relay 225, battery, winding of this relay and the "grounding" contacts of relay 218; for relay 226 battery, winding of relay 226, lowermost front contacts of relay 225, next right-hand normal contacts of relay 220 to ground at the next right-hand front contacts of relay 218; for relay 227, battery, winding of relay 226 to ground through the alternate contacts of relay 226; for the relay 220 battery, winding of relay 220, right-hand contacts of relay 218, normal contacts of relay 228, right-hand normal contacts of relay 229, and right-hand armature and front contacts of relay 227 to ground; for relay 230, battery and the lower winding of this relay to ground through the upper alternate contacts of relay; for relay 231, battery, winding of this relay, next lower alternate contacts of relay

225, and the right-hand alternate contacts of relay 222 to ground over the contacts of relay 222; for the relays 324 and 325 (Fig. 3), battery, windings of these relays to ground over the upper alternate contacts of relay 225; and for the relay 233, battery, normal contacts of relay 234, winding of relay 233, lowermost normal contacts of relay 235, normal contacts of relay 236 to ground over the contacts of the next right-hand armature of relay 218.

In the above operations, separation of the next left-hand normal contacts of the relay 220 removes a shunt from the right-hand winding of the relay 218 which continues energized with its windings in series. This is in preparation for subsequent effects as will presently appear. The next left-hand contacts of the relay 220 transfer the ground for the relay 226 from the relay 218 to the contacts of the relay 222. The upper contacts of the relay 230 close an obvious energizing circuit for the tubes 300, 303 and 304, the next upper contacts close the filament circuit for the tube 316, while the lower contacts of this relay close an obvious circuit for a motor 326, which drives a direct current generator 302. The upper contacts of the relay 231 connect the condenser 306 in tuning the oscillator to the lower carrier frequency. Relays 324 and 325 switch the transmitter T to the low pass filter LF and the receiver R to the high pass filter HF. The right-hand transfer contacts of the relay 233 disconnect ground in disabling the telephone set 101, and dial 102, and close a circuit for displaying the busy signal, 204, while the left-hand contacts of this relay prepare a circuit, presently to be described.

The energizing of the transmitter T applies the "lower frequency" carrier current through the filter LF and the combined filter and protective couple PLF to the power line PL, thence to the receiving circuits at the stations C, D and E. At station C this current traverses couple PLF4, filter LF4, and the receiver R4 to cause the operation of relay 410. Relay 410 in operating closes an obvious circuit for the operation of relay 411 and 411 in operating closes an obvious circuit for the operation of relay 412. The left-hand armature of relay 412 disconnects ground to disable the telephone set 401 while energizing a busy signal 404. In addition to the signal 404 indicating that the power line is busy, the disabled condition of the telephone sets at this station C further insures against interference in the event that the receiver may be removed from its switchhook in attempting to make a call from this point. Similarly, the relays 510, 511 and 512 at station D respond. The left-hand armature of relay 512 disconnects ground from the lead to a vibrator 517 in disabling the telephone sets 501 and 505, while applying this

ground to display the busy signals 508 and 504.

At station E the carrier current traverses PLF6, LF6 and R6 to cause the operation of
 5 relays 610 and 611 and the lighting of busy signal 606. All segments excepting segments 4 and 5 of the right hand bank of selector 608 are joined together thence to ground through the winding of a relay 614.
 10 Therefore, during periods the brush of this bank may be on any of the joined segments the relay 614 will be energized over an obvious circuit, in removing ground to disable the telephone set 601, and connecting a vibrator
 15 615 to the trunk 605. The lighting of signal 606 indicates to the subscriber of set 601 that the power line is in use by other stations. In case a call from the stations of Fig. 7 may now be attempted vibrator 615
 20 will respond to send a busy-tone signal over the trunk 605 to such calling party.

The operations above described, constitute the initial automatic effects to establish busy signal, lock-out and seizing effects in preparing for selective operations. Therefore, following the dialing tone indication in the receiver at station A dialing may be proceeded with at that point. When the dial 102 is moved from normal, the relay 117 is operated
 30 over a circuit as follows: battery, winding of relay 117, left-hand normal contacts of relay 117, off-normal contacts 118 of the dial 102, the upper switchhook contacts of telephone set 101 to ground over the right-hand armature and back contact of relay 110. Relay
 35 117 in operating provides a locking circuit for itself from battery, through its winding and inner armature and front contact to ground through the upper switchhook contacts, the right-hand armature and back contact of relay 110. A shunt path on the output
 40 winding of transformer 112 may now be traced from the upper terminal of winding 113, the upper or pulsing contacts of the dial 102, and the left-hand armature and upper forward contact of the relay 117 to the lower terminal of the winding 113.

The vibratory relay 106 is now disconnected at the separated left-hand normal contacts of relay 117, while a circuit for vibrator
 50 107 is connected from battery, lower normal contacts of relay 111, next left-hand winding of repeating coil 112, winding of vibrator relay 107, normal contacts of relay 119, contacts 120 of relay 117, dial contacts 113 to ground over the upper contacts of the switchhook and the right hand back contacts of relay 110. Relay 107 will vibrate by short-circuiting itself through its own contacts and
 60 the right-hand armature and upper front contact of relay 109 to ground.

As the dial 102 returns to normal its upper contacts are successively interrupted, as well understood in the art, in intermittently dis-
 65 connecting the short-circuit from winding

113 of the transformer. Therefore, impulses formed of the frequencies produced by vibrating relays 105 and 107 are transmitted through coil 113 over line L to correspondingly "pulse" the vibratory relays 205 and 207 which, in turn, pulse the relays 216 and 224, respectively. During each response of
 70 the relays 216 and 224 they disconnect the respective windings of relay 222 so that this relay and, in turn, the relays 226 and 231 are pulsed. The relay 227, of slow-to-release type, is not affected by these pulses therefore during each release of relay 226 ground potential will be applied through the left-hand armature and front contact of relay 227 for
 80 the operation of relays 237 and 238 and magnet 209. The circuit for relay 238 is obvious, while the circuit for relay 237 and magnet 209 may be traced from battery, normal contacts of relay 239, windings of magnet 209 and relay 237 in series, left hand armature and front contact of relay 227, armature and back contact of relay 226 to ground. The relay
 85 237 is also slow-to-release as indicated, so that it does not release during a series of pulses corresponding with return of the dial at station A. The magnet 209 however follows the impulse and advances the brushes of the selector 208 a corresponding number of steps. In this case the number of the station
 90 C is assumed to be 3 and it should be observed that when the brush of the left-hand bank of the selector 208 is on the third contact, this contact will be found to be without connection so that nothing will result at this station. However, pulsing of relay 231 will have the effect of alternately changing the tuning of the transmitter T from the lower to the
 95 higher carrier frequency, thus three impulses or interruptions of the carrier current will take place to the power line PL, as due to the operated position of the relays 324 and 325 the low frequency filter LF blocks the high frequency currents present during instants the relay 231 is in its released position. At
 100 station C each cessation of the carrier current results in release of the relay 410 so that for the present assumed call of three impulses this relay 410 released and reoperated three times. While relay 411 will also be correspondingly pulsed, the relay 412 will remain operated, however, due to its slow-to-release characteristics. Therefore, the magnet 408 for selector 404 will be pulsed three times, in a circuit from battery, armature and back
 105 contact of relay 414, winding of magnet 408, right-hand winding and front contact of relay 412, right-hand armature and back contact of relay 411 to ground. Magnet 408 in pulsing, advances the brushes of selector 407 three steps. Then, the right-hand brush will be in contact with the third terminal and close a circuit from battery, winding of relay 416, third terminal and this brush to ground at
 110 the armature and front contact of relay 411.

The selector brush now remains on this contact to retain the relay 416 which closes a circuit from battery, left-hand armature and front contact of relay 416, call signal 403, lower closed contact and switchhook of set 401, right-hand armature and front contact of relay 416 to ground at the left-hand armature and back contact of relay 417.

The selector 509 at station D and selector 608 at station E have also been advanced to their third terminals. This terminal is blank at station D while at station E it is common with other segments to the relay 614 so this relay continues energized.

In response to operation of the signal 403 at station C, removal of the receiver from the switchhook at set 401 disconnects this signal, and applies battery through the winding of relay 420, the upper contact and switchhook of set 401, right hand armature and front contact of relay 416 and the armature and back contact of relay 417 to ground. Response of relay 420 which corresponds to relay 230 in Fig. 2, serves to energize the filaments of the vacuum tubes in the transmitter T4, and to start a motor generator set in conditioning the transmitter T4 to produce and transmit the high frequency carrier over filter HF4 and the couple PLF4 to the power line PL.

At station B this current traverses the couple PLF, filter HF and receiver R and effects operation of relay 240. This results in response of relays 236, 228 and 213, to connect line L to the conductors L1 which serve the terminating equipment of the power line PL. In addition, circuit changes also take place to transfer subsequent control and final breaking down of this assumed connection from station A to the station C. In describing these operations, relay 236 responds in an obvious circuit. For relay 228 the circuit is from battery, normal contacts of relay 237, contacts of relay 238, left hand brush and bank terminal 3 common to other terminals as shown, of selector 208, winding of relay 228 to ground at the lower front contacts of relay 236. Ground potential over the lower sets of contacts of relay 236 now substitutes for the previous ground in retaining relay 233 which maintains the busy signal 204, while the upper contacts of relay 240 and 236 substitute ground to retain the relays 226, (227), and also substitutes ground to retain the relays 225 and 231 following disconnection of relay 220 due to operation of relay 228, and release of relay 218 on release of relay 220. For the relay 225 this ground potential is applied over the lowermost alternate contacts of relay 225 and the next right hand contacts of relay 220 to battery through the winding of the relay 225. The substitute circuits for the other relays are believed to be obvious. The alternate contacts

of relay 228 close a circuit from battery, winding of relay 213, left hand normal contacts of relay 242, left hand contacts of relay 233, alternate contacts of relay 228, right hand normal contacts of relay 229, to ground over the contacts of relay 227. The operation of relay 213 transfers the line L from the transformer 214 to leads which extend by way of respective sets of normal contacts of relay 243 to the line L1. The latter line connects through the hybrid coil 330 to the input winding of a transformer 327 of the transmitter T.

At station A when the dial 102 reached its normal position, relay 111 operated in a circuit from battery, winding of relay 111, right hand armature and front contact of relay 117, lower normal contacts of dial 102, switchhook of set 101 and right hand armature and back contact of relay 110 to ground. The set 101 is now connected through the upper and next upper alternate contacts of relay 111, to the transformer 116 of line L, while the leads to the transformer 112 are disconnected and battery is connected to the transmitter of the set 101.

Speech currents from this transmitter will now modulate the lower frequency carrier of transmitter T (Fig. 3). At station C this modulated current may traverse couple PLF4, filter LF4, receiver equipment R4 and transformer 423 to the telephone receiver of the set 401, while speech currents from the transmitter of this telephone set energize a transformer 422 to modulate the "higher frequency" carrier current produced at T4. This current traverses high pass filter HF4 and couple PLF4, the line PL to station B, thence over couple PLF, high pass filter HF, alternate contacts of relay 325, receiver R, the hybrid coil 310, and line section L1 and L to the receiver of the telephone set at station A. It will now be clear that in the present assumed connection, carrier current for transmission of speech from station A to station C is of "lower frequency" while the carrier current for transmission from station B to station A is of the "higher frequency", thus providing two separate transmission channels or duplex working over the power circuit PL.

After the conversation, return of the receiver to its switchhook at station C effects release of relay 420 thus disconnecting the transmitter T4 to discontinue the carrier current supplied from this point. The resulting release of relay 240 at station B effects release of relays 226, 225, 231, 230, 236, 324, 325, 227, 228, 233 and 213. A circuit now completed for the stepping magnet 209 of the selector 208 is from battery normal contact of relay 239, winding and contacts of magnet 209, right hand brush and commonly joined segments of this selector bank and the normal contacts of relays 227 and 226 to ground.

In responding, magnet 209 interrupts its own circuit so that it is alternately operated and released and thus advances all brushes of the selector 208 to normal. Actual movement of the brushes is on the recoil or release direction of the armature stroke. On leaving the last segment, therefore, the "step" magnet 209 is disconnected. As just described, the devices of Figs. 2 and 3 have been deenergized and returned to their normal positions.

For the assumed call under description, when station C answered station A the control relative to the retaining and breaking down of the connection was, due to relay responses at station B as described, transferred to station C. Therefore, assuming the instant when the transmitter T was disconnected by release of relay 230 at station B, cessation of the carrier current supplied from this point, deenergizes the line relay at the station C as well as the line relays at stations D and E. At station C, release of the line relay 410 is followed by release of relays 411 and 412, and ground over the serially connected right-hand normal contacts of relays 410 and 412, the left-hand brush and joined segments of selector 408, contacts and winding of step magnet 409, and the contacts of relay 414 to battery, permits magnet 409 to operate and restore the switch 408 to normal, in a manner similar to that just described for the switch 208, at station B. Relay 412 also disconnects the busy signal 404. The operations just described as having taken place due to return of the receiver to its switchhook at station C may take place in an inappreciably short time. Ordinarily, therefore, the left-hand brush of the selector 408 will have left the third segment of its sector bank and thus permitted release of the relay 416 for disconnect of the signal 403 and restoral of the normal grounding circuit through the left-hand contacts of relay 412, for the switchhook of the telephone set 401, so that reoperation of the signal 403 may not take place. In the event, however, that delay or failure of the devices to restore at station B should occur and the carrier current from that point should therefore remain on the power line, the devices including the relay 416 would continue energized at station B. Therefore, return of the receiver to its switchhook would effect response of the signal 403, which, in such an instance, would indicate the failure condition.

At station D successive release of relays 510, 511 and 512 close a circuit similar to the one just described for station C whereby magnet 509 may restore the selector 508 to normal while the busy signals 504 and 510 will be disconnected.

At station E relays 610 and 611 restore and complete a circuit from ground over the serially connected normal contacts of relays

620, 610, 611, left-hand brush and sector bank terminals of selector 608, contacts and winding of step magnet 609 to battery over the right-hand normal contacts of relay 627. The magnet 609 restores the selector 608 in a manner similar to that just described for restoral of the selector at the other stations. At "normal" the right-hand brush of the selector 608 disconnects the relay 614, and the vibrator 615 is removed from the trunk circuit 605. Busy signal 606 is disconnected by the relay 610 and devices at this station are now at normal.

Entire clearing out of the foregoing assumed connection is had when return of the receiver to its switchhook at station A effects release of relays 117, 109 and 111.

In describing how the station A may control the "breaking down" of a connection on failure of a called station to answer, let it now be considered that for the assumed call from station A to station C which has just been described, the station C failed to answer. Return of the receiver to its switchhook at station A disconnects relays 117 and 111. As relay 111 is slow-to-release a momentary circuit for relay 119 is closed from battery, lower alternate contacts of relay 111, winding of relay 119, lower contact and switchhook of set 101 to ground at the right-hand armature and back contact of relay 110. Relay 119 is also slow-to-release so that momentary circuits will be completed for vibrators 105, 106, and 107 as well as a substitute circuit for retaining the relay 109. For these circuits when the relay 111 restores battery is supplied to the vibrators 105, 106 and 107, with obvious paths over grounding contacts of relays 109 and 119 for vibrators 105 and 107, respectively. Relay 109 is retained by the grounding contacts of relay 119. This ground is also applied over the power contacts of the dial 102, right-hand contacts of relay 117, and the inner right-hand contacts of relay 109 to the vibrator 106. During an interval following the release of relay 111 and until release of relay 119, current formed of the frequencies produced by the three vibrators will be transmitted over line L to station B. Relay 119 finally releases and disconnects relay 109 and the vibrator 105, 106 and 107, so that all devices at station A are then at normal. At station B vibratory relays 205, 206 and 207 respond to the impulse of three frequencies received, and effect operation of relays 216, 217 and 224. Relay 224 applies ground to shunt the left-hand winding of relay 218, while the right-hand winding is shunted by ground potential over the serially connected contacts of relays 216, 217 and 221, thus effecting release of relay 218. Relay 222 first disconnected by response of relays 216 and 224, is also disconnected from battery on release of the relay 218 and there-

fore, may not reoperate on release of the relays 216 and 224 due to cessation of the alternating currents from over line L and deenergization of relays 205, 206 and 207. All other relays at station B now release, the selector returns to normal, while the resulting disconnection of the transmitter T discontinues the carrier current. Thereupon, relays at the other station will deenergize, releasing the associated equipment thus permitting the selectors to return to normal as hereinbefore described.

Let it now be assumed that station C calls station A. Removal of the receiver from the switchhook at telephone set 401 initiates the following operations. For energizing the carrier current transmitter T4 relay 420 operates in a circuit from battery, winding of this relay, upper contacts of the switchhook, thence to ground over the right and left-hand normal contacts, respectively of the relays 416 and 412. A circuit for producing a dialing tone extends from battery over the left-hand normal back contacts of relay 416, the winding and right-hand normal contacts of relay 421, a vibrator 405, primary winding of transformer 422, the transmitter of the telephone set 401 and the upper switchhook contacts to ground as just traced for the relay 420. The vibrator 405, in operating, is of high resistance so that the serially connected relay 421 will not tend to operate at this time. Current changes set up by the vibrator 405 may become effective through a condenser and the middle winding of the transformer 423 to produce a tone in the receiver of the telephone set 401 which indicates that the circuits are idle and that "dialing" may proceed. Operation of the dial 402 first effects closure of the off normal contacts. This bridges the connection at the right-hand normal contacts of relays 421 so that this relay may respond to the ground already traced over the upper contacts of the switchhook. This disconnects the control of line relay 410, and the vibrator 405, while closing one circuit to energize by way of the pulsing contacts of the dial 402 to energize a relay 426. Relay 426 tunes the transmitter T4 to the "lower frequency" and the relays 424 and 425 operate to transpose the connections to the filters HF4 and LF4 so that the transmitter T4 will be connected to the LF4 filter and the receiver to the HF4 filter. Therefore, transmitter T4 will now send "lower frequency" carrier current to the power line PL. The effect of this carrier current at the various stations D and E will be the same as that already described for the low frequency carrier current from station B relative to operating the busy signals and disabling of the several stations against interference with the present call.

At the station B the carrier current is

translated through the receiver system R to effect operation of relay 240. This results in the operation of relays 236, 226, 227 and 233, vibrator 207 and busy lamp 204. Tracing the various paths for these responses, the relay 236 is energized in an obvious circuit; relay 226 in series with battery and the upper sets of contacts of relays 236 and 240 to ground; relay 227 then responds in an obvious circuit; ground potential over the lower sets of alternate contacts of relay 236, lower normal contacts of relay 235, winding of relay 233 to battery over the left-hand normal contacts of relay 234, operates relay 233 to disconnect ground in disabling the telephone set 101 while closing an obvious circuit for display of busy signal 204; a circuit from ground over the right-hand contacts of relay 227, left-hand normal contacts of relay 220, right-hand normal contacts of relay 242, winding of vibrator 207 thence over the winding of relay 224 to battery energizes this vibrator. Response of relay 224 at this time is an idle operation and without effect. Current changes set up by the vibrator 207 energize the transformer 214, and thence may traverse the line L and through the transformer 112 operate vibratory relay 107 over an obvious circuit. A circuit from ground, the winding of a relay 110, a resistance, the right-hand normal contacts of relay 109, contacts of relay 107 (now in vibration) next left-hand winding of transformer and the lower normal contacts of relay 111 permits response of relay 110. This removes ground to disable the telephone set 101 against possible interference with the present call, while also energizing a busy signal 104 in an obvious circuit.

The operation just described took place during an instant following actuation of the dial 402 at station C to its "off normal" position. Under return of the dial mechanism to normal its upper contacts are intermittently opened thereby "pulsing" the relay 426. This switches the tuning of the oscillator of transmitter T4 from low to high carrier current production, in a manner similar to that already described in connection with station B.

At station B relays 324 and 325 are in their normal positions, the low pass filter LF thus being intermediate the line PL and the receiving system R. Thus, while the impulses of high frequency carrier current from station C are excluded from this receiver the lower frequency carrier is passed thereto and effect corresponding pulsing of master control or line relay 240. In controlling the selector 208, the relay 240, in turn, pulses the relay 226. During each release of the latter relay ground over its normal contact, the alternate contacts of relay 227, the serially connected windings of relay 237 and "stepping" magnet 209 and the normal contacts of relay

239 to battery. Relay 237 and the magnet 209 respond, and while the latter may follow the pulsing, the slow-to-release characteristics of the relays 237 and 227 retain these relays. A brush disconnect relay 238 also operates in parallel with the series formed of the relay 237 and magnet 209. As the assumed call is for station A the pulsing will cease after the second impulse, when the brushes of the selector 208 will come to rest on the second segments of the respective sector banks. Just before restoral of slow-to-release relay 237, response of relay 221 will be had in a circuit from battery, winding of relay 221, second segment and brush of the left-hand bank of selector 208, the left-hand armature and back of contact of relay 238, left-hand armature and front contact of relay 237 and the armature and front contact of relay 226 to ground. Relay 221 closes an obvious circuit for the operation of relay 242 which provides a locking circuit for itself through its inner right-hand sets of front contacts to ground over the right-hand armature and front contact of relay 227, while separation of the right-hand normal contacts of relay 242 disconnects the vibrator 207. This effects cessation of the alternating current over the line L and at station A vibrator relay 107 restores. This releases the relay 110 which disconnects the busy lamp 104 and restores ground to the switchhook control of the telephone set 101. The momentary operation of relay 221 also applies ground over obvious series parallel circuits for the operation of vibrators 205 and 206. Although the relays 216 and 217 respond at this time they are without effect as ground has been removed from their controls due to separation of the left-hand normal contact of relay 221. The operation of vibrators 205 and 206 causes the respective frequencies produced thereby to effect through the transformer 214 an impulse over the line L. At the station A this impulse reaches the transformer 112 and effects operation of the respectively tuned vibrator relays 105 and 106. These relays in turn close a circuit from battery over the lower armature and back contacts of relay 111, the next right-hand winding of the repeating coil 112, armatures and front contacts of relays 106 and 105 in series, left-hand armature and back contact of relay 109, winding of relay 121, lower contact and switchhook of set 101 to ground at the right-hand armature and back contact of relay 110. Relay 121 responds and closes a locking circuit for itself from battery over its left-hand armature and front contact and its winding, the lower set of contacts of the switchhook of the telephone set 101 to ground over the right-hand normal contacts of relay 110. Relay 121 closes an obvious circuit for response of call signal 103 and for response of relay 117. Relay 109 now responds to ground by way of

the inner alternate contacts of relay 117 and the right-hand contacts of relay 121, while this ground by way of the lower contacts of dial 102 and the right-hand alternate contacts of relay 117 effects response of relay 111.

At station B release of relay 237 disconnects relay 221 to open the circuits for the vibrators 205 and 206 thus discontinuing the alternating current impulse over the line L; while relay 213 will operate over a circuit from battery, winding of relay 213, left-hand armature and a front contact of relay 242 to ground over the armature and back contact of relay 221. Relay 230 is also operated over a circuit from battery, upper winding of relay 230, left-hand front sets of contacts of relay 242 to ground over the armature and back contact of relay 221. Relays 213 and 230 will be maintained operated as long as relay 242 is operated. The operation of relay 213 switches the line L from the transformer 214 to line L1 and the operation of relay 230 causes the transmitter T to be energized to transmit the higher frequency carrier over the power line PL. This high frequency is received at station C through PLF4 and HLF4 and the contacts of relays 424 and 425 of the receiver R4 in preparation of serving as a carrier for the talking currents from station A to station C.

Response at station A to the call signal by removal of the receiver from its switchhook disconnects relay 121 which is slow-to-release so that relay 117 is thus retained until a locking circuit for it is closed through its inner right-hand armature and front contact, the upper contact and switchhook of the set 101 to ground at the right-hand armature and back contact of relay 110. This ground also retains relays 109 and 111 operated. Relay 111 completing a talking connection from the set 101 to line L, while disconnecting the transformer 112. Conversation may now be carried on between the stations C and A.

When the conversation is concluded and the receiver is replaced on its switchhook at station C, relays 420, 421, 424, 425 and 426 release. The transmitter system T4 is thus disconnected and cessation of the carrier current results. The line relays at the various stations consequently release and permit the respective devices to restore to normal in a manner similar to that already described, while return of the receiver to the hook of set 101 will effect release of relays 117, 111 and 109.

In making a call from station B to station A removal of the receiver from the switchhook of set 201 will result in a dialing tone signal in the receiver provided the power line circuits are idle. The circuit for the buzzer or tone producing device 245 may be traced from battery, left-hand armature and back contact of relay 234, winding of relay

235, lower inner armature and back contact of relay 235, buzzer 245, transmitter of the set 201, upper contact and switchhook of set 201 to ground at the right-hand armature and back contact of relay 233. Operation of the buzzer produces current changes in the primary winding of the induction coil of set 201 due to the presence of the condenser 248 and energizes the receiver of the telephone set with this tone. The buzzer 245 may be of the interrupter rather than the short circuiting type and present a high resistance, to insure that relay 235 will not operate at this time. The switchhook also closes a circuit for relay 230 from battery, lower winding of relay 230, upper normal contacts of relay 225, lower normal contacts of relay 235, upper contacts of the switchhook to ground at the normal contacts of relay 233. The operation of relay 230 energizes the carrier current transmitter T as hereinbefore described. Operation of the dial 202 first effects closure of its off-normal contacts which results in the operation of relays 235, 324, 325, 231, 226, 227 and the vibrator 207. In tracing the respective circuits; that for relay 235 is from battery, normal contacts of relay 234, winding of relay 235, off-normal contacts of dial 202, upper contact and switchhook of set 201 to ground at the right-hand armature and back contact of relay 233; for relays 324 and 325, battery, the parallel connected windings of these relays and the next upper contacts of relay 235 to ground; for relay 231, battery, winding of this relay, upper contacts of relay 235, pulsing contacts of the dial 202 and the upper contacts of the switchhook to ground over the normal contacts of relay 233; for relay 226, battery, winding of this relay, lowermost normal contacts of relay 225 to ground over the lower contacts of relay 231; for relay 227, relay 226 closes an obvious circuit, while for vibrator 207 the circuit is from battery, serially connected windings of relays 224 and 207, right-hand normal contacts of relay 242, left-hand normal contacts of relay 220 to ground over the right-hand contacts of relay 227. Operation of the vibrator 207 sets up an alternating current through transformer 214 and line L to effect response of correspondingly timed relay 107 and in turn response of relay 110 which energizes the busy signal 104 and disables the telephone set 101 as hereinbefore described.

The operation of relay 231 tunes the transmitter T to produce current of the lower carrier frequency while relays 324 and 325 effect transposition of the HF and LF filters, so that their frequency may reach the power line PL. At stations C, D and E this current initiates relay responses to display respective busy signals and also to exclude these stations with respect to possible interference with the present assumed call. Under operation, the lower alternate contacts of relay 235

close a self locking circuit by way of the upper contacts of the switchhook 202 to ground, while the next upper sets of contacts of relay 235 substitute ground for retaining the relay 230, thus relay 235 is rendered independent of its initial circuit over the off-normal contacts of the dial.

As already mentioned, the selector assignment for station A is 2. Therefore, automatic return of the dial 202 will effect two interruptions of its pulsing contacts. Relays 231 and 226 are correspondingly pulsed, and effect operation of step magnets 209, 409, 509 and 609 in advancing the selector at the respective stations two points. While this is without effect at the other stations, at the present "home" station B, response of relays 221, 242, vibrators 205, 206, relays 246, 229, 243 and 213 is effected while vibrator 207 is disconnected. Response of relays 237 and 221 and vibrators 205 and 206 is for a brief interval only, the cycle of response and release being entirely controlled by circuit changes set up by the various relays. In describing these operations resulting from the selector 208 having come to rest in its second position the circuit for relay 221 is from battery segment 2 and brush of the left-hand sector, normal contacts of relay 238 and the serially connected alternate contacts of relays 237 and 226 to ground; for the relay 242, battery winding of this relay and the alternate contacts of relay 221; vibrator 207 is disconnected at the right-hand normal contacts of relay 242; for relay 246, battery next right-hand contacts of relay 242, winding of relay 246, upper contacts of the switchhook to ground over the normal contacts of relay 233; for relay 229, battery over the contacts of relay 246, winding of relay 229, right-hand normal contacts of relay 220 and the inner sets of right-hand contacts of relay 242, to ground over the alternate contacts of relay 221; for relay 243 battery, winding of this relay, right-hand alternate sets of contacts of relay 229 to ground through the right-hand contacts of relay 227 and for relay 213 the circuit is prepared from battery, winding of this relay, left-hand alternate contacts of relay 242 to the normal contact of relay 221 in readiness for release of this relay as presently will appear. Cessation of the first alternating current from line L follows the described disconnection of vibrator 207. At station A relays 107 and 109 release to extinguish the busy lamp 104 and remove the interference so that the present call may be received. Thereupon, an impulse formed of the two frequencies produced by vibrators 205 and 206 traverse the line L and effect response of relays 105, 106, and in turn relays 121, 117, 109, 111, and call signal 103. Relay 121 now locks over its left-hand contacts independently of line relays 105 and 106. At station B, the slow-to-release relay 237 which respond-

ed in series with the magnet 209 during the last described operation of the selector 208, finally having restored, disconnects relay 221. Relay 221 disconnects vibrators 205 and 206.

While completing the circuit prepared for operation of relay 213, relay 242 is now retained over the inner alternate contacts and the right-hand normal contacts of relay 220 to ground over the left-hand contacts of relay 229.

In its operated position, relay 243 switches the line L1 from the artificial line network 210 to the other artificial line AL2 which then serves with the artificial line AL3 to maintain balance of the hybrid coil 330 to prevent circulating or interacting currents between the transmitter T and receiver system R. Relay 243 also switches the telephone set 201 from the network 210 to alternate contact points of relay 213. Under operation relay 213 switches the line L from the transformer 214, disconnects the network 210 and extends the line L over the circuit already prepared over respective contacts of relay 243 to the telephone set 201.

At station A, removal of the receiver from its switchhook, in responding to the present assumed call from station B, results in disconnect of relay 121 and signal 103, and retention of relays 117, 109 and 111 as already described under the assumed call from station C to station A.

The circuits will now be in condition for conversation between station A and station B. During this period, relays 109, 111 and 117 at station A will stand operated, and at station B, relays 213, 226, 227, 229, 230, 231, 235, 242, 243 and 246 will be retained energized.

On completion of the conversation return of the receiver to its switchhook at station B disconnects the relay 235, following which all other relays and the selector 208 at this point, will restore to normal, while similar disconnect at station A effects release of relay 117, and in turn, release of the other relays at this station. The removal of the carrier from the power line PL due to release of relay 230 will permit the relays and the selectors at stations C, D, and E to be restored to normal, the busy signals extinguished and the interference removed as hereinbefore described.

At station D, two telephone sets 501 and 505 in different locations, have been provided. The arrangement is such that both outward and inward calls may be handled from these instruments on a non-interference basis, one telephone set with respect to the other, so that the operating procedure may be the same as the procedure from any other station on the system.

Let it now be assumed that a call is made from the set 501 at station D (Fig. 5). Removal of the receiver from its switchhook

completes a circuit from battery through the right-hand winding of relay 515, the upper contact and switchhook of set 501, left-hand contacts of relay 516, winding of vibrator relay 517, left-hand contacts of relay 518, left-hand contacts of relay 519 and the left-hand contacts of relay 512 to ground. Vibrator 517 may be of the short-circuited type such as the vibrators 105, 205, etc. shown in Figs. 1 and 2 and already described. Current changes set up in the primary winding of the induction coil by way of the condenser 521 of the telephone set 501 produce a dialing tone in the telephone receiver of this set. The short circuiting effect of the vibrator 517 insures a low resistance path for initial operation of relay 515. The latter relay closes circuits to energize the carrier current transmitter T5 and to display the busy signals 504 and 528, respectively associated with the telephone sets 501 and 505.

Following the dialing tone indication that dialing may proceed, the dial 502 may be operated. The descriptions already given are believed to render it unnecessary to trace the present assumed call beyond this originating point, as shown in Fig. 5. Therefore, no distant station will be assumed for the operation of the dial now under description. A circuit from battery, right-hand normal contacts of relay 518, winding of relay 522, the off-normal contacts of dial 502, left-hand normal contacts of relay 516, contacts of vibrator 517 (still operating) and the serially connected left-hand normal contacts of relays 518, 519 and 512 to ground, effects response of relay 522. Separation of the left-hand normal contacts of relay 522 disconnects the initial "grounding" circuit over vibrator 517 from the controls of the telephone set 505 and dial 506; the next left-hand normal contacts disconnect ground from the controls of line relay 510; the left-hand alternate contacts shunt the vibrator 517; the next left-hand alternate contacts apply ground from over the next left-hand normal contacts of relay 516 to energize parallel connected relays 523 and 524 and by way of the pulsing contacts of dial 502 to operate relay 526, while the right-hand alternate contacts of relay 522 close a locking circuit to ground at the switchhook to retain this relay independently of the initial circuit over the off normal contacts of the dial 502. Under return of the dial mechanism to normal its pulsing contacts will be interrupted to pulse the "tuning" control relay 526. Under transposition of the filter HF5 and LF5 by the relays 523 and 524 impulses formed of the current of lower carrier frequency may reach the power line PL and thereover control the selective equipments of the other stations in a manner similar to that already described for the previously assumed calls. Carrier current of the higher

frequency supplied by and through response of the called station, will serve merely for speech transmission only, as response of line relay 510 to that carrier current will be without effect due to the controls of this relay having been disconnected by the operation of relay 522 as described.

Disconnect at the set 501 by return of the telephone receiver to its switchhook, effects release of relays 522, 523, 524 and 526, in restoring the circuits to normal at this point. The resulting cessation of carrier current from this point effects release of devices at the station which may have been under call as well as release of devices at all other stations. Therefore, in the event there should be delay in disconnecting at the called station circuit changes at that point would result in seizure of the circuits, as for the initiation of a call. This applies to all stations immediately associated with a transmitter for producing carrier currents. For other points on station A, etc. reseizure of the circuits will not take place. The circuits and devices for the telephone set 505 at station D, are identical with those of the set 501. For a call originating at the set 505, the left-hand rather than the right-hand winding of relay 515 is used, the relay 516 instead of the relay 522 would be operated in disabling the devices of set 501, while a relay 530 to switch the transmission leads of the hybrid coil 528 from the set 501 to the set 505 would be energized over the "grounding" contacts of the relay 516. Therefore, a detailed description of a call from the set 505 is not believed to be necessary.

For an incoming call for the telephone set 501, carrier current from over the power line PL results in response of relays 510, 511 and 512 in obvious circuits. Slow-to-release relay 512 disconnects the grounding circuit to disable the set equipments 501 and 505, connects the busy signals 504 and 529 and prepares a circuit for the "step" magnet 509. Arriving impulses of carrier current may then result in pulsing of relays 510, 511 and magnet 509 in bringing the brushes of selector 508 to rest on the fourth segments, so that a circuit from battery, winding of relay 519, segment A and right-hand brush of the selector to ground over the alternate contacts of relay 511 effects response of this relay 519. Ground over the right-hand contacts to the shaded conductor, is supplied to the switchhook control of set 501, and battery connected over the next right-hand alternate contacts of relay 519 may then energize call signal 503 to this ground, while the left-hand normal contacts of relay 519 disconnect battery from the winding of relay 516 as an additional precaution against possible idle manipulation of the dial 506 at the set 505.

Removal of the receiver from its switch-

hook at set 501 in responding to this call, disconnects the bell 503, and applies ground over the upper contact of the switchhook and the right-hand winding of relay 515 to battery. Response of this relay energizes the transmitter T5 to produce high frequency carrier so that the conversation may then proceed. Following disconnection by the station of this assumed connection it should now be obvious as to how the devices and circuits may automatically restore to normal.

For an incoming call to the telephone set 505, selector 508 may advance and come to rest on segment 5, where response of relay 518 may effect energization of the call signal 507 and transfer relay 530 while conditioning the set 505 so that removal of the receiver may result in energization of relay 515 over its left-hand winding. Relay 518 also disconnects battery from the relay 522 as an additional guard against idle manipulation of the dial 502 of the set 501, at this time. In all other respects, the operations are similar to those already described for receiving and releasing a connection to the telephone set 501.

For convenience in sending out general orders, meeting emergencies and like situations, the present system has been arranged so that the dialing of a predetermined code may call and permit simultaneous transmission of a message to all or any number of stations which may form a respective group for such service. For the sake of simplifying the drawings, this feature has been illustrated in connection with one station point only. From this, however, it will be clear that like equipment may be provided at other stations which it may be desired to associate for a call of this nature which for convenience may be designated as a "group" call. For this service, a relay 417 is connected to a segment 19 of the selector 408 at station C, Fig. 4. When a calling station may dial a particular group call the selectors at all stations will be advanced and the brushes brought to rest on respective segments 19. At station C, battery over the winding of relay 417, segment 19 and right-hand brush of selector 408 to ground over the alternate contacts of relay 411, effect response of relay 417 to energize a call signal 428 which will indicate that the call is a group or emergency call. The relay 417 also disconnects ground to disable the switchhook controls of the telephone set 401, in order that no relays may respond when the receiver of the set is lifted in responding to this special call. Thus the carrier frequency transmitter T4 is purposely left inert so that conflict of a plurality of different carrier currents of the higher frequency is avoided. The receiver of the telephone set 401 is however effective to receive a message from the station originating the group call. A key 429 is for convenience in silencing the signal 428, if desired. On disconnect at the calling station

the selector 408 will restore to normal in a manner similar to that already described. Thus, the relay 417 will be released in disconnecting the signal 428 and restoring ground to the telephone set 401. Let it now be assumed that a call is originated from the station E, Fig. 6. Removal of the receiver from its switchhook at telephone set 601 applies battery over the right-hand normal contacts of relay 627, right-hand winding of relay 616, next upper sets of contacts of the switchhook to ground over the normal contacts of relay 614. Relay 616 responds and switches the transmission leads (shaded lines) of the hybrid coil 618 from the trunk 605 to this telephone set 601. This closes a loop from battery, right-hand winding of relay 619, left-hand normal contacts of relay 627, left-hand alternate contacts of relay 616, the closed pulsing contacts of dial 602, upper contacts of the switchhook of this set 601, the transmitter and primary winding of the induction coil of this set, inner right-hand alternate contacts of relay 616, next right-hand normal contacts of relay 627 to ground through the middle winding of relay 619. Operation of relay 619 applies ground over an obvious circuit for response of a relay 620, and by way of the normal contacts of relay 630 and the left-hand winding of relay 621 for response of the latter relay. Relay 620 removes a shunt from the winding of relay 630 in preparing a circuit, therefore, while applying ground over obvious paths to effect response of filter transposing relays 623 and 624 and relay 622 for energizing the carrier current transmitter T6. Relay 621 disconnects ground to prevent response of a relay 629 and also closes a timing circuit for the transmitter T6. Direct current from the energized transmitter T6 may now traverse a resistance 634 and a short-circuiting type vibrator 628 to ground over the left-hand normal contacts of relay 629. Operation of this vibrator sets up current changes through a condenser 635 and the left-hand winding of relay 619. The latter may serve as a transformer in energizing the loop circuit just traced through the telephone set 601 in energizing the receiver of this set with this current which serves as a dialing tone or signal. Operation of the dial 602 effects interruption of its pulsing contacts to correspondingly pulse the relay 619. The slow-to-release characteristic of relay 620 prevents its release during these pulses while relay 621 responds thereto in pulsing the low frequency carrier current to the power line PL. During the first release of relay 621 under this pulsing, ground is applied over the right-hand normal contacts of relay 629 to place its winding in parallel with the vibrator 628. Relay 629 responds, disconnects the vibrator 628, while applying ground to lock itself

energized independently of the relay 621. This removes the dialing tone.

At the present station E the coordination of the devices and circuits differs in certain important respects from the arrangement at other of the stations in one particular that outward calls from this point or call originating by way of the trunk 605 do not result in disabling of the receiving relay system at this point. Therefore, for the assumed call, response of the distant called station to send out the high frequency carrier current effects response of relay 610 and in turn response of relays 611, 630, 627 and 626. For relays 611 and 630, the circuit is from battery winding of relay 611, alternate contact of relay 610, and the winding of relay 630 to ground, while for relay 627 the circuit is from battery, winding of this relay, right-hand alternate contacts of relay 611 to ground over the left-hand contacts of relay 630. Relay 630 substitutes ground for that from relay 619 in returning relay 620, following disconnect of relay 619. Response of relay 627 switches the loop from the telephone set 601 from the relay 619 to be energized by battery and ground potentials over respective left-hand normal contacts of relay 625 and the windings of relay 626. Ground over the contacts of relay 626, right-hand normal contacts of relay 625 and the right-hand alternate contacts of relay 630 now retains the relay 621. The purpose of the non-interrupting form of these contacts on the relay 630 is to insure retention of the relay 621 during the several relay responses described. The circuits are now continued for conversation between the telephone set 601 and the distant station which may have been called. During the talking period the relay 616 will be retained by current from battery through a resistance 636 connected to bridge the right-hand normal contacts of the relay 627. Due to its marginal characteristics, however, the relay 616 may not respond to the strength of current permitted by the resistance 636, this also applies to the step magnet 609 which is thus disconnected at the battery supply contacts of relay 627 as well as at the normal contacts of the relay 610.

Following disconnect at the station which may have been called, as just described, the resulting cessation of carrier current from that point permits release of relays 610, 611, 630, 627, 626 and the reoperation of relay 619. Under its slow-to-release characteristics relay 620 retains the relay 622 until restoral of relay 627 has switched the loop for the telephone set 601 from the relay 626 back to its original circuit through the windings of relay 619, whereupon, response of the latter relay applies ground to retain the relay 620 and also relay 621. The intermeshing of the several contacts of the relay 630 during its release, insures retention of the relay 621

during the interval between release of relay 626 and response of relay 619. Disconnect of the set 601 by restoral of the receiver to its switchhook effects release of relays 616, 619, 620, 621 and 622, thus bringing the circuits to normal. In case disconnect has first been made at the set 601 rather than at the distant station, relays 626, 620, 621, 622, 630 and 627 would have released, the relay 620 shunting down the relay 630, while substituting ground for retention of the relay 611. This ground over the normal contacts of the relay 620 and alternate contacts of relay 610 also effects display of a busy signal 606 to battery by way of the right-hand normal contacts of relay 616. Pending disconnect at the distant station, the signal 606 merely indicates such condition during which period the telephone set is not barred but may be operated to come in on the circuit as for further conversation. Following disconnect at the distant point relays 610, 611 and signal 606 will restore and the circuits then will be at normal.

Let it now be assumed that the station E receives a call from a distant station on the power line PL. Arrival of the carrier current results in response of relay 610 which closes a circuit from ground, the left-hand normal contacts of relay 620 and the alternate contacts of relay 610, thence branching over busy signal 606 and the right-hand normal contacts of relay 627 to battery, and over the winding of relay 611 to battery. The slow-to-release relay 611 prepares the circuit for step magnet 609 while the lamp 606 serves as a busy signal. The relay 610 responds to impulses and causes the magnet 609 to advance the switch 608 to its sixth position. The first movement of the selector first completed a circuit, however, from battery, right-hand brush and first segment of that sector bank and the winding of a relay 614 to ground. Response of relay 614 disconnects ground to disable the circuit controls of the telephone set 601, and to connect the vibrator 615 to the trunk circuit 605, although this vibrator remains connected to the main conductors of the telephone set 601. Therefore, for an attempted call either from this telephone set or from over the trunk circuit this vibrator will operate to produce a busy signal tone to indicate the present assumed condition of the circuit. In the sixth position a circuit will be completed for relays 616 and 625 as follows: Battery, brush of the right-hand bank of selector 608, the sixth terminal thereof, left-hand winding of relay 616, winding of relay 625 to ground. Relay 616 in operating connects the buzzer 615 across the conductors 605 to make this trunk busy and the ringer 603 is actuated over a circuit as follows: battery, outer right-hand armature and front contact of relay 616, ringer 603, lower contact and switchhook of set 601 to

ground at the make-before-break contacts of relay 614. It should be observed that the busy signal 606 which was operated at the time that relay 610 was operated will be extinguished on the operation of relay 616. Relay 625 in operating connects the windings of relay 626 in series through the left-hand armatures and front contacts of this relay and the make-before-break contacts of relay 637. When relay 625 operates a circuit will also be closed for the operation of relay 627 as follows: battery, winding of relay 627, outer right-hand armature and front contact of relay 611, outer left-hand armature and front contact of relay 625 to ground. Relay 627 in operating disconnects the windings of relay 619 from the conductors that now lead to the subscriber set 601 and connect instead the windings of relays 626 to these conductors. When the subscriber of set 601 removes his receiver from the hook the loop completed for the windings of relay 626 will be closed at the set and relay 626 will now operate to close a circuit for the relay 622 as follows: battery, winding of relay 622, right-hand armature and front contact of relay 625 to ground at the armature and front contact of relay 626. Thus the "higher frequency" carrier will be supplied by the transmitter T6 to the power line PL and the subscriber of set 601 will now be in a position to talk over the hybrid coil 618 to the calling station. When the subscriber at 601 hangs up his receiver relay 626 will be released causing the release of relay 622. The release of relays 610 and 611 when the calling subscriber hangs up his receiver causes the selector 608 to be returned to normal and release relay 627 followed by the release of relays 616 and 625.

A description will now be made of a call from the automatic exchange F through station E to and from any station on the power line.

If an automatic subscriber is called from a station on the power line PL relays 610 and 611 will be operated and the magnet 609 will advance the selectors 608 to the seventh terminals. When this takes place a circuit will be completed for the operation of relay 625. Relay 625 completes the above mentioned loop for the windings of relay 626 and causes the operation of relay 627 so that a connection is now completed to the conductors of trunk 605. This trunk extends through the armatures and back contacts of relays 721 and 722 to battery and ground through the windings of relay 720, and relay 626 will therefore operate. The operation of relay 626 closes the circuit for relay 622 so that transmitter T6 will now transmit the "higher frequency" carrier over the power line for talking purposes.

To select a subscriber through the automatic exchange, a succeeding series of impulses will be received through relay 610 to

- select the desired subscriber. These impulses cause the alternate operation and release of relay 637. The operating circuit for relay 637 is as follows: From battery, outer right-hand armature and front contact of relay 627, winding of relay 637, inner right-hand armature and front contact of relay 611, armature and back contact of relay 610 to ground at the armature and back contact of relay 620. The operation and release of relay 637 in response to these impulses will open and close the loop through the windings of relays 626 and 720. The release of relay 620 in response to these impulses will not affect the release of relay 622 as it is slow to release, besides, a circuit for this relay will extend to ground through the high resistance winding of relay 621, when relay 626 is in the actuated position. The pulsing of relay 720, which is the regular pulsing relay in the automatic exchange causes, through the usual operations of automatic exchange equipments, the selecting of the desired line through the selectors 701, 702 and 703 and the connector 704.
- If the subscriber wanted, may be reached through the manual exchange G, the trunk 705 is selected and the usual trunk lamp (not shown) will be lighted at jack 706 to call the operator having charge of cord 707 to connect this cord to the jack and communicate with the calling subscriber to ascertain the number of the wanted subscriber. If an automatic subscriber is desired, connector 704 will connect to terminals 710 and ring the subscriber of set 709. When the subscriber of set 709 or the operator at exchange G answers a call, relay 724 will be operated to connect relay 725 for control by relay 720 for supervisory purposes as is well known in the art. When the connection is released by the subscriber of set 709 or the operator at exchange G, relay 722 will operate to release relay 626 and the equipment at station E will be restored to normal as hereinbefore described.
- If the subscriber at station 709, or any other station having access to the automatic exchange F, or the operator at station G, desires to extend a connection to a station on the power line PL, such a subscriber or operator causes, in the usual manner, the selector 705, or selector 714, or a similar selector to select through the selectors such as 716 and 717 the line 726 and cause the operation of relay 721 to connect the conductor 726 to trunk 605. A loop circuit will thus be completed from such a subscriber or the station G to the conductors of trunk 605 to relay 619.
- If the power line PL is idle the subscriber of set 709 or the operator at station G will receive a dialing tone from the vibratory relay 628. This will be effected in the following manner: When relay 619 operates a circuit will be completed for relays 620, 622 and 621 and relays 623 and 624. Relays 622 and 621 prepare the transmitter T6 for the transmission of the "lower frequency" and also supply battery to lead 634. The circuits for this supply of battery have not been shown in detail in transmitter T6 but the connection through 634 may be completed to one side of the B battery generator. This connection may be established to the generator in transmitter T6 at a point corresponding to the point 334 in Fig. 3 in the transmitter T. Battery from this connection is applied through the winding of the buzzer 628 to ground at the armature and back contact of relay 629. As the buzzer 628 operates a tone will be induced through the condenser 635 and the left-hand winding of relay 619 through the other windings of relay 619 to trunk 605. When now the subscriber of set 709 or the operator at G actuates the dial 712 or 711 impulses will be transmitted through the automatic exchange to trunk 605 to cause the alternate release and operation of relay 619. Relay 621 will follow these impulses and as relay 621 releases the first time, a circuit will be completed from battery connected through resistance 634, through the winding of relay 629, make-before-break contacts of this relay, left-hand armature and back contact of relay 621 to ground. Relay 629 operates and removes ground for the circuit of buzzer 628 which will thereby remove the dialing tone from the trunk.
- When the called station answers relay 610 will be operated. As this relay operates relay 611 and relay 630 operate, and relay 630 in operating causes the operation of relay 627 to transfer the connections of trunk 605 through relay 626, the windings of which are now connected to battery and ground at the armatures and back contacts of relay 625. Relay 626 operates and closes a circuit for the maintaining of relay 621 operated through the contacts 631 of relay 630 while relay 620 is maintained operated through the inner left-hand armature and front contact of relay 630. Transmitter T6 will therefore now be maintained energized to transmit the "lower frequency" carrier for talking purposes.
- When either the subscriber of set 709 or the operator at G breaks the connection, relay 626 will be released and when the called subscriber on the power line replaces his receiver, the circuits of station E will be returned to normal as hereinbefore described.
- The power line stations may be so arranged that any of the stations may break in on an existing connection between any two of the other stations. How this may be done is illustrated in the equipment at station B, Fig. 2. All that is necessary is to operate key 260 which supplies a ground for the switchhook of set 201 so that when the operator at this station removes his receiver from the hook, his station will function in the usual manner

and he will be able to select any desired station on the line.

What is claimed is:

1. In a telephone system including a power line, a plurality of stations associated with said line, high frequency current sources associated with said stations, means for establishing a communicative connection between any two of said stations and for disabling the other stations in response to impulses from a high frequency source at the calling station, and means for utilizing current waves of one frequency as the speech current carrier from the calling station, and current waves of another frequency as the speech current carrier from the called station.

2. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a tone device, a ringing signal, a busy signal and a selector at each of said stations, means responsive to the lifting of the receiver off the switchhook at any one of said stations for transmitting a dialing tone from said tone device to said lifted receiver if the power line is idle and for actuating the busy signals and disabling the telephone sets and dials at all of the other stations, means responsive to the operation of the dial at said calling station for actuating the selectors at all of the other stations during the selection of one of said stations, and means responsive to the selection of a station for actuating the ringing signal thereat and for preparing said station for connection with the calling station.

3. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a ringing signal, a busy signal, a selector and a source of high frequency current at each of said stations, means responsive to the removal of the receiver from the switchhook at any one of said stations for transmitting a signal of high frequency current from the associated source over the power line to the other stations, means responsive to the reception of said high frequency current signal for actuating the busy signals and for disabling the telephone sets and dials at said other stations, and means responsive to the operation of the dial at the calling station for transmitting impulses of high frequency current from said station to the other stations for actuating all of the selectors and for actuating the ringing signal at one of said stations, depending upon the number of impulses transmitted and for preparing the selected station for connection with the calling station.

4. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a step-by-step selector, and a source of high

frequency current at each of said stations, means responsive to the removal of the receiver from the switchhook and the operation of the dial at any one of said stations for actuating the selectors at all of the other stations and for associating a wanted station with a calling station and excluding all the other stations from associating with the calling station, said association being accomplished through high frequency current impulses from the source at the calling station transmitted over the power line and controlled by said switchhook and dial operations, and means responsive to the connection between the calling station and the called station for transmitting high frequency current of one frequency from the source at the calling station as the carrier for the speech current from the calling station and for transmitting high frequency current of another frequency from the source at the called station as the carrier for the speech current from the called station.

5. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a ringing signal and a source of high frequency current at each station, means responsive to the removal of the receiver from the switchhook and the actuation of the dial at any one of said stations for transmitting controlling impulses of high frequency current from the source at the calling station to select any one of the other stations and disable the remaining stations and for transmitting high frequency waves from the source at said calling station to the power line as a carrier for the speech current from the calling station, means responsive to the removal of the receiver from the switchhook at the called station for transmitting high frequency waves of another frequency from the source at said called station to the power line as a carrier for the speech currents from the called station, and means responsive to the replacement of the receiver on the switchhook at the called station for releasing the communicating connection between the calling station and the called station.

6. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a ringing signal and a source of high frequency current at each station, means responsive to the removal of the receiver from the switchhook and the actuation of the dial at any one of said stations for transmitting controlling impulses of high frequency current from the source at the calling station to select any one of the other stations and disable the remaining stations and for transmitting high frequency waves from the source at said calling station to the power line as a carrier for the speech current from the calling station, means

responsive to the removal of the receiver from the switchhook at the called station for transmitting high frequency waves of another frequency from the source at said called station to the power line as a carrier for the speech currents from the called station, means responsive to the replacement of the receiver on the switchhook at the called station for releasing the communicating connection between the calling station and the called station, and means responsive to the removal of the receiver at another station for disabling the former calling station if the receiver at said calling station has not been replaced on the switchhook and the communicated connection has been released by the replacing of the receiver on the switchhook at the former called station.

7. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a ringing signal and a source of high frequency current at each station, means responsive to the removal of the receiver from the switchhook and the actuation of the dial at any one of said stations for transmitting controlling impulses of high frequency current from the source at the calling station to select any one of the other stations and disable the remaining stations and for transmitting high frequency waves from the source at said calling station to the power line as a carrier for the speech current from the calling station, means responsive to the removal of the receiver from the switchhook at the called station for transmitting high frequency waves of another frequency from the source at said called station to the power line as a carrier for the speech currents from the called stations, and means operative from any station for breaking up any existing communicating connection between two stations to permit the establishing of a new communicating connection between the two stations.

8. In a telephone system including a power line, a plurality of stations associated with said power line, a telephone set, a dial, a ringing signal and a source of high frequency current at each station, means responsive to the removal of the receiver from the switchhook and the actuation of the dial at any one of said stations for transmitting controlling impulses of high frequency current from the source at the calling station to select any one of the other stations and disable the remaining stations and for transmitting high frequency waves from the source at said calling station to the power line as a carrier for the speech current from the calling station, means responsive to the removal of the receiver from the switchhook at the called station for transmitting high frequency waves of another frequency from the source at said called station to the power line as a carrier for the speech currents from the called station, means re-

sponsive to the replacement of the receiver on the switchhook at the called station for releasing the communicating connection between the calling station and the called station, and means responsive to the replacement of the receiver on the switchhook at the calling station before the receiver at the called station is removed from its switchhook for releasing the connection between said stations.

9. In a telephone system including a power line, a plurality of stations associated with said power line, a tributary line terminating at one end in a telephone station and at the other end at one of said power line stations, a telephone set and a dial at each of said stations, and means responsive to the lifting of the receiver off the switchhook at a calling station for preventing the other stations from originating calls, and means responsive to the operation of the dial of said calling station for selecting any one of the other stations.

10. In a telephone system including a power line, a plurality of stations associated with said power line, a tributary line terminating at one end in a telephone station and at the other end in one of said power line stations, a telephone set and a dial at each of said stations, means responsive to the lifting of the receiver off the switchhook and to the operating of the dial at any one of said stations for selecting any one of said stations and for disabling the remaining stations, said means including in case the tributary line station and the power line station on which said tributary line terminates are involved a plurality of high frequency current producing and responsive devices actuated during the selection of the tributary line station by a power line station or during the selection by the tributary line station of a power line station to transmit and receive combinations of high frequency current impulses serving as the medium of control.

11. A telephone system according to claim 10 characterized in this, that said high frequency current producing and responsive devices consist of vibratory relays of the short circuiting type, each relay having its armature tuned to a different frequency and arranged so that each vibratory relay serves as a high frequency transmitting means as well as a high frequency receiving means, the high frequency transmitted and received by the same relay being of the same order.

12. In a telephone system including a power line, a plurality of stations associated with said power line, a tributary line terminating at one end in a telephone station and at the other end in one of said power line stations, a telephone set and a dial at each of said stations, means responsive to the lifting of the receiver off the switchhook and to the operating of the dial at one of said stations for selecting any one of the other stations and dis-

abling the remaining stations, a high frequency source at each of said power line stations, talking battery at the tributary line station, and means whereby current waves from the high frequency source serve as the speech current carrier for communication between power line stations and whereby current from the talking battery serves as the speech current for communications from the tributary line to the power line station in which this line terminates and if the connection extends from the tributary line station to another power line station the current waves from the high frequency source at the power line station in which the tributary line terminates serve as the carrier over the power line for the speech current incoming over the tributary line and whereby the high frequency current waves serve as the carrier for communications from a power line station to the tributary line station.

13. In a telephone system including a power line, a plurality of stations associated with said power line, a tributary line terminating at one end in a telephone station and at the other end at one of said power line stations, a telephone set and a dial at each of said stations, means responsive to the lifting of the receiver off the switchhook and operating a dial at any one of said stations for selecting any one of the other stations and disabling the remaining stations, and means responsive to the replacement of the receiver on the switchhook at a power line station after the connection between the tributary line station and said power line station has been established for releasing the said connection irrespective of whether the power line station was the calling or the called station.

14. In a telephone system including a power line, a plurality of stations associated with said power line, an automatic exchange, a trunk line terminating at one end at said automatic exchange and at the other end at one of said power line stations, a telephone set and a dial at each of said stations, means at said automatic exchange for seizing said trunk, and means responsive to the lifting of the receiver from the switchhook and operating the dial at any one of said power line stations or responsive to the seizing of said trunk and transmission of dialing impulses over said trunk for selecting any one of the power line stations and for disabling the remaining stations.

15. In a telephone system including a power line, a plurality of stations associated with said power line, an automatic exchange, a trunk line terminating at one end at said automatic exchange and at the other end at one of said power line stations, a telephone set and a dial at each of said stations, means responsive to the lifting of the receiver off the switchhook and operating the dial at any one of said power line stations for se-

lecting any one of the other stations or the trunk line except that the trunk line may not be selected by the power line station at which it terminates, and means responsive to said last mentioned means for disabling the stations not selected and in the case the trunk line is not selected for making said trunk line busy.

16. In a telephone system including a power line, a plurality of stations associated with said line, a telephone set and a dial at each of said stations, means responsive to the removal of the receiver from the switchhook at a calling station for preventing the other stations from originating a call, and means responsive to the actuation of the dial at said calling station for establishing a communicative connection with any one of the other stations.

17. In a telephone system including a power line, a plurality of stations associated with said line, high frequency current sources associated with said stations, a telephone set and a dial at each of said stations, means responsive to the removal of the receiver from the switchhook at a calling station for preventing the other stations from originating a call, means responsive to the actuation of the dial at said calling station for transmitting impulses from a source at said calling station for establishing a communicative connection with any one of the other stations, and means for utilizing current waves from said sources as the speech current carrier.

18. In a telephone system including a power line, a plurality of stations associated with said line, high frequency current sources associated with said stations, a telephone set and a dial at each of said stations, means responsive to the removal of the receiver from the switchhook at a calling station for transmitting a current signal from a source at said calling station over said line, means responsive to said signal for preventing the other stations from originating calls, and means responsive to the actuation of the dial at the calling station for transmitting current impulses from a source at said calling station for establishing a communicative connection with any one of the other stations.

19. In a telephone system including a power line, a plurality of stations associated with said line, high frequency current sources associated with said stations, a telephone set and a dial at each of said stations, means responsive to the removal of the receiver from the switchhook at a calling station for transmitting a current signal from a source at said calling station over said line, a relay at each station operative in response to said transmitted current signal, means responsive to the operation of said relays for preventing the other stations from originating calls, and means responsive to the actuation of a dial at said calling station for transmitting

current signals from a source at said calling station for establishing a communicative connection with any one of the other stations.

⁵ In witness whereof, I hereunto subscribe my name this 21 day of December A. D., 1927.

HENRY W. O'NEILL.

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