

March 19, 1940.

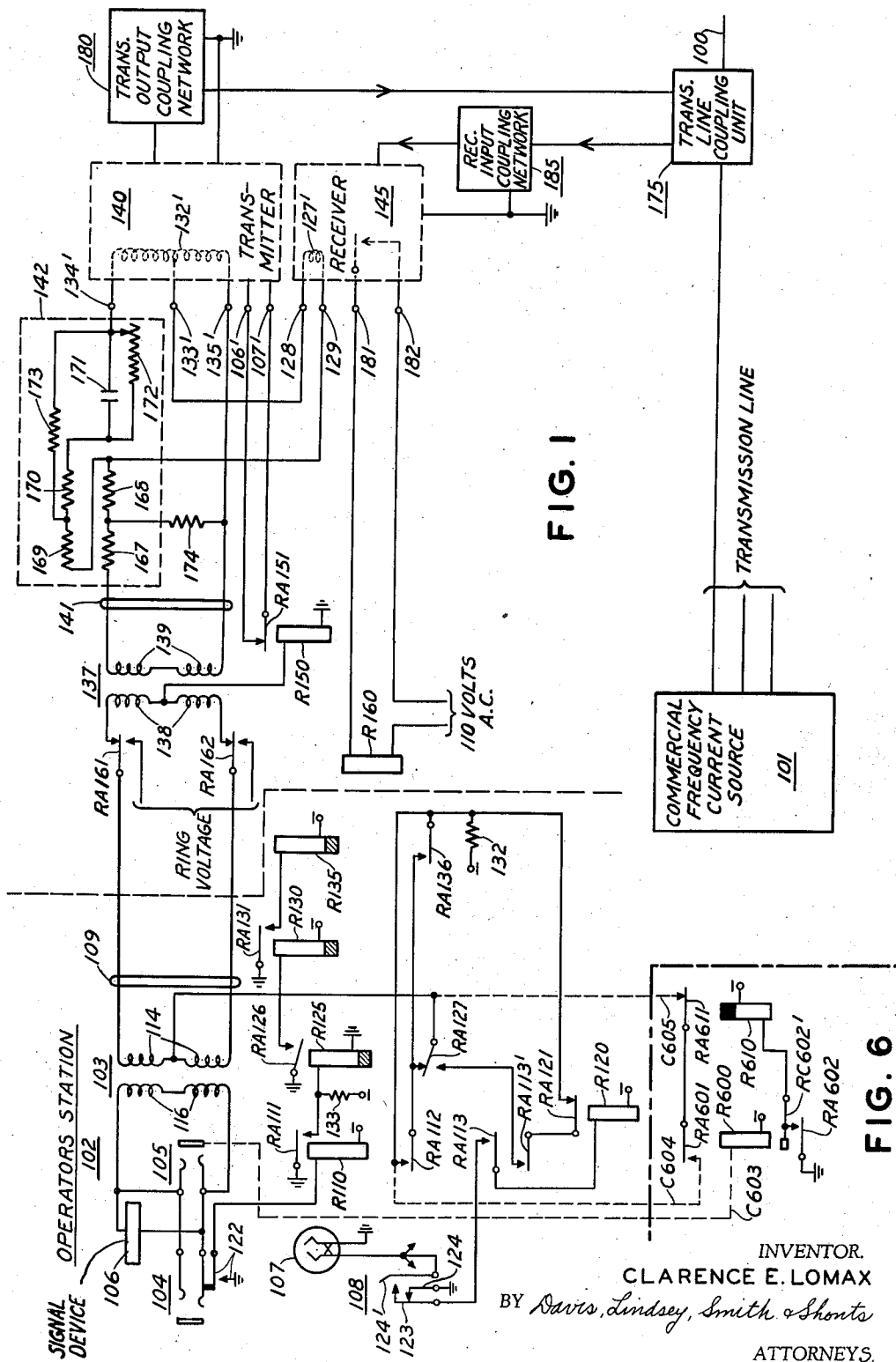
C. E. LOMAX

2,193,973

TELEPHONE SYSTEM

Filed April 4, 1938

9 Sheets-Sheet 1



March 19, 1940.

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2,193,973

TELEPHONE SYSTEM

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9 Sheets-Sheet 2

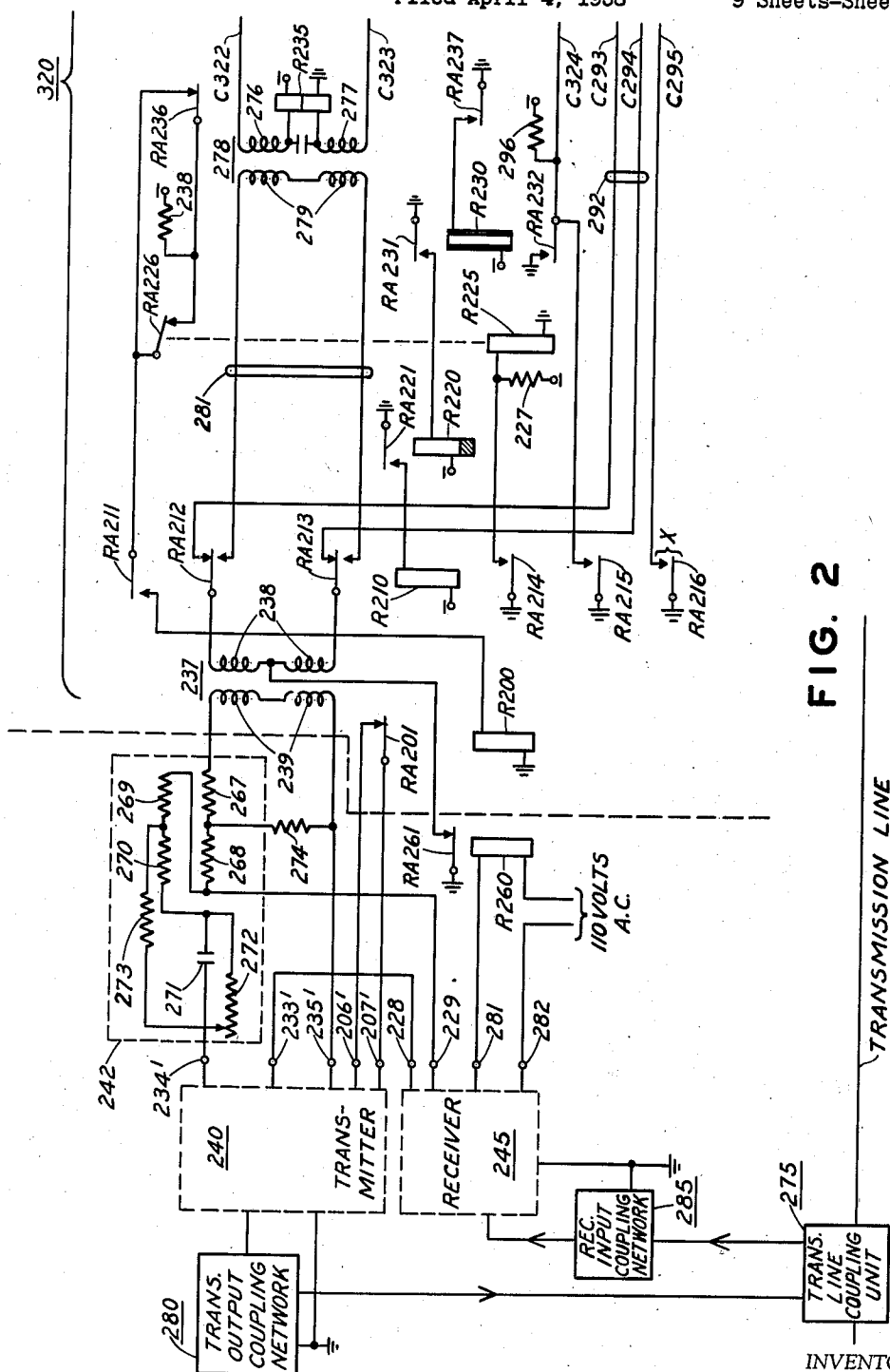


FIG. 2

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9 Sheets-Sheet 3

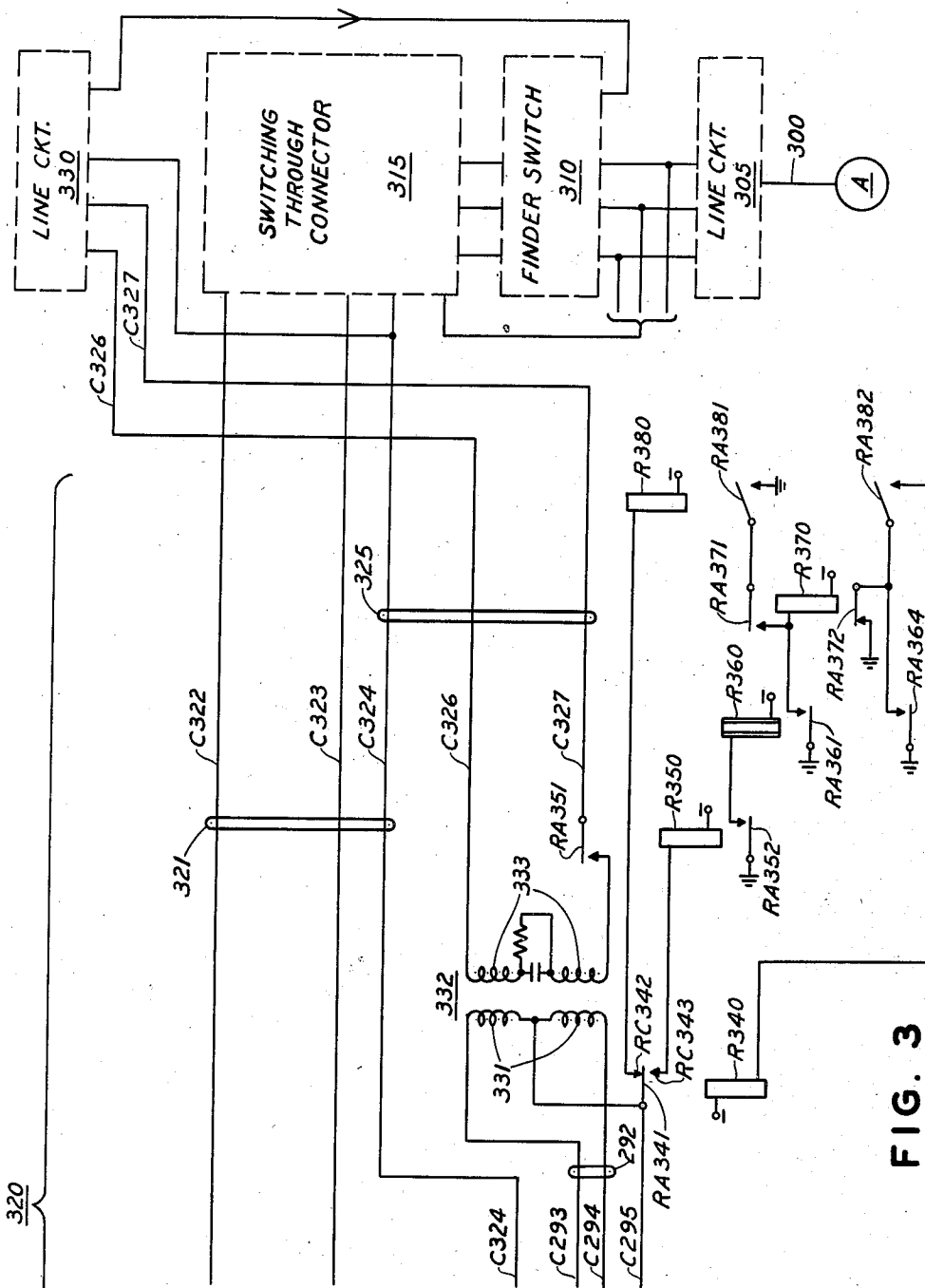


FIG. 3

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TELEPHONE SYSTEM

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9 Sheets-Sheet 4

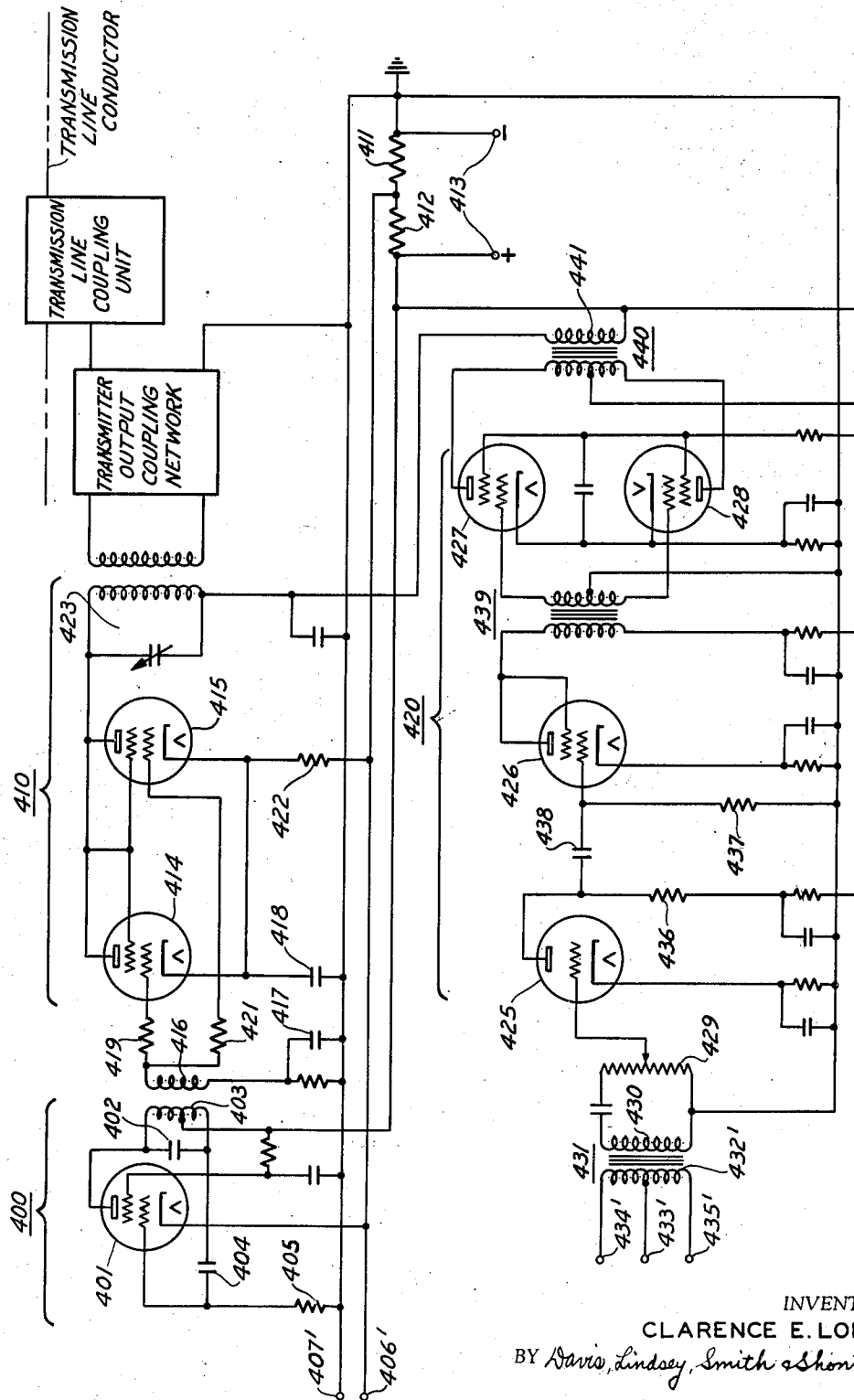


FIG. 4

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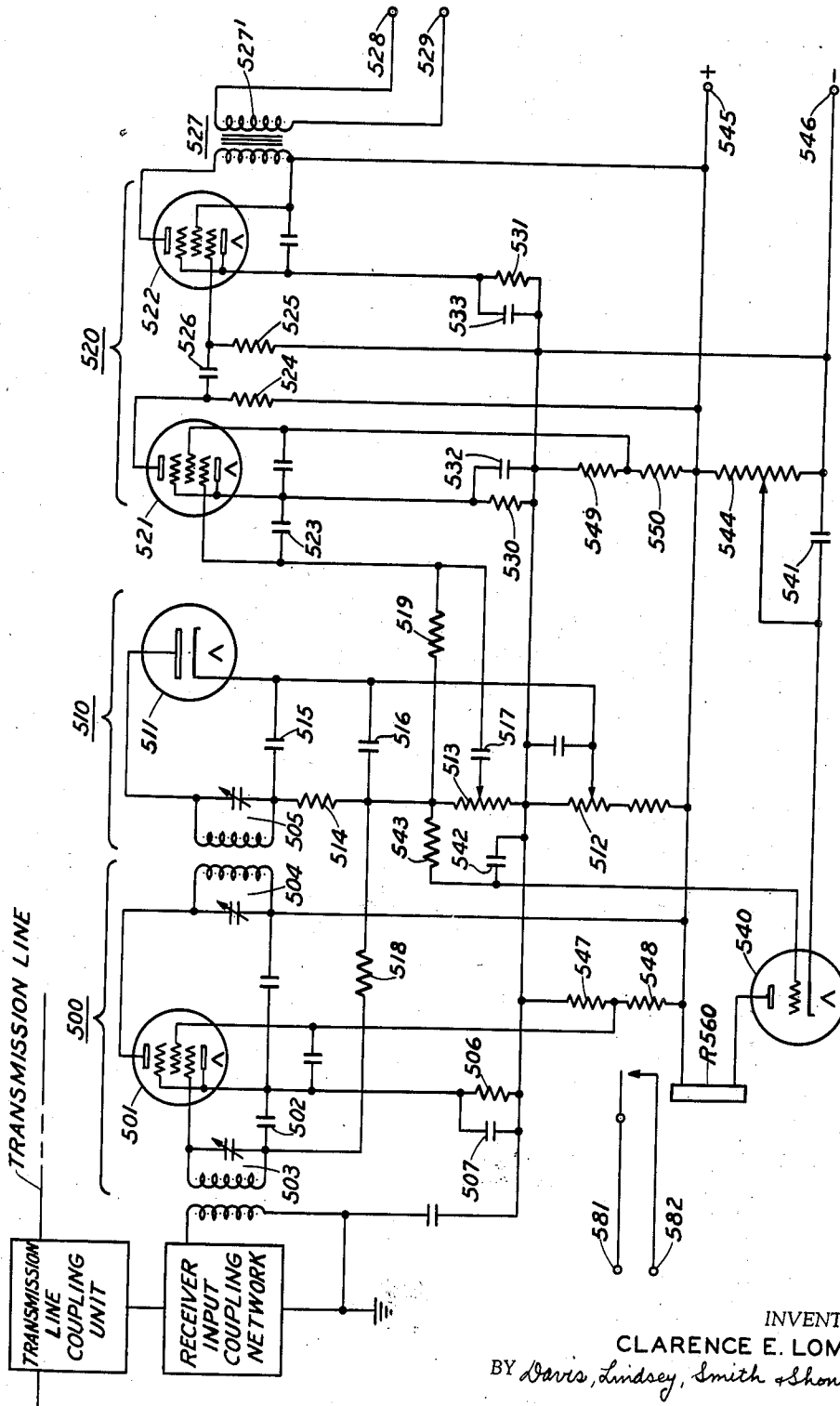
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TELEPHONE SYSTEM

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9 Sheets-Sheet 5



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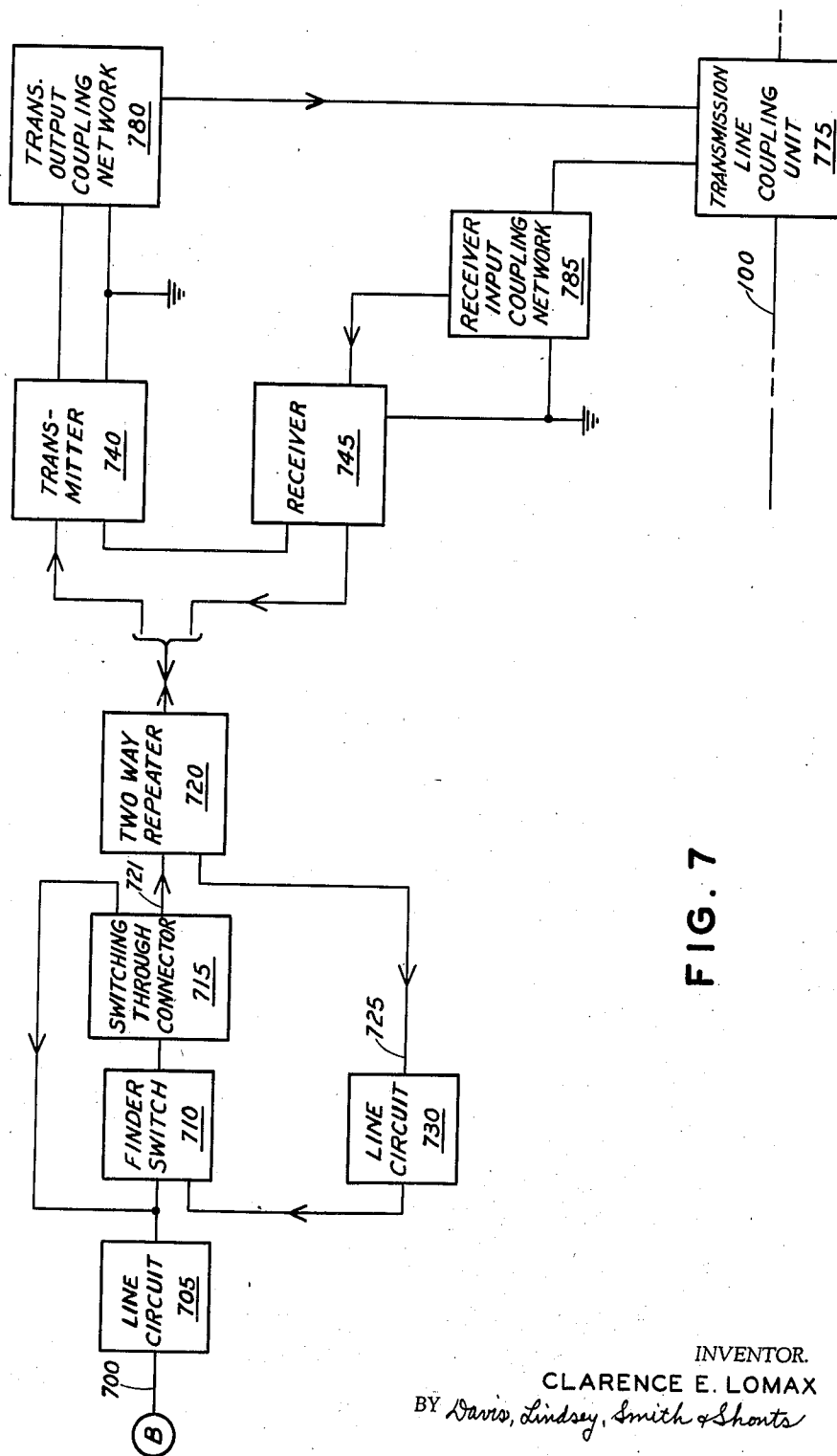
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TELEPHONE SYSTEM

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9 Sheets-Sheet 6



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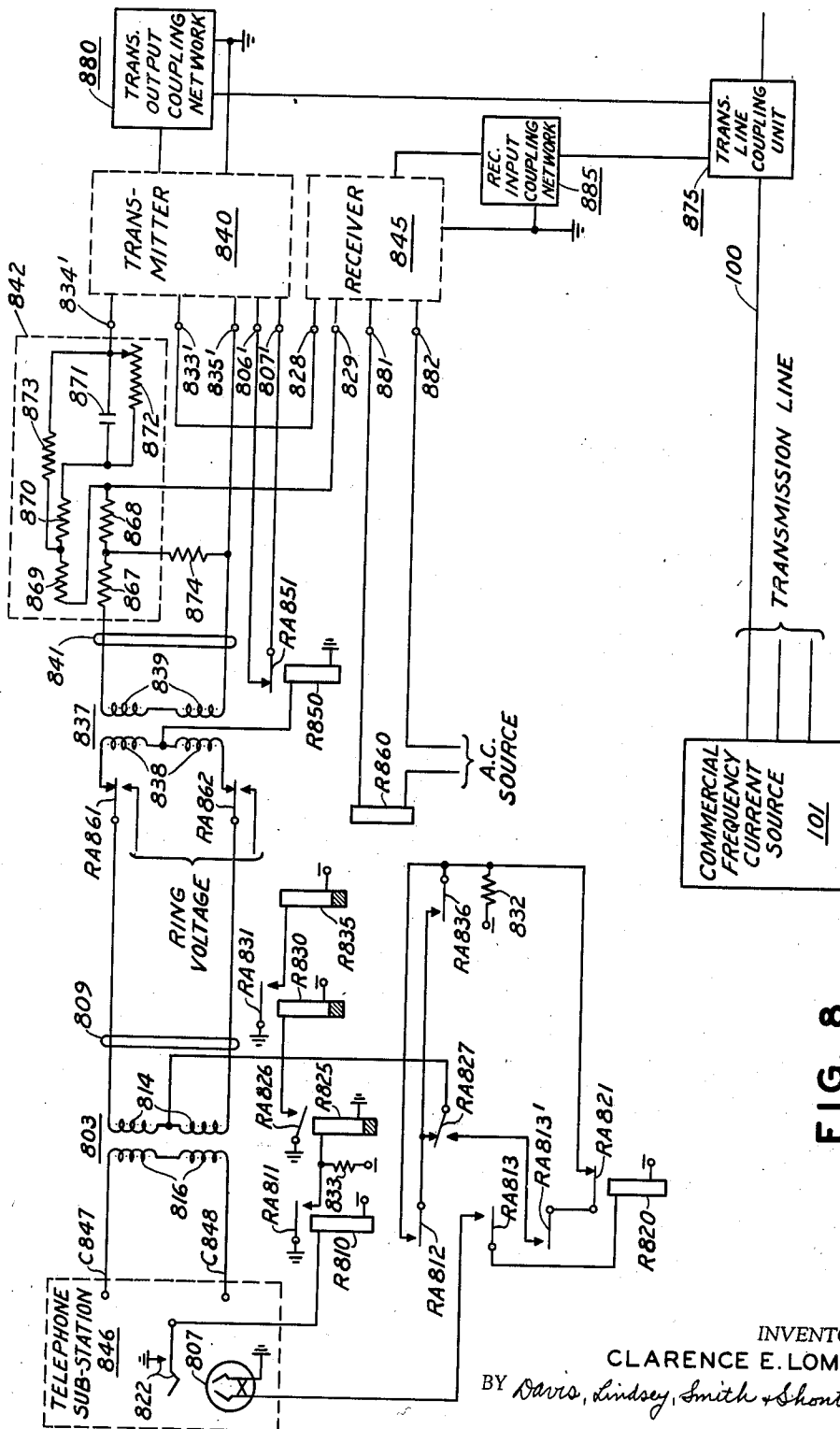
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TELEPHONE SYSTEM

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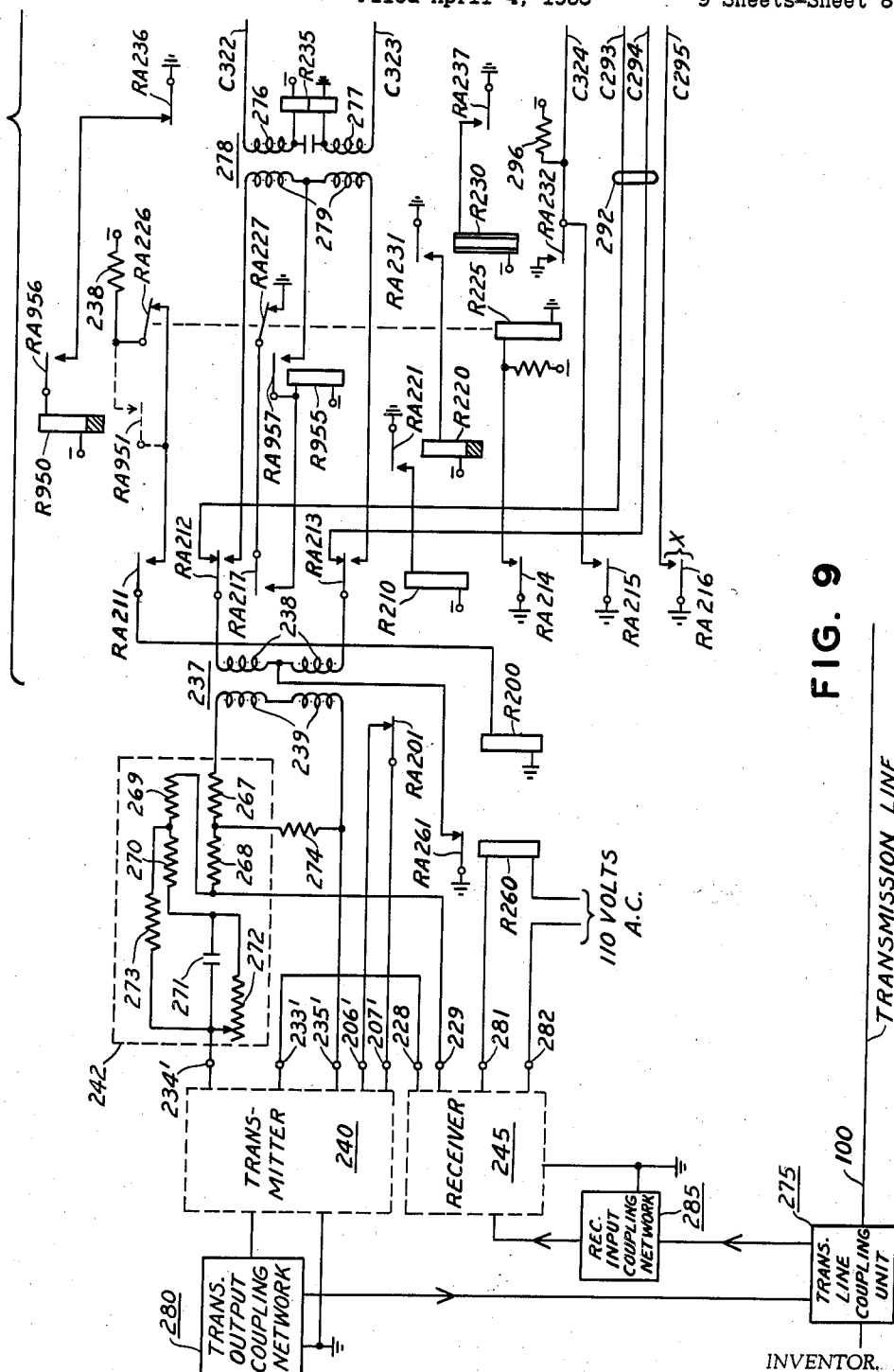
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9 Sheets-Sheet 8



TRANSMISSION LINE

100

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9 Sheets-Sheet 9

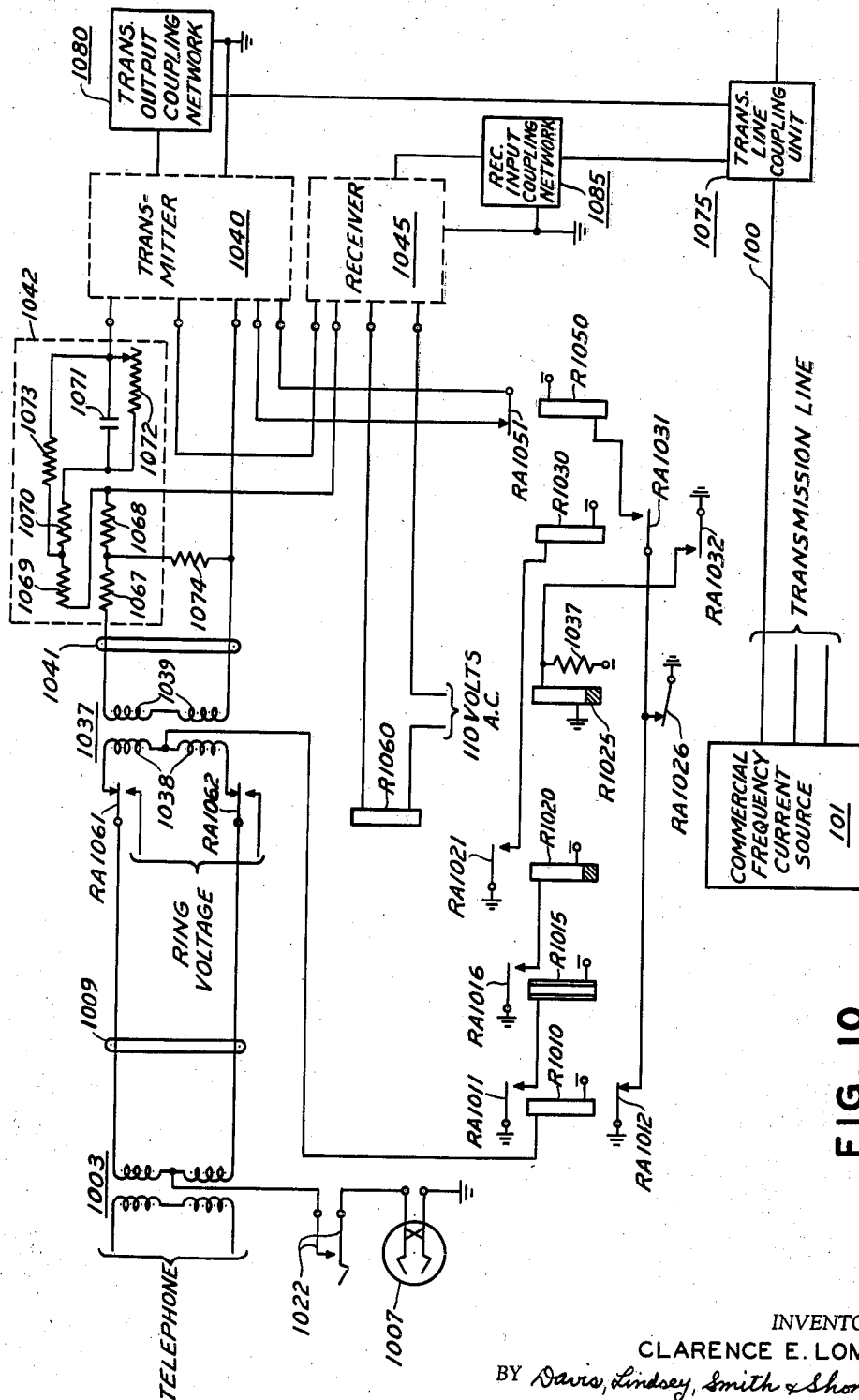


FIG. 10

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UNITED STATES PATENT OFFICE

2,193,973

TELEPHONE SYSTEM

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Application April 4, 1938, Serial No. 199,797

36 Claims. (Cl. 179—2.5)

The present invention relates to signaling systems and has for one of its objects the provision of an improved automatic telephone system wherein automatic switch control impulses and auxiliary control pulses and signals are transmitted by way of carrier current channels for the purpose of controlling automatic line switching equipment.

It has heretofore been proposed to utilize carrier current channels including commercial current power transmission lines for signaling and communication purposes. The use of high voltage commercial current frequency lines for this purpose is extremely advantageous in certain applications because it eliminates the cost of constructing and maintaining telephone lines. In the usual arrangement of this character, manually controlled switching equipment is utilized exclusively for setting up connections between the various telephone lines of the system.

It is an object of the present invention to provide an improved automatic telephone system wherein commercial frequency current power transmission lines are utilized for signaling and communication purposes, and wherein automatic switching equipment provided in a regular automatic exchange may be controlled by high frequency impulsing over a power transmission line forming a link between the automatic exchange and another exchange or a remotely located automatic telephone substation.

It is another object of the invention to provide a system of the above character wherein calls may be routed by way of the power transmission line in either of two directions, one or more two-way repeaters being utilized for controlling the carrier current equipment for operation in routing calls in the respective two directions of call transmission.

It is a further object of the invention to provide an arrangement of the character described having included therein improved apparatus wherein the functions auxiliary to line switching operations of an automatic telephone system and including the transmission of dial, busy and ring-back tones and the automatic ringing of a called substation are all provided.

Three embodiments of the invention are described in detail hereinafter, all of which are commonly characterized as comprising a system including a power transmission line having a source of commercial frequency current connected thereto and adapted to be used as a carrier current link between the telephone lines of the system. High frequency carrier current trans-

mitters and receivers are provided which are located at two separated points, are coupled to the transmission line by apparatus which is operative to block the commercial frequency current therefrom and are so connected and arranged that two independent carrier channels are provided for transmitting, as modulation components of the high frequency carrier currents, audio frequency currents over the line in the respective two directions of transmission. In each of the three embodiments of the invention a telephone line is coupled to the carrier transmitter and receiver located at one of the two points and the transmitter and receiver located at the other point are coupled or connected by way of a two-way repeater to have access to and to be accessible to the automatic switching equipment of an automatic exchange. Variations in this general arrangement pertain to modifications in the apparatus whereby calls may be routed by way of the carrier channels, the two-way repeater and the automatic switching equipment in an automatic exchange, to and from an operator's position in a manual exchange or an automatic subscriber's substation to a desired line terminating in the automatic exchange. In the third embodiment of the invention, provisions are made whereby the transmission line may be utilized as a link between two automatic exchanges, suitable improved apparatus being provided for adapting the automatic switching equipment provided in each of the two exchanges to utilize the carrier channels as a connecting link in setting up a connection and for the transmission of voice frequency currents when the connection is established. In each of the three embodiments one of the carrier channels is utilized for the transmission of automatic switch seizing and release pulses from the calling telephone to the automatic switching equipment in the distant automatic exchange and also for the transmission of the automatic switch control impulses to one or more of the impulse responsive switches provided in the exchange. In one modified arrangement of the apparatus this carrier channel is also utilized for the transmission of ring cut-off control pulses to the distant automatic exchange. As distinguished from this one carrier channel the other carrier channel is utilized for the transmission of dial tone, busy tone and ring-back tone signals produced as an incident of the operation of the automatic switching equipment in the automatic exchange to a calling telephone station. This other carrier channel is also utilized for the transmission of ringing control pulses in the two ar-

rangements wherein the transmission line is used as a link between a manual operator's position or an automatic subscriber's substation and an automatic exchange. One improved feature of

5 this ringing control arrangement is that apparatus is provided whereby a calling automatic subscriber may repeatedly ring the called operator or substation, as the case may be, by repeatedly actuating the dial controlled impulsing
10 device provided at the calling substation. In each of the three embodiments of the invention the two carrier channels are normally operative to transmit audio frequency energy in the respective two directions of transmission.

15 Further features of the invention pertain to the particular arrangement of the apparatus whereby the above and additional objects are attained.

The novel features believed to be characteristic of the invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will best be understood by reference to the specification, taken in connection with the accompanying drawings, in which Figures 1 to 3, inclusive, illustrate an automatic telephone system having incorporated therein certain features of the present invention;
30 Figs. 4 and 5 illustrate, respectively, a high frequency transmitter and a high frequency receiver adapted for use in all embodiments of the invention; Fig. 6 illustrates apparatus which may optionally be provided in combination with the
35 apparatus shown in Fig. 1 only when the apparatus of Fig. 1 is combined with that shown in Figs. 9 and 3 to form a complete telephone system; Fig. 7 schematically illustrates an automatic telephone subsystem which is adapted to be combined with the apparatus illustrated in
40 Figs. 2 and 3 to form a larger system in which a power transmission line is utilized as a carrier current link between two automatic exchanges; Figs. 8, 9 and 3, considered together, illustrate
45 a modified arrangement of the system; and Fig. 10 illustrates a modification of the apparatus shown in Fig. 8.

Referring now more particularly to Figs. 1, 2 and 3 of the drawings, there is illustrated a telephone system comprising a manual office, indicated as including the apparatus to the left of the broken line shown in Fig. 1, and an automatic exchange including the apparatus shown in Fig. 3 and that portion of the apparatus shown in Fig. 2 to the right of the broken line. The two exchanges are interconnected by a power transmission line including a transmission line conductor 100 and having connected thereto a source of commercial frequency current schematically indicated at 101. The transmission line 100 is indicated as being of the three-phase type, although only a single one of the line conductors is utilized for communication purposes. Located at two separated points along the power transmission line are two sets of carrier current equipment comprising two carrier current transmitters 140 and 240 and two carrier current receivers 145 and 245, all diagrammatically illustrated in the drawings. These transmitters and
70 receivers, which are normally in operation, are so connected and arranged that two independent carrier channels of different carrier frequencies are provided for transmitting, as modulation components of the high frequency carrier currents, audio frequency currents by way of the

transmission line conductor 100 between the manual office and the automatic exchange in the respective two directions of transmission. More specifically, the output carrier frequency of the transmitter 140 is different from the output carrier frequency of the transmitter 240, the receiver 245 is tuned to respond only to the output carrier of the transmitter 140, and the receiver 145 is tuned to respond only to the output carrier of the transmitter 240.

10 Located in the manual office is an operator's telephone station indicated generally at 102, which station includes a repeating coil 103 at which a first telephone line 109 terminates. The operator's telephone station 102 further comprises
15 a calling jack 104, an answer jack 105, a signal device in the form of a drop 106 which is connected to be energized by way of the line 109, a dial controlled impulsing device 107, a dial key 108, and five control relays R110, R120, R125, R130 and R135 connected and arranged in the manner illustrated. Of the enumerated relays, the relay R110 functions to condition the remaining relay equipment for operation when a call is initiated at the station 102, the relay R120
20 is an impulsing relay, the slow-to-release relay R125 is a call initiating relay, and the two slow-to-release relays R130 and R135 are time delay relays which are primarily utilized during the release of a connection involving the operator's station 102.

The end of the line 109 remote from the operator's station 102 is normally coupled by means of a second repeating coil 137 to the input circuit of the transmitter 140 and to the output circuit of the receiver 145. More particularly, the secondary winding 139 of the repeating coil 137 is connected by way of a link line 141 and a line balancing impedance network 142 to the input circuit of the transmitter 140 and to the output circuit of the receiver 145. For the purpose of transmitting switch seizing and switch release pulses and of repeating impulses dialed at the operator's station 102 by way of one of the carrier channels to the automatic switching equipment in the distant automatic exchange, there is provided an impulsing relay R150 which is arranged for energization over a simplex circuit including the two conductors of the line 109. In order to apply ringing current to the line 109 on calls incoming to the operator's telephone station 102, there is provided an alternating current ringing relay R160 which is controllable by way of the other of the carrier channels in the manner pointed out in detail hereinafter.

The transmitter 140 includes an input transformer having a primary winding 132' and the receiver 145 includes an output transformer having a secondary winding 127', both shown in dotted lines in Fig. 1. The primary winding 132', the secondary winding 127', and the secondary winding 139 of the repeater coil 137 are interconnected to form an antiside tone impedance network which includes, as a part thereof, the balancing network 142. The purpose of this arrangement is to prevent the audio signal voltages produced across the terminals of the secondary winding 127' from being modulated on the carrier generated by the transmitter 140, thereby to be retransmitted back to the transmitting party in the form of feed-back energy. This is accomplished by the arrangement illustrated, wherein audio output voltages produced across the terminals of the secondary
75

winding 127' cause equal and opposite currents to flow through the primary winding 132' of the transmitter input transformer. The voltage drops occasioned by these currents are substantially equal in magnitude and opposite in phase, so that the net input voltage to the transmitter for a substantial output voltage across the winding 127' is substantially zero. It is the purpose of the balancing network 142 to insure that the currents traversing the two halves of the primary winding 132' will be substantially equal in magnitude and opposite in phase at all frequencies within the signaling band, thus providing the maximum antiside tone effect. Specifically, the network 142 comprises four series-connected resistors 167, 168, 169 and 170 which are connected in series with a parallel resistance-capacitance circuit including a capacitor 171 and the adjustable portion of a resistor 172. Bridged across the series parallel arrangement comprising the resistor 170, the capacitor 171, and the adjustable resistor 172 is another fixed resistor 173. Connected between the lower line conductor of the line 141 and the junction point between the resistors 167 and 168 is a parallel padding or loss resistor 174. By properly proportioning the impedance values of the respective enumerated circuit elements 167 to 174 with respect to each other and relative to the impedance values of the transformer windings 132' and 127' and the repeater winding 139, it is possible to secure an arrangement wherein the currents flowing through the upper and lower halves of the winding and occasioned by voltage across the secondary winding 127' are substantially equal in magnitude and substantially opposite in phase for all frequencies within the signaling band. A certain amount of adjustment of the phase and magnitude of current flowing through the upper half of the primary winding 132' is possible by adjustment of the indicated slider arm along the resistor 172.

For the purpose of impressing the output carrier, either modulated or otherwise, of the transmitter 140 on the transmission line conductor 100, and for the further purpose of impressing modulated or unmodulated carrier voltages produced by operation of the transmitter 240 on the input circuit of the receiver 145, there is provided a transmission line coupling unit, indicated schematically at 175, a transmitter output coupling network, indicated at 180 in association with the transmitter 140, and a receiver input coupling network schematically indicated at 185 in association with the receiver 145. The coupling unit 175 is non-resonant in character and may be of any of several well-known conventional arrangements. For example, this unit may constitute the well-known capacitance type of coupling unit wherein a counterpoise paralleling the conductor 100 and capacitively coupled thereto is relied upon to provide coupling paths between the conductor 100 and the receiver input coupling network 185 and between the transmitter output coupling network 180 and the indicated transmission line conductor. The transmitter output coupling network, on the other hand, is preferably resonant in character, being tuned to the output carrier frequency of the transmitter 140, which corresponds to the input carrier frequency of the receiver 245, and being arranged in any conventional manner. Similarly, the receiver input coupling network 185 is resonant in character, being tuned to the output carrier frequency of the transmitter 240

and being arranged in any desired manner. Since the elements 175, 180 and 185 per se, form no part of the present invention, and several types of each are known to the art, these elements have been only diagrammatically illustrated in the drawings.

The automatic exchange illustrated in Figs. 2 and 3 has extending thereto a plurality of subscribers' telephone lines, one of which is indicated at 300, and includes a plurality of subscriber controlled automatic switches for setting up connections between the various lines of the system. More particularly, each of the subscriber lines terminates in a line circuit, that to which the line 300 extends being indicated at 305, and a group of finder-connector links are provided for performing the line switching operations. One such finder-connector link is illustrated as comprising a finder switch 310 and a switching-through connector switch 315. For the purpose of assigning finder-connector links to successive calling ones of the lines terminating in the exchange, there is provided, in accordance with conventional practice, an allotter, not shown, which may be of any desired arrangement.

It is pointed out that the finder switch 310 and the other similar switches corresponding thereto are nonnumerical switches, in the sense that they are ineffective to perform any line selecting functions other than that of automatically selecting calling ones of the telephone lines terminating in the bank contacts thereof. The connector switches, on the other hand, are commonly known as numerical switches, in that they are individually operative to perform particular line selecting functions in response to switch control impulses transmitted thereto. It will be understood that a plurality of finder-connector links are provided for performing the line switching functions, the number of links being determined by the maximum volume of traffic the exchange is required to handle. Further in accordance with conventional practice, each of the telephone lines terminating in the exchange is multipled to the corresponding bank contacts of each of the finder-connector switches whereby a plurality of links are available for setting up connections between each line and every other line of the system.

The end of each subscriber's line remote from the automatic exchange terminates in a subscriber's substation of the automatic type, that associated with the line 300 being indicated schematically at A. In brief, each of these substations may comprise the usual hand-set type of transmitter and receiver, a cradle or hook switch, a ringer, and an impulsing device for transmitting switch control impulses by way of the associated line to the automatic switching equipment located in the line terminating exchange.

The arrangement of the line circuits individually terminating the telephone lines extending to the automatic exchange may be of conventional arrangement. Similarly, the schematically indicated finder and connector switches may be of any desired arrangement, although preferably each of these switches is of the well-known Strowger type. The connector switch 315 is indicated as being of the switching-through type, provisions being made therein for establishing a clear metallic circuit through the switch on trunk calls, whereby switch control impulses may be transmitted by way thereof to distant impulse responsive equipment as, for example, to an impulse

repeater associated with an outgoing interoffice trunk line.

For the purpose of routing calls from the automatic exchange by way of the carrier channels to the distant manual office, or vice versa, there is provided a two-way repeater, indicated generally at 320, which is coupled to carrier current equipment including the carrier transmitter 240, the carrier receiver 245, a transmission line coupling unit 275, a transmitter output coupling network 280 and a receiver input coupling network 285. The same antiside tone arrangement as is illustrated in Fig. 1 is utilized for coupling the carrier equipment to the repeater 320 and a balancing network 242 is similarly provided for enhancing the effectiveness of the antiside tone arrangement at all frequencies within the signaling band. Since the carrier equipment shown in Fig. 2 is substantially a duplication of that illustrated in Fig. 1 and described above, no further description is deemed necessary to render clear an understanding thereof. It is pointed out, however, that the corresponding elements of Fig. 2 are indicated by reference characters which correspond to the characters used in Fig. 1, with the difference that a hundreds digit of two is used in Fig. 2 whereas a hundreds digit of one is used in Fig. 1.

The repeater 320 comprises an outgoing link line 321 which terminates in the bank contacts of the connector switches in the automatic exchange, and an incoming link line 325 which terminates in the line circuit 330 individual thereto and by way of which access is gained to the non-numerical switches provided in the automatic exchange. The line 321 includes talking conductors C322 and C323 connected to opposite terminals of the secondary windings 276 and 277 of a repeating coil 278 having a primary winding 279 adapted to be connected by way of a link line 281 to the secondary winding 238 of a second repeating coil 237. Normally the secondary winding 238 of the repeating coil 237 is connected to a link line 292 having conductors C293 and C294 terminating at opposite terminals of the primary winding 331 of a third repeating coil 332 which includes a secondary winding 333 arranged for connection to the link line 325.

The repeater 320 also includes a group of control relays of which the five relays R340, R350, R360, R370, and R380, illustrated in Fig. 3, are utilized on calls incoming to the automatic exchange, and the six relays R200, R210, R220, R225, R230 and R235, illustrated in Fig. 2, are utilized in extending a connection by way of the carrier channels to the distant manual office. There is also provided, under the control of the receiver 245, a pulsing relay R260 which corresponds to the relay R160 illustrated in Fig. 1 and which is operative to repeat received impulses by way of the repeater 320 to the impulse responsive automatic switches in the automatic exchange.

Each of the transmitters 140 and 240 illustrated in Figs. 1, 2, 7, 8, 9 and 10 may be of the form shown in Fig. 4. In general, the transmitter illustrated in Fig. 4 comprises an oscillator section 400 for developing high frequency current of the desired carrier frequency, a carrier frequency amplifier section 410, and an audio frequency or signaling amplifier section 420. More particularly, the carrier current channel of the transmitter includes a vacuum tube 401 of the screen grid type, embodied in the oscillator section 400 and having output electrodes coupled to the upper portion of an inductance element 403 forming a part of a tuned output circuit

402 which is resonant at the desired output carrier frequency. The output circuit 402 is coupled to the input electrodes of the tube 401 by means of the lower portion of the inductance element 403 and a condenser 404. The input control grid of the tube 401 is connected to ground through a filter resistor 405. This grid is, during operation of the oscillator section, maintained slightly negative with respect to the associated cathode due to the direct voltage drop provided by rectified grid current flowing through the resistor 405. The cathode of the tube 401 is also normally maintained at substantially direct ground potential through the provision of a bridge, not shown, but normally connected across the terminals 406' and 407', which bridge, as will be pointed out hereinafter in greater detail, comprises a set of armature springs of a control relay. With a direct current bridge across the terminals 406' and 407' such that the cathode of the tube 401 is at substantially the same direct potential as the associated control grid, the oscillator section 400 operates to deliver substantially its maximum carrier output voltage. In order to control the output of the oscillator section, or more generally, the carrier output in accordance with the control pulses delivered to the transmitter, provisions are made for driving the cathode of the tube 401 more positive with respect to the potential of the associated control grid, which is tantamount to biasing the control grid of the tube negatively toward cutoff. More particularly, the positive bias for the cathode of the tube 401 is derived from a voltage dividing resistor comprising the two elements 411 and 412 connected across a source of direct voltage, not shown, but connected between the terminals 413. Specifically, the arrangement is such that the voltage drop across the resistor 411 is impressed on the cathode of the tube 401 when the bridge normally connected across the terminals 406' and 407' is opened. The magnitude of this bias voltage is sufficient to reduce the voltage amplification through the tube 401 to a point where the carrier output of the oscillator section 400 is interrupted, or reduced substantially to zero.

The output circuit 402 of the tube 401 is coupled to the input circuit of the carrier amplifier section 410, which amplifier section comprises a pair of parallel connected vacuum tubes 414 and 415, each of the screen grid type. More specifically, the input circuit to the two tubes 414 and 415 includes an inductance element 416 coupled to the inductance element 403, and the carrier voltage developed across the inductance element 416 is impressed between the input electrodes of the two tubes 414 and 415 through the two coupling condensers 417 and 418, suitable lossier resistors 419 and 421 being provided for preventing the amplifier section from oscillating. For the purpose of biasing the cathodes of each of the two tubes 414 and 415 positive with respect to the respective associated control electrodes, there is provided a cathode biasing resistor 422 which is included in the cathode leg of the output circuit for the two tubes 414 and 415. Normally only the bias voltage developed across the resistor 422 is impressed on the cathodes of the tubes 414 and 415. When, however, the direct current bridge across the terminals 406 and 407 is interrupted, the voltage drop across the resistor 411 is also impressed upon the cathodes noted, thereby to increase the positive bias on these cathodes to a point approaching cutoff such that a further blocking effect on the carrier out-

put of the carrier channel is effected. The output circuit of the amplifier section 410 includes a circuit 423 tuned to the output carrier frequency and coupled to the input circuit of the transmitter output coupling network in the manner illustrated.

The audio frequency or signal amplifying channel 420 of the transmitter comprises a voltage amplifier vacuum tube 425 of the triode type, a driver stage including a vacuum tube 426 of the screen grid type, and a power amplifier stage comprising two vacuum tubes 427 and 428, each of the screen grid type and connected in push-pull in the manner illustrated. More particularly, the input electrodes of the tube 425 are coupled to the adjustable terminals of a manually operable gain control potentiometer including a voltage dividing resistor 429 having its non-adjustable terminals coupled across the secondary winding 430 of an input coupling transformer 431. This transformer is provided with a primary winding 432' having a center tap brought out to a terminal 433' and two end terminals connected to the terminals 434' and 435'. The manner in which this primary winding is connected and arranged in the antiside tone arrangement illustrated in Fig. 1 is described previously, it being pointed out in this regard that the terminals 406', 407', 433', 434' and 435' correspond, respectively, to the terminals 106', 107', 133', 134' and 135' shown in Fig. 1 and to the terminals 266', 267', 233', 234' and 235', shown in Fig. 2. The output electrodes of the tube 425 are resistance coupled to the input electrodes of the tube 426 by a coupling network of conventional arrangement comprising the two resistors 436 and 437 and the audio frequency coupling condenser 438. The driver tube 426 is in turn coupled to the input electrodes of the push-pull connected tubes 427 and 428 by means of a coupling transformer 439. Suitable cathode biasing resistors shunted by alternating current by-pass capacitors are provided for each of the four tubes 425 to 428, inclusive, in the conventional manner illustrated in the drawings.

Plate circuit modulation is employed for modulating the carrier output of the carrier amplifier section 410 in accordance with amplified audio or signal voltages developed across the output circuit of the audio or signaling channel 420. To this end there is provided in the output circuit of the push-pull connected tubes 427 and 428 a coupling transformer 440 having a secondary winding 441 included in the output circuit of the parallel connected amplifier tubes 414 and 415, in series with the tuned tank circuit 423. Screen and anode voltages are supplied to each of the tubes illustrated in Fig. 4 from the source of direct voltage connected between the terminals 413.

Referring now to Fig. 5, there is illustrated a modulated carrier receiver which may be incorporated in the apparatus illustrated in any one of Figs. 1, 2, 7, 8, 9 and 10. In general, the receiver comprises a modulated carrier amplifier 500, a detector and automatic gain control unit 510, and an audio frequency amplifier 520. More particularly, the carrier amplifier 500 comprises a vacuum tube 501 of the pentode type having input electrodes to which are coupled, by means of a condenser 502, an input circuit 503 which is tuned to the carrier frequency and is coupled to the receiver input coupling network in the manner indicated. The output electrodes of the tube 501 are coupled to an

output circuit 504, also tuned to the carrier frequency, which is in turn coupled to an input circuit 505 resonant at the carrier frequency and forming a part of the detector and automatic gain control unit. For the purpose of maintaining the proper bias on the control grid of the carrier amplifier tube 501, there is provided in the cathode leg of the output circuit an output biasing resistor 506 which is by-passed for carrier frequency currents by a condenser 507. The detector and automatic gain control unit 510 comprises, in addition to the tuned input circuit 505, a vacuum tube diode 511, and a load circuit comprising an adjustable portion of a biasing resistor 512 connected in series with a load resistor 513 and a filter resistor 514. The load circuit is shunted at two points by two carrier current filter condensers 515 and 516 connected in the manner shown. The audio amplifier 520 comprises two vacuum tubes, 521 and 522, each of the pentode type, connected in tandem in the order named. The first of these tubes has its input electrodes coupled by means of a coupling condenser 517 to an adjustable portion of the load resistor 513, so that the audio voltage appearing across this portion of the load resistor is impressed between the control grid and cathode of the tube 521. For the purpose of preventing carrier frequency voltages from being impressed on this control grid there is provided a carrier frequency filter condenser 523, which is connected between this control grid and the cathode of the tube 521. The output electrodes of the tube 521 are resistance coupled by means of a coupling network comprising the two resistors 524 and 525 and a coupling condenser 526 to the input electrodes of the second audio amplifying tube 522, which latter tube has its output electrodes coupled by means of a coupling transformer 527 to the receiver output terminals 528 and 529. The terminals 528 and 529 correspond respectively to the terminals 128 and 129, which latter terminals are illustrated in Fig. 1 as being connected in the antiside tone impedance network arrangement described previously. For the purpose of maintaining proper bias potentials on the control grids of the two audio amplifying tubes 521 and 522, cathode biasing resistors 530 and 531 are respectively provided in the cathode legs of the output circuits of these tubes, which resistors are by-passed for audio frequency currents by condensers 532 and 533, respectively.

As indicated above, automatic gain control is provided for maintaining the audio level at the output terminals 528 and 529 substantially constant even though the amplitude of the carrier received on the input circuit 503 is varied within wide limits. To this end the direct voltage drop across the load resistor 513, which varies directly in accordance with the intensity of the incoming carrier, is utilized as a bias voltage for controlling the two tubes 501 and 521. Thus, this voltage is impressed through a filter resistor 518 on the control grid of the carrier frequency amplifier tube 501 and through a resistor 519 on the control electrode of the first audio amplifier tube 521. The automatic gain control action thus realized is well-known in character.

The rectified carrier output voltage appearing across the load resistor 513 is also utilized to control a relay R560 which corresponds to the relay R160 shown in Fig. 1 and the relay R260 shown in Fig. 2. The relay R560 is provided with a pair of armature springs which are connected

to the two terminals 581 and 582 respectively corresponding to the terminals 181 and 182 illustrated in Fig. 1 and the terminals 281 and 282 illustrated in Fig. 2. The winding of the relay R550 forms an output or load circuit for a vacuum tube triode 540 having its input electrodes coupled to the load resistor 513 by means of a coupling condenser 541 and a resistance capacitance filter network comprising a condenser 542 and a resistor 543. A biasing voltage derived from the adjustable portion of a voltage dividing resistor 544 is impressed on the cathode of the tube 540 for the purpose of maintaining the proper potential relations between this cathode and the control grid of the tube. This bias voltage is adjusted to a point such that the anode current traversing the winding of R550 is sufficient to cause the operation of this relay when no rectified carrier voltage appears across the load resistor 513. When a carrier is being received, the rectified carrier voltage impressed on the control electrode of the tube 540 drives this electrode sufficiently negative with respect to the associated cathode to reduce the anode current to a value such that the relay R550 restores. This may or may not be beyond cutoff, depending upon the design of the relay R550. Screen and anode voltages for the tubes indicated in Fig. 5 are derived from a source of direct voltage, not shown, but connected across the two terminals 545 and 546. More particularly, two resistors 547 and 548 are connected in series across the source, and the junction point therebetween is connected to the screen of the tube 501 for dropping the voltage on this electrode to a value below that of the voltage on the associated anode. Similarly, two resistors 549 and 550 are connected in series across the source, and the junction point therebetween is connected to the screen electrode of the tube 521 for the purpose of operating this electrode at a voltage lower than the voltage of the associated anode. It will be noted that a slight positive bias voltage, i. e., the drop across the adjustable portion of the resistor 512, is impressed on the cathode of the diode 511. This bias has the effect of completely cutting off the anode current through the diode 511 in the absence of an incoming carrier and of maintaining the anode current substantially at zero until a carrier of substantial amplitude is received, thereby to render the receiver completely inoperative when the received carrier intensity is not sufficient greatly to predominate over the background noise.

Referring now more particularly to the operation of the apparatus illustrated in Figs. 1 to 3, inclusive, to establish a connection between one of the subscribers' lines terminating at the automatic exchange illustrated in Fig. 3 and the operator's station illustrated in Fig. 1, and assuming that a call intended for the operator's station is initiated at the substation A associated with the line 300; when the calling party removes his receiver from its associated switch hook, a loop circuit is completed, in the usual manner, for causing the line circuit 305 to operate. In response to the operation of this line circuit, an idle one of the finder-connector links is assigned to the use of the calling line, and the finder portion thereof is set in operation to search for and seize the calling line. Assuming that the link illustrated, namely, the link comprising the finder switch 310 and the connector switch 315, is the link assigned to the use of the calling line,

when the finder portion thereof is operated to the position corresponding to the line 300 it operates to switch the calling subscriber's loop circuit through to the connector switch 315 and to condition this switch to respond to the switch control impulses dialed at the calling substation. When the first digit is dialed by the calling subscriber, the wiper carriage structure embodied in the connector switch 315 responds by elevating the wipers embodied therein to a position opposite the level of bank contacts terminating a group of ten lines including the link line 321. If a single such trunk line is terminated in the banks of the connector switch 315, a second predetermined digit must be dialed at the calling substation for the purpose of selecting this trunk line from the selected group of lines. On the other hand, if all of the lines terminating at the selected level of bank contacts are lines corresponding to the line 321, an automatic trunk hunting operation may be utilized for selecting an idle one of these lines. Assuming the latter case and assuming further that the line 321 is the first available idle line of the selected group, when the wipers of the connector switching mechanism encounter the contacts terminating the conductors of this line, the operation of the switching mechanism is arrested and the calling subscriber's loop circuit is switched through to the repeating coil 278 in the conventional manner characterizing the switching-through type of connector switch. Also, ground is placed on the control conductor C324 of the line 321 for the purpose of marking this line as busy in the bank contacts of the other connector switches to which it extends. When the calling subscriber's loop circuit is switched through to the repeater 278, a bridge is placed across the two line conductors C322 and C323 to complete an obvious circuit for energizing the relay R235.

At RA236, the relay R235, upon operating, opens one point in the circuit traced hereinafter for energizing the relay R200. At RA237, the relay R235 completes an obvious circuit for energizing the slow-to-release hold relay R230. Upon operating, the last-mentioned relay applies, at RA232, multiple ground to the control conductor C324 and, at RA231, completes an obvious circuit for energizing the slow-to-release relay R220. When R220 operates it completes, at RA221, an obvious circuit for energizing the relay R210.

The relay R210, upon operating, first completes, at RA216, an alternative circuit for maintaining the relay R380 energized. In this regard, it will be noted that R380 is normally energized over a circuit extending from ground at RA261 and by way of a parallel circuit including the upper and lower halves of the winding 238, RA212 and RA213, C293 and C294, and the upper and lower halves of the repeater winding 331; RA341, RC342, and the winding of R380 to battery. When R210 operates, it interrupts, at RA212 and RA213, both sides of the above-traced simplex circuit. The relay R380 does not restore, however, since the above-mentioned alternative circuit is completed at RA216, this circuit extending by way of C295, RA341, RC342, and the winding of R380 to battery. At RA212 and RA213, the relay R210 disconnects the repeater winding 238 from the conductors of the link line 292 and connects this winding to the conductors of the link line 281, thereby further to prepare the talking loop between the calling subscriber's substation and the operator's station in the distant manual office. At RA215, the relay R210 completes a

multiple path for applying ground to the control conductor C324.

At RA214, the relay R210 completes an obvious path for short-circuiting the winding of R225, which latter relay is normally energized by current flowing from battery through the resistor 227. Due to the time required for the flux in the core of the relay R225 to die out, this relay is quite slow to restore. At RA211, the relay R210 completes a circuit for energizing R200, this circuit extending from battery by way of the resistor 238, the operated armature RA226, RA211, and the winding of R200 to ground. As a result of its energization over this circuit, R200 operates, but stays operated only for the short time interval required for the restoration of R225. Obviously, when R225 restores, the above-traced operating circuit for R200 is interrupted at RA226. During the interval when R200 is operated, the bridge across the terminals 206' and 207', which respectively correspond to the terminals 406' and 407' shown in Fig. 4, is interrupted at RA201. From the preceding description and a further consideration of the transmitter shown in Fig. 4, it will be apparent that the opening of this bridge results in the application of a high negative bias on the oscillator and amplifier tubes included in the carrier channel of the transmitter 240. As a result, the carrier output of this transmitter is interrupted for the interval when the relay R200 is operated and, hence, a control pulse is transmitted by way of one carrier channel to the distant carrier equipment.

The response of the receiver 145 located at the distant point of the transmission line will best be understood by again referring to the receiver illustrated in Fig. 5. As was pointed out above, when the carrier input to this receiver is interrupted, the voltage drop across the load resistor 513 included in the circuit of the diode 511 is reduced to zero, so that the negative bias impressed on the control electrode of the control tube 540 is reduced to a value such that the anode current traversing the relay R560 is increased sufficiently to cause the operation of this relay. When the carrier input to the receiver is interrupted, therefore, the relay R560 places a bridge across the terminals 581 and 582. Similarly, when the carrier input to the receiver 145 is interrupted, a bridge is placed across the terminals 181 and 182 which correspond, respectively, to the terminals 581 and 582. Obviously, when the terminals 181 and 182 are shunted, a circuit is completed for energizing the alternating current relay R160. Upon operating, the relay R160 operates its armatures RA161 and RA162 to project ringing current over the line 109 and through the winding 114 of the repeater 103 in an obvious manner. The resulting induced voltage in the winding 116 of the repeater 103 energizes the drop or signal device 106 over an obvious circuit and causes this drop to operate to signal the operator that an incoming call awaits attention.

Since the relay R200 is only operated for a short time interval, it will be understood that only a short pulse of ringing current is projected over the line 109, after which the transmitter 240 is again conditioned to transmit its carrier output by way of the transmission line conductor 100 to the receiver 145. The receiver 145 responds to the received carrier by causing the operating circuit for R160 to be interrupted.

As indicated previously, provisions are made whereby the calling subscriber may ring the operator's station any desired number of times by

actuating the dial controlled impulsing device provided at the calling substation. More particularly, if the calling party at the substation A fails to get an answer from the operator within a reasonable time interval, he may again operate the impulsing device at the substation A repeatedly to open the loop circuit over which R235 is being held energized. Each time this loop circuit is opened, R235 restores to complete an alternative circuit for energizing R200, the last-mentioned circuit extending from battery through the resistor 238, RA236, RA211, and the winding of R200 to ground. Obviously, each time the relay R235 restores, the operating circuit for R230 is interrupted, but this latter relay, due to its slow-to-release characteristic, remains operated during the short time intervals when R235 is restored. The relay R200 operates each time the above-traced alternative circuit is completed and causes the carrier output of the transmitter 240 to be interrupted in the manner pointed out above. The receiver 145 responds to the interrupted carrier pulses by completing the operating circuit for R160, thus causing ringing current to again be projected over the line 109. The drop 106 responds to this current by vibrating its armature to give an audible signal to the operator that a call awaits attention.

The operator answers the call in the usual manner by inserting the answer plug terminating her telephone set in the answer jack 105. Following this operation a talking loop is established between the operator's telephone set and the calling subscriber's substation, and the operator may converse with the calling subscriber as desired. In this regard, it is again pointed out that separate communication channels are provided in the respective two directions of voice frequency current transmission in so far as the link comprising the transmission line conductor 100 is concerned. More particularly, voice frequency currents produced by sound waves impinging upon the diaphragm of the operator's transmitter are repeated through the repeating coil 103 and over the line 109 to the repeating coil 137, and the audio voltage appearing across the secondary winding 139 of this repeating coil is impressed between the input terminals 134' and 135' coupled to the audio channel of the transmitter 140. By referring to Fig. 4, it will be seen that these currents are amplified in the audio amplifier section and are modulated on the carrier output of the carrier current channel of the transmitter. As indicated above, the carrier frequency output of the carrier current channel is different from the carrier current frequency output of the transmitter 240. The modulated carrier output of the transmitter 140 is impressed on the transmission line conductor 100 through the transmitter output coupling network 100 and the transmission line coupling unit 175. This modulated carrier voltage is impressed on the input circuit of the receiver 245 through the transmission line coupling unit 275 and the carrier frequency discriminating receiver input coupling network 285. By referring to Fig. 5 it will be seen that the modulated carrier voltage is amplified and rectified and that the audio component of the rectified voltage is further amplified in the audio amplifier section and impressed on the output terminals 228 and 229 which respectively correspond to the terminals 528 and 529 shown in Fig. 5. The level of the amplified output voltage is maintained substantially constant through the provision of the automatic gain control arrangement described previ-

ously. From the receiver output terminals 228 and 229 the amplified audio currents are passed through the antiside tone and line balancing network which is connected in circuit with the winding 239 of the repeater 237. This repeater functions to repeat the audio currents by way of the line 281, the repeater 278, the line 321, the connector switch 315, the finder switch 310, and the calling subscriber's line 300 to the receiver at the calling substation.

Voice frequency currents produced through operation of the transmitter at the calling substation A are conducted by way of the calling loop circuit to the repeater 278 and are repeated by this repeater over the line 281 and through the repeater 237 to the input terminals 234' and 235' of the transmitter 240. In the transmitter 240, the audio frequency currents are amplified in the audio channel and are modulated on the output carrier current of the transmitter in a manner which will be apparent from the preceding description. The modulated carrier current is impressed on the transmission line conductor 100 through the transmitter output coupling network 280 and the transmitter line coupling unit 275. The modulated carrier voltages impressed on the transmitter line conductor 100 are, in turn, impressed on the input circuit of the receiver 145 by means of the transmission line coupling unit 175 and the carrier frequency discriminating receiver input coupling network 185. In the receiver 145 the incoming modulated carrier voltage is amplified and rectified, and the rectified audio component thereof is amplified in a manner identical to that described above. The amplified audio voltage, which is held at a substantially constant level through the provision of the automatic gain control circuit, is impressed across the terminals 128 and 129 which correspond, respectively, to the terminals 528 and 529 illustrated in Fig. 5. Due to the antiside tone arrangement, including the line balancing network 142, the terminals 128 and 129, and the winding 139 of the repeater 137, only a portion of the audio voltage developed between the terminals 128 and 129 is impressed across the repeater winding 139 and substantially none of this voltage is impressed between the input terminals 134', 135' of the transmitter 140. As a result of the audio frequency currents flowing through the winding 139, corresponding induced voltages are developed in the coupled repeater winding 138 which cause currents to flow in the closed circuit including the repeater winding 114, so that the audio frequency currents are repeated through the repeater 103 and are reproduced by the receiver of the operator's telephone.

If the calling subscriber at the substation A is calling another subscriber having a line terminating at the manual office in which the operator's station 102 is located, the operator, after conversing with the calling party and ascertaining the number of the line desired or the name of the party desired, may extend the connection to the desired called line in the manner usually employed in this type of exchange.

The release of a connection as established between the substation A and the operator's station 102 in the manner just described, is entirely under the control of the calling party. For the purpose of giving the operator a disconnect signal in those cases wherein she only functions as an intermediary for the purpose of extending a connection to one of the subscribers' lines terminating in the manual office, an arrangement

is provided for ringing over the line 109 to re-actuate the drop 106 when the calling subscriber hangs up. More particularly, when the calling subscriber at the substation A restores his receiver to its hook, the loop circuit, extending to the repeater 278 and by way of which the relay R235 is held energized, is interrupted, causing this relay to restore. Upon restoring, the relay R235 immediately completes, at RA236, the above-traced alternative circuit for energizing R200. The relay R200, when energized over the above-traced circuit, opens, at RA201, the shunt around the above-mentioned biasing path for the oscillator and amplifier tubes included in the carrier channel of the transmitter 240. As a result, the carrier output normally impressed on the transmission line 100 is interrupted. The receiver 145 responds to the interruption of its carrier input by completing the circuit for energizing the relay R160 in the manner described previously. Upon operating, the relay R160 again causes ringing current to be projected over the line 109 to energize the drop 106. The resulting operation of the drop 106 indicates to the operator that the connection has been released at the calling end thereof and that she may disconnect from the line 109 by withdrawing the plug terminating her telephone set from the answer jack 105. Following this operation, the apparatus illustrated in Fig. 1 is entirely released.

Returning to a consideration of the automatic switch train by way of which the connection was established, when the relay R235 restores, it not only completes the above-traced circuit for energizing R200 but, in addition, interrupts, at RA237, the operating circuit for the slow-to-release relay R230. The last-mentioned relay restores, after an interval, to interrupt, at RA231, the operating circuit for the slow-to-release relay R220 and to open, at RA232, one of the paths for applying multiple ground to the control conductor C324. When R220 restores, after an interval, it interrupts, at RA221, the operating circuit for R210, which latter relay immediately restores to open, at RA211, the above-traced alternative circuit for energizing R200; to recomplete, at RA212 and RA213, the circuit for normally energizing R380; to interrupt, at RA216, the alternative circuit for energizing R380; to remove, at RA215, ground from the control conductor C324; and to interrupt, at RA214, a point in the path short-circuiting the winding of R225. Following the restoration of R210, the relay R200 restores and the relay R225 reoperates. Thus, the relay equipment included in the repeater 320 is returned to its normal condition. When R200 restores, it re completes, at RA201, the shunt across the terminals 206' and 207', thereby causing the transmitter 240 to again impress its carrier output on the transmission line conductor 100. The receiver 145 is thus caused to open the circuit for energizing R160 and this relay, upon restoring, disconnects the conductors of the line 109 from the ringing current source.

When ground is removed from the control conductor C324 in response to the restoration of R210 and at RA215, the holding circuits for certain of the operated relays in the connector switch 315 are interrupted in a well-known manner, causing these relays to restore to initiate the release of the connector switch 315 and the finder switch 310. Thus, the switch train utilized in setting up the connection is entirely released. It will be noted that, when ground is removed from the control conductor C324, battery potential is ap-

plied thereto through the resistor 296, thereby to mark the line 321 as idle in the bank contacts of the connector switches to which this line extends.

5 In order to route a call from or by way of the operator's station 102 to a substation associated with one of the lines terminating at the automatic exchange illustrated in Figs. 2 and 3, the operator inserts the plug terminating her
10 telephone set in the calling jack 104 and, in so doing, closes the springs 122 to complete an obvious circuit for energizing the relay R110. Upon operating, the relay R110 completes, at RA111, an obvious path for short-circuiting the winding of R125 and completes, at RA113, a circuit for energizing R120, this last-mentioned circuit extending from ground at the switch spring 124, by way of the spring 123, RA113, and the winding of R120 to battery. At RA112, the relay R110
15 completes a circuit for energizing R150, this circuit extending from battery, by way of the resistor 132, RA112, RA127, to the junction point between the upper and lower halves of the repeater winding 114, where it divides, one branch extending by way of the upper half of the winding 114, the upper conductor of the line 109, RA161, the upper half of the repeater winding 138, and the winding of R150 to ground; and the other branch extending by way of the lower half
20 of the winding 114, the lower conductor of the line 109, RA162, the lower half of the winding 138, and the winding of R150 to ground. At RA151, the relay R150, upon operating, opens the bridge across the terminals 106' and 107', which terminals respectively correspond to the terminals 406' and 407' of the transmitter illustrated in Fig. 4 and described above. The opening of this bridge results in the application of a high negative bias on the oscillator and amplifier tubes in the carrier channel of the transmitter 140 in a manner which will be apparent from the preceding description, causing the carrier output of the transmitter to be interrupted. The receiver 245
25 responds to the interruption of the carrier output of the receiver 140 in the exact manner described above with reference to the receiver 145; that is, it operates to complete the circuit for energizing the alternating current relay R260 and to hold this circuit completed so long as the carrier output of the transmitter 140 is interrupted. The relay R260 responds by operating to interrupt, at RA261, the above-traced circuit by way of which R380 is normally energized, causing the last-mentioned relay to restore. Upon restoring, the relay R380 completes, at RA382, a circuit for energizing R340, this circuit extending from ground at RA372, by way of RA382, and the winding of R340 to battery. Upon operating, the relay R340 interrupts, at RA341 and RC342, a further point in the circuit for normally energizing R380, and prepares, at RA341 and RC342, a point in the circuit traced hereinafter for energizing the pulsing relay R350.

A short time interval after the operation of R340 the relay R125, which is short-circuited in response to the operation of R110, restores, to interrupt, at RA127 and its associated upper contact, the above-traced operating circuit for R150. When R150 restores it re completes, at RA151, the
30 path shunting the terminals 106' and 107', thereby to unblock the carrier channel provided by the carrier output of the transmitter 140 and to cause carrier current to be transmitted over the transmission line conductor 100 to the receiver 245. The receiver 245 responds to this current

by interrupting the operating circuit for R260, causing this relay to restore to complete, at RA261, the above-mentioned circuit for energizing the pulsing relay R350, this circuit being similar to that traced previously for R380 but extending by way of RA341 and RC343 and the winding of R350 to battery, rather than by way of RA341 and RC342 and the winding of R380 to battery. When energized over this circuit, the relay R350 operates to complete, at RA351, an obvious circuit for energizing the slow-to-release hold relay R360. At RA351, the relay R350 completes a loop circuit extending to the line circuit 330. The relay R360, upon operating, completes, at RA361, an obvious circuit for energizing R370 and, at RA364, an obvious holding circuit for R340. The relay R370, upon operating, interrupts, at RA372, the above-traced operating circuit for R340 and completes, at RA371, an obvious holding circuit for itself.

When the loop circuit extending to the line circuit 330 is completed at the armature RA351 of the relay R350, this line circuit operates to cause an idle one of the finder-connector links to be assigned to the use of the calling link line 325. If it be assumed, for example, that the link comprising the finder switch 310 and the connector switch 315 is the link allotted to the use of the calling link line 325, when the line circuit 330 operates the finder switch 310 is set in operation to search for and seize the line 325. When this last-mentioned line is found by the finder switch 310, the loop circuit extending from the repeater 332 is switched through to the connector portion of the link, namely, to the connector switch 315, and this connector switch is conditioned to respond to the impulses dialed at the operator's station 102.

From the immediately preceding description it will be apparent that when a call is initiated at the operator's telephone station 102, the relays R110, R125, and R150 cooperate to cause a switch seizing control pulse to be transmitted by way of one of the carrier channels to the distant carrier equipment comprising the receiver 245. This control pulse is responded to by the four relays R340, R350, R360 and R370 which cooperate to cause an idle link to be assigned to the use of the link line by completing the loop circuit extending to the line circuit 330.

All of the connector switches are provided with means for returning a dial tone signal over an established calling loop to the calling subscriber to indicate that the dialing operation may be started. So here, when the calling loop including the link line 325 is switched through to the connector switch 315, dial tone current is returned over the loop and is repeated by the repeaters 332 and 237 to the input terminals of the transmitter 240. In the transmitter 240 this audio frequency current is amplified and modulated on the carrier output, so that it is transmitted by way of one of the carrier channels to the receiver 145. In the receiver 145 the audio dial tone component is separated from the carrier and amplified, and is then delivered by way of the output terminals 128 and 129 to the repeater 137. The amplified dial tone current is repeated by way of the repeater 137, the line 109 and the repeater 103 to the operator's receiver, and the resulting operation of this receiver gives the operator an audible indication that the dialing operation may be started.

Returning now to the operation of the control apparatus provided at the operator's station 102,

when the relay R125 restores to interrupt the above-traced operating circuit for R150 it prepares, at RA127 and its associated lower contact, an alternative operating circuit for this relay.

At RA126 the relay R125 completes an obvious circuit for energizing the slow-to-release relay R130, which latter relay, upon operating, completes, at RA131, an obvious circuit for energizing the slow-to-release relay R135. Following the operation of R135, the apparatus at the operator's station is prepared to repeat impulses dialed at the operator's station to the seized link located in the distant automatic exchange.

Before dialing the directory number of the desired subscriber, the operator actuates the dial key 108 to the off-normal position to place the pulsing relay R120 under the control of the impulsing springs embodied in the impulsing device 107. More particularly, when the key 108 is operated to the off-normal position, the springs 123 and 124 are opened and the springs 123 and 124' are closed, to complete an obvious alternative circuit for holding R120 operated. During the back stroke of each operation of the impulsing device 107, the impulsing springs embodied in this device are repeatedly opened and closed in the usual manner. Obviously, each time the springs are opened the operating circuit for R120 is interrupted, causing this relay to restore. Hence, R120 follows the impulses of each digit dialed. During each open-circuit period of each impulse, or when R120 is restored, the above-mentioned alternative circuit is completed for energizing R150, this circuit extending from battery, by way of the resistor 132, RA121, RA113', RA127 and its associated lower contact, the simplex circuit including the two line conductors of the line 109, and the winding of R150 to ground. Thus, R150 is energized and operates to interrupt, at RA151, the bridge across the terminals 106' and 107' during the open-circuit pulse of each impulse. The transmitter 140 responds in the exact manner set forth above; that is, during each period when the shunt across the terminals 106' and 107' is opened, the carrier normally impressed on the transmission line conductor 100 is interrupted. Hence, carrier current impulses are caused to be transmitted over the line 100 to the receiver 245. During the interrupted carrier period of each carrier current impulse, the receiver 245 operates, in the manner set forth above, to complete the circuit for energizing the alternating current relay R260, which relay operates to interrupt, at RA261, the above-described circuit over which the pulsing relay R350 is being held energized. This last-mentioned relay is thus caused to follow the impulses dialed at the operator's station 102 and, by interrupting at RA351 the loop circuit as extended to the operated connector switch 315, causes the wipers embodied in the switching mechanism of this connector switch to be elevated to a position opposite the level of bank contacts terminating the group of ten lines including the desired called line. To summarize, it will be seen from a step-by-step analysis of the operations which intervene between the opening of the impulsing springs in the impulsing device 107 and the response of the relay R350 that this relay is caused to restore when the impulsing springs noted are opened.

It will be apparent from the preceding description that, when the impulses of the first digit are ended, the relay R120 remains operated, the relay R150 restores, the transmitter 140 continuously impresses its carrier current output

on the transmission line conductor 100, the receiver 245 holds the operating circuit for R260 open, and the relay R350 remains operated to hold the loop circuit extending to the connector switch 315 completed. Due to its slow-to-release characteristic, the hold relay R360 remains operated during impulsing. The number of impulses making up the first digit will, of course, depend upon the directory number identifying the desired called substation. If, for example, it be assumed that the substation A is being called and that the directory number of the substation is 33, the first digit will necessarily comprise three impulses so that at the conclusion thereof the wipers of the switching mechanism embodied in the connector switch 315 will be left standing opposite the third level of bank contacts. When the first impulse is delivered to the connector switch 315, the path for applying dial tone current to the calling loop including the link line 325 is interrupted by the control apparatus provided in the connector switch, in the usual manner. During the dialing of the impulses of the second digit, the apparatus illustrated in Figs. 1, 2 and 3 operates in the exact manner just described. More particularly, the relay R350 is caused to restore to open the loop circuit extending to the connector switch 315 each time the impulsing springs of the impulsing device 107 are opened. In this case the connector switch noted responds by rotating its wipers over the contacts of the selected level and into engagement with the set of contacts corresponding to the number of impulses making up the second digit. In the case assumed, these wipers will be left standing in engagement with the sixth set of contacts in the third level, which contacts terminate the conductors of the called line 300. Suitable provisions are made in the connector switch 315 for returning busy tone over an established calling loop in the event a selected called line is found busy; for projecting ringing current out over the called line to signal the called subscriber in case the called line is idle; and for returning ring-back tone current over the calling loop to indicate that the desired substation is being rung. In this regard, it will be noted that busy tone and ring-back tone signal currents are returned over the line 325, repeated by the repeater 332 to the line 292, and from this line by the repeater 237 to the input terminals 234' and 235' of the transmitter 240, where they are modulated on the carrier current generated in this transmitter. From this point on, the busy and ring-back tone signal currents are transmitted over one of the carrier channels to the operator's telephone station in the exact manner described above with reference to audio frequency dial tone current transmitted from the connector switch 315 to the operator's station.

When the call is answered at the called substation A, the desired conversational loop circuit is completed between this substation and the operator's telephone station. Here again, two independent carrier channels are utilized for transmitting audio frequency currents in the respective two directions of voice frequency transmission in so far as the link comprising the transmission line conductor 100 and the two sets of carrier equipment is concerned. It will be noted that in this case the link line 292, the repeater 332 and the link line 325 are utilized in the connection rather than the line 281, the repeater 278 and the line 321 as was the case described

above for a call outgoing from the automatic exchange to the distant manual office.

The release of the connection as established to the substation A is entirely under the control of the operator in the distant manual office. More particularly, when the plug terminating the operator's telephone set is withdrawn from the calling jack 104, the operating circuit for R110 is interrupted at the springs 122, causing this relay to restore to interrupt, at RA111, the path short-circuiting the winding of R125 and to open, at RA112, the operating circuit for R120. At RA113, the relay R110 opens a point in the above-traced alternative circuit for energizing R150. The relay R125 reoperates, following the restoration of R110, and completes, at RA127, a third circuit for energizing R150, this circuit extending from battery by way of the resistor 132, RA136, RA127, the simplex circuit including the line 109, and the winding of R150 to ground. Simultaneously with the completion of this circuit, the operating circuit for R130 is interrupted at RA126.

The relay R150, upon operating, opens, at RA151, the shunt across the terminals 106' and 107', thereby to cause the carrier output of the transmitter 140 to be interrupted. The receiver 245 responds to the interruption of the carrier current output of the transmitter 140 by completing the operating circuit for R260 in the manner pointed out above. Upon operating, R260 opens, at RA261, the above-described circuit over which the pulsing relay R350 is being held energized, causing this relay to restore to interrupt, at RA351, the loop circuit extending to the operated connector switch 315 and, at RA352, the operating circuit for the slow-to-release hold relay R360. After an interval, the last-mentioned relay restores to interrupt, at RA364, the holding circuit for R340 and, at RA361, the operating circuit for R370. The relay R340, upon restoring, interrupts, at RA341 and RC343, a further point in the circuit for energizing R350 and reprepares, at RA341 and RC342, the circuit, traced previously, for energizing R380.

The time interval required for the successive restoration of the three relays R350, R360 and R340 forms a part of the time interval required for the successive restoration of the two slow-to-release relays R130 and R150 provided at the operator's station 102. Thus, after an interval following the reoperation of R125, the relay R130 restores to interrupt, at RA131, the operating circuit for R135, which latter relay also restores, after an interval, to interrupt at RA136 the above-traced alternative circuit for energizing R150. The transmitter 140 responds to the restoration of R150 by again impressing on the transmission line conductor 106 a carrier voltage to which the receiver 245 responds by interrupting the operating circuit for R260. The relay R260, upon restoring, recompletes, at RA261, the previously traced circuit over which R380 is normally held energized, causing the last-mentioned relay to operate. It is pointed out here that the time interval required for the successive restoration of R130 and R150 is substantially greater than the time interval required for the restoration of R350, R360 and R340 in the order named and, hence, the operating circuit for R380 is reprepared at RA341 and RC342 and the operating circuit for R350 is interrupted at RA341 and RC343 before the relay R260 restores in response to the restoration of R150 to reprepare the common portion of the operating circuits for R380

and R350. When R380 operates, it interrupts, at RA381, the holding circuit for R370, causing the last-mentioned relay to restore, to interrupt, at RA371, a further point in its holding circuit, and to reprepare, at RA372, a point in the operating circuit for R340, it being pointed out, however, that the last-mentioned circuit is opened at the operated armature RA382 before the relay R370 restores. When the loop circuit extending from the repeater 322 to the operated connector switch 315 is interrupted at RA351 upon the restoration of R350, the release of the switch train comprising the connector switch 315 and the finder switch 316 is initiated. The manner in which these two switches are restored to normal is entirely conventional. During the release of the connection, busy ground is removed from the control conductor C324 in the connector switch 315 and battery potential is applied to this conductor through the resistor 295, thereby to substitute an idle marking for the busy marking which prevailed during the time when the repeater 320 was occupied with the call.

As indicated in the introductory portion of the specification, the power transmission line and the associated carrier current equipment coupled thereto at two separated points may be utilized as a link for interconnecting two automatic exchanges. Such an arrangement is formed by combining the automatic exchange and associated equipment schematically illustrated in Fig. 7 with the second automatic exchange and associated equipment illustrated partially in detail and partially schematically in Figs. 2 and 3. The apparatus illustrated in Fig. 7 in schematic form is an exact duplicate of that shown in Figs. 2 and 3. More particularly, the automatic exchange shown in Fig. 7 comprises a plurality of subscribers' lines, one of which is indicated at 700, and a plurality of subscriber controlled automatic switches for setting up connections between the various lines. Individually associated with the subscribers' lines are substations of the automatic type which may be of any desired arrangement, that associated with the line 700 being indicated at B. The automatic switching equipment embodied in the exchange comprises line circuits individual to the subscribers' lines and a plurality of finder-connector links, one of which is indicated as including a finder switch 710 and a connector switch 715. Each of the connector switches has access to a trunk or link line 721 extending to a two-way repeater 720 by way of which access is gained to the carrier current equipment illustrated to the right in Fig. 7. The two-way repeater 720 also includes a link line 725 extending to a line circuit 730 by way of which the automatic switching equipment is rendered accessible to the carrier equipment on calls incoming to the automatic exchange of Fig. 7. The carrier current equipment is in all respects an exact duplicate of that shown in Figs. 2, 4 and 5. Thus, a transmitter 740 is provided which corresponds to the transmitter 240 shown in Fig. 2 and is of the form illustrated in detail in Fig. 4. A receiver 745 is likewise provided which corresponds to the receiver 245 shown in Fig. 2 and is an exact duplicate of that illustrated in detail in Fig. 5. The transmitter output coupling network 780, the receiver input coupling network 785 and the transmission line coupling unit 775 respectively correspond to the similar units 280, 285 and 275 shown in Fig. 2. In the modified system formed by combining the apparatus of Fig. 7 with the apparatus illustrated in Figs. 2 and 3,

the receiver 245 responds only to the carrier, modulated or unmodulated, transmitted by the transmitter 740, and the receiver 745 responds only to the carrier output, modulated or unmodulated of the transmitter 240. Since the frequencies of the transmitted carriers are substantially different, two independent carrier channels are provided for transmitting audio frequency energy in the respective two directions of transmission.

The mode of operation of the system comprising the combined arrangements of Figs. 2, 3 and 7 may best be explained by briefly reconsidering the operation, as described in detail above, of the system of Figs. 1, 2 and 3. A call routed from the substation A by way of the switches 310 and 315 and the repeater 320 and intended for the substation B shown in Fig. 7, is initiated in the exact manner set forth previously. When the link line 321 is seized by the connector switch 315 and the calling subscriber's loop circuit is switched through to the repeater 278, the four relays R235, R230, R220 and R210 are caused to operate in the order named and in a manner which will be apparent from the foregoing description. The relay R210, upon operating, short-circuits the winding of R225 in the manner pointed out above. During the interval required for the restoration of R225, which relay is inherently slow-to-release, the relay R200 operates to cause the carrier output of the transmitter 240 to be interrupted. The manner in which the receiver 745 responds to the interruption of the carrier output of the transmitter 240 will best be seen by considering the manner in which the receiver 245 responds to a like interruption of the carrier output of the transmitter 740. Thus, when the carrier input to the receiver 245 is interrupted, this receiver responds by completing the operating circuit for R260 and, when R260 operates, it interrupts, at RA261, the circuit normally holding R380 energized, causing the last-mentioned relay to restore. As was pointed out above, when R380 restores, it completes the operating circuit for R340 and, when R340 operates, a circuit is prepared for energizing R350 when the carrier current is again delivered to the receiver 245. The resumption of the carrier input to the receiver 245 results in the restoration of R260, followed by the operation of R350, R360 and R370, all in the order named. When R350 operates, a loop circuit is completed to an allotted one of the finder-connector links forming a part of the automatic switching equipment in the automatic exchange. Similar operations occur in the apparatus illustrated in Fig. 7 when the control pulse occasioned by the momentary operation of R200 is transmitted by way of one of the carrier channels to this apparatus. Thus, when the carrier output of the transmitter 240 is momentarily interrupted, the receiver 745 responds by causing the two-way repeater 720 to complete a loop circuit to the line circuit 730. The completion of this loop circuit results in the operation of an allotted one of the finder-connector links to search for and seize the calling line 725. When the calling line is found, the loop circuit is switched through to the connector portion of the link in the usual manner. Assuming that the finder-connector link comprising the finder switch 710 and the connector switch 715 is allotted to the use of the calling line 725, when the loop circuit is switched through to the connector switch 715, this switch is conditioned to

respond to impulses dialed at the calling substation A.

As indicated above, the period during which the carrier output of the transmitter 240 is interrupted is of short duration for, shortly following the operation of R210 to complete the operating circuit for R200, the relay R225 restores to interrupt this operating circuit and thereby cause the restoration of R200. When this occurs the transmitter 240 again operates to transmit a carrier by way of the transmission line conductor 100 to the distant receiver 745. In order to secure a connection to the desired called line, the calling party at the substation A now dials the final two digits of the directory number designating the desired substation B. During each impulse of each digit, the loop circuit as extended to the repeating coil 278 is interrupted at the impulsing springs of the impulsing device provided at the calling substation and the relay R235 is, therefore, caused to restore. Each time the relay R235 restores it completes, at RA236, the above-traced alternative circuit for energizing R200 and each time the last-mentioned relay operates it causes the carrier output of the transmitter 240 to be interrupted in the manner pointed out previously. Thus, during each digit dialed at the calling substation a series of carrier current impulses are transmitted by way of the transmission line conductor 100 to the receiver 745. Here again, the response of the apparatus illustrated in Fig. 7 will best be understood by briefly summarizing what happens when carrier current impulses are delivered to the receiver 245 on a call incoming to the automatic exchange illustrated in Figs. 2 and 3. It was pointed out in a preceding portion of the specification that, during the period of each impulse when no carrier current is delivered to the receiver 245, this receiver functions to close the operating circuit for the relay R260, which relay, upon operating, interrupts the circuit over which R350 is being held energized. The relay R350, in turn, restores to interrupt, at RA351, a point in the loop circuit extending to the operated connector portion of the seized finder-connector link. The same response is achieved in the arrangement illustrated in Fig. 7. Thus, during the open circuit period of each impulse dialed at the calling substation A, the receiver 745 causes the impulsing relay embodied in the two-way repeater 720 to interrupt the loop circuit extending through to the operated connector switch 715. The connector switch responds to the repeated impulses of the first series of received impulses by elevating its wipers to a position opposite the level of bank contacts terminating the group of lines including the desired called line 700. During the second series of impulses received by the connector switch 715, the wipers of this switch are rotated into engagement with the set of contacts terminating the called line 700.

The connector switch 715, like the switch 315, is equipped with apparatus for testing the condition of the called line, for returning busy tone to the calling subscriber in the event the called line is busy at the time it is selected, for applying ringing current to the called line in the event it is idle, and for returning ring-back tone to the calling subscriber in the last-mentioned case. In this regard it will be understood that busy or ring-back tone signal currents are amplified and modulated on the carrier output of the transmitter 740, and are detected, amplified and delivered through the repeater 320 to the calling

loop circuit by the receiver 245. If the called line 700 is idle and the called subscriber answers, the desired conversational connection is completed, it being pointed out that the transmitter 740 and the receiver 745, as interconnected by the transmission line conductor 100, provide one carrier channel for transmitting voice frequency currents from the substation B to the substation A, while the transmitter 240 and the receiver 745, as interconnected by the same transmission line conductor, form a carrier channel for conducting voice frequency currents from the substation A to the substation B.

The release of the connection as established between the subscribers A and B in the manner just described, is entirely under the control of the calling subscriber at the substation A, the apparatus being so arranged that, when the called subscriber at the substation B restores his receiver to its hook, the entire switch train is held operated. When the calling subscriber hangs up, however, the loop circuit extending to the repeater 278 is interrupted, causing the relays R235, R230, R220 and R210 to restore in the order named. During the appreciable time interval between the restoration of R235 and the restoration of R210, the above-traced alternative circuit for energizing R200 is completed at RA236. The resulting operation of R200 causes the carrier

output of the transmitter 240 to be interrupted for a rather long time interval. The manner in which the receiver 745 and the associated operated switch train comprising the repeater 720 and the two switches 710 and 715, respond to this long interrupted carrier impulse can best be explained by again considering the response of the repeater 320 to a similar pulse delivered during the release of a connection routed by way of this repeater to a line in the automatic exchange shown in Figs. 2 and 3. In this regard, it will be recalled that on this type of call, the relay R380 is restored and the four relays R340, R350, R360 and R370 are operated. When the carrier input to the receiver 245 is interrupted, the relay R260 is caused to operate to interrupt, at RA261, the circuit over which R350 is being held energized, causing the last-mentioned relay to restore to initiate the sequential restoration of R360 and R340 in the order named. When R340 restores, it opens at RA341 and RC343 a further point in the operating circuit for R350 and prepares, at RA341 and RC342, the operating circuit for R380. The last-mentioned circuit is completed at the end of the interrupted carrier pulse or when the carrier input is again delivered to the receiver 245 to cause the restoration of R260. When R380 operates, it interrupts, at RA381, a point in the holding circuit for R370, causing this latter relay to restore, and opens, at RA382, a point in the operating circuit for R340. When the impulsing relay R350 restores at the beginning of the pulse, it interrupts, at RA351, a point in the loop extending to the operated switch train, thereby to initiate the release of the automatic switches involved in the connection. Similar operations occur in the apparatus illustrated in Fig. 7 in response to the interrupted carrier pulse caused by the reoperation of R200. Briefly to summarize, when the carrier output of the transmitter 240 is interrupted, the three relays included in the repeater 720 and corresponding to the relays R350, R360 and R340, as shown in Fig. 3, are caused to restore in the order named, and when the pulse is ended, the relay corresponding to R380 is caused to operate, to cause the restora-

tion of the relay corresponding to R370. When the impulsing relay embodied in the repeater 720 and corresponding to R350 restores, the loop circuit extending by way of the line 725, the line circuit 730 and operated finder switch 710 to the connector switch 715 is interrupted to initiate the release of the operated switch train in a manner which will be clearly apparent from the preceding description.

Returning now to a consideration of the apparatus illustrated in Figs. 2 and 3, it is indicated above that the interrupted carrier pulse is terminated by the restoration of the relay R210 following the restoration of R220. The relay R210, upon restoring, performs the functions previously set forth in detail; that is, it interrupts the operating circuit for R200, opens the alternative circuit for energizing R380, and removes ground from the control conductor C324. The removal of ground from the control conductor noted serves to initiate the release of the operated switch train comprising the switches 315 and 310. Also, when ground is removed from C324, battery is applied thereto through the resistor 296 to mark the link line 321 as idle in the bank contacts of the connector switches to which this line extends. Thus, the connection is entirely released and the apparatus involved therein is in readiness for further use.

The manner in which a call is routed from a substation associated with a line terminating at the exchange illustrated in Fig. 7 by way of the automatic switching equipment in this exchange, the repeater 720, the carrier current equipment illustrated in Fig. 7, the transmission line conductor 100, the carrier current equipment illustrated in Fig. 2, the repeater 320, and the automatic switching equipment provided in the exchange illustrated in Figs. 2 and 3 to a substation on a line terminating at the last-mentioned exchange, is in all respects similar to the operation of the apparatus on a call routed in the reverse direction. The manner in which such a connection is released when the calling subscriber hangs up is also similar to the mode of releasing the connection described in detail immediately above. No further explanation is, therefore, deemed necessary to an understanding of the operation of the apparatus on a call routed by way of the exchange illustrated in Fig. 7 and the exchange illustrated in Figs. 2 and 3 to a line terminating at the last-mentioned exchange.

Referring now more particularly to Figs. 8 and 9, there is illustrated apparatus which may be combined with the apparatus shown in Fig. 3 to form an arrangement wherein the carrier current equipment and the power transmission line are utilized as a link between a remotely situated subscriber's substation and an automatic telephone exchange. The arrangement of the apparatus shown in Figs. 8 and 9 is, in all essential respects, similar to that shown in Figs. 1 and 2. Accordingly, the same reference characters have been used to indicate corresponding elements in Figs. 9 and 2. In Fig. 8 the reference characters indicating elements corresponding to similar elements shown in Fig. 1 have the same tens and units digits as the reference characters used in Fig. 1, but have a hundreds digit of eight rather than a hundreds digit of one. It will be noted from a comparison of Figs. 2 and 9 that the Fig. 9 arrangement differs from that of Fig. 2 only by the addition of the two relays R950 and R955 and by certain changes in the circuit connections. The Fig. 8 arrangement differs from

that of Fig. 1 in that a telephone substation circuit 846, schematically indicated, is substituted for the operator's station 102, shown in Fig. 1. The telephone substation circuit of Fig. 8 is of the local battery automatic type and comprises a ringer or signal device, a receiver, and a transmitter, all not shown but connected to the line conductor C347 and C848, an impulsing device 307 and a calling key comprising the switch springs 822.

The mode of operation of the system formed by combining the apparatus illustrated in Figs. 8 and 9 with the apparatus shown in Fig. 3, to set up a connection to the telephone substation 846 on a call initiated at one of the substations associated with a line terminating in the automatic exchange illustrated in Figs. 9 and 3 is, in all fundamental respects similar to the operation of the apparatus illustrated in Figs. 1 to 3, inclusive, to set up a connection between the substation A and the operator's station 102 on a call initiated at the substation A. If, for example, the link comprising the finder switch 310 and the connector switch 315 is used to forward the connection to the repeater 320, when the link line 321 is selected by the connector switch 315 the calling subscriber's loop circuit is switched through to the repeater to complete a circuit for energizing the line relay R235. This relay, upon operating, interrupts at RA236 a point in the operating circuit for R950 and at RA237 completes the circuit for energizing R230, thereby to cause the sequential operation of R230, R220 and R210 in the order named. When the relay R210 operates it first completes at RA216 the above-traced alternative circuit for holding R380 energized and then completes at RA214 an obvious path for short-circuiting the winding of R225. At its armatures RA212 and RA213 the relay R210 opens the normally closed operating circuit for R380 and further prepares a talking loop to the desired called substation.

At RA217, the relay R210 completes a circuit for energizing R955, this circuit extending from ground at RA227 by way of RA217 and the winding of R955 to battery. The relay R955, upon operating, completes a holding circuit for itself, this circuit extending from ground at RA261 by way of the simplex circuit including the two operated armatures RA212 and RA213, RA957 and the winding of R955 to battery. At RA956, the relay R955 prepares the operating circuit for R950, this operating circuit now being held open at the operated armature RA236.

At RA215, the relay R210 applies multiple ground to the control conductor C324, thereby to maintain the link line 321 marked as busy and to hold operated the connector switch 315 by way of which the call was routed. At RA211, the relay R210 completes a circuit for energizing the relay R200, this circuit extending from battery by way of RA226, RA211 and the winding of R200 to ground. The period during which this circuit is completed is limited, however, since shortly following the operation of R210 the slow-to-release relay R225 restores to interrupt the circuit just traced at its armature RA226. During the interval when R200 is energized, this relay opens at RA201 the shunt across the two terminals 206' and 207', thereby to bias the oscillator and amplifier tubes embodied in the carrier channel of the transmitter 240 to a point where the carrier output of this transmitter is interrupted. When R200 restores, the bias is removed from the oscillator and amplifier tubes

in the carrier channel of the transmitter 240 and this transmitter resumes its normal operation to impress its output carrier on the transmission line conductor 100 in the manner described previously.

When the carrier output of the transmitter 240 is interrupted, the receiver 245 responds by completing the circuit for energizing R860 in a manner which will be apparent from the preceding description. When the relay R860 operates it completes at RA861 and RA862 a path for projecting ringing current over the line 339, which current traverses the winding 814 of the repeater coil 803 and causes an induced voltage to be developed in the coupled repeater winding 816. This voltage serves to energize the ringer or signal device bridged across the line conductor C847 and C848 at the called substation 846. The period during which ringing current is applied to the line 309 is determined by the slow-to-release characteristic of the relay R225, since, when this relay restores to cause the restoration of R200, the transmitter again impresses an output carrier voltage on the transmission line conductor 100 and the receiver 245 responds to this voltage by interrupting the operating circuit for the relay R860. The last-mentioned relay is thus caused to restore to open the ringing current path and further to prepare the talking loop between the calling and called substations.

If the connections shown in solid lines between the left terminal of the resistor 238 and the contact associated with RA211 are alone used, the calling subscriber cannot re-ring the called substation 846 except by hanging up and initiating the call a second time to cause the operations as described above to be repeated. This is true for the reason that when the relay R225 restores the circuit for energizing R200 is held open at RA226 for the duration of the call. Thus, it will be seen that the two relays R950 and R955 and the control circuits therefor may be omitted if the solid line connections mentioned above are alone used.

If the circuit connections shown in dotted lines and extending between the resistor 238 and the armature springs controlled by the armature RA211 of the relay R210 are used in combination with the solid line connections also shown between these two points, the calling subscriber may, by further actuation of the impulsing device provided at the calling substation, cause ringing current to again be projected over the called line to energize the ringer or signal device at the called substation. With the last-mentioned circuit arrangement, and if the call as initiated at the substation A is not answered at the called substation 846 within a reasonable interval, the calling party at the first-mentioned substation may dial another digit comprising any number of impulses. During each impulse of this additional digit, the loop circuit extending to the repeating coil 278 is opened and, hence, the relay R235 is caused to follow the impulses. With R955 operated, a circuit is completed, at RA236, for energizing R950 the first time R235 restores. The relay R950, upon operating, completes, at RA951 an alternative circuit for energizing R200, this circuit extending from battery by way of the resistor 238, RA951, RA211 and the winding of R200 to ground. Upon operating, the relay R200 causes the carrier output of the transmitter 240 to be interrupted in the manner pointed out above and the receiver 245 responds by completing the operating circuit for R860. The ringing relay R860, upon operating, again completes a

path for projecting ringing current over the line 339 and through the repeater 303 to energize the ringer at the called substation. During succeeding impulses of the additional digit, the relay R950, due to its slow-to-release characteristic, remains operated. For the same reason, the slow-to-release relay R230 is held operated to maintain the three relays R220, R210 and R955 energized. At the end of the additional impulse, the calling subscriber's loop circuit is reclosed so that the relay R235 is held in its operated position to maintain the circuit for energizing R230 completed and to interrupt, at RA236, the operating circuit for R950. The last-mentioned relay restores, after an interval, to interrupt, at RA951, the alternative operating circuit for R200, which latter relay, upon restoring, reconditions the transmitter 240 to transmit a carrier output by way of the transmission line conductor 100 to the receiver 845. Obviously, the calling subscriber may, by repeated actuation of the impulsing device provided at the calling substation, re-signal the called substation 846 as many times as desired.

When the call is answered at the called substation 846, the desired conversational circuit between the calling and called parties is set up, which circuit includes the two independent carrier current channels of different carrier frequencies for transmitting voice frequency currents between the two substations in the respective two directions of transmission. The call is answered in the usual manner by lifting the receiver at the called substation from its supporting cradle or hook and without actuating the calling key comprising the springs 822 to the off-normal position.

The release of the connection as established between the calling substation A and the called substation 846 is entirely under the control of the calling party. More particularly, when the calling party hangs up, the loop circuit extending to the repeating coil 278 is interrupted and the relay R235 restores. Upon restoring, the last-mentioned relay interrupts, at RA237, the operating circuit for R230 and completes, at RA236, the circuit for energizing the slow-to-release relay R950. At this point, it is noted that, if the dotted line wiring illustrated in Fig. 9 is used in combination with the wiring shown in solid lines, the operation of R950 following the restoration of R235 during the release of the connection results in the reoperation of the relay R200 for a short time interval. As a consequence of the reoperation of R200, the carrier output from the transmitter 240 is interrupted and the receiver 845 operates to complete the operating circuit for R860, so that ringing current is again projected over the line 809 to the called substation. With this arrangement and if the calling party is the first to hang up, a ringing operation is performed which may be uncomfortable to the called party since a portion of the ringing current is passed through the receiver at the called substation. Thus, while the addition of the dotted line wiring arrangement of Fig. 9 and the two relays R950 and R955 is advantageous in that it permits a calling party repeatedly to ring the substation 846, it is open to the objection that ringing current is projected over the called line 339 during the release of the connection. When the solid line wiring arrangement is alone used, however, the last-mentioned objectionable feature is obviated, since the relay R225 remains operated to hold the circuit for energizing the

relay R200 open until after the relay R210 has restored further to open this circuit at RA211.

Following the restoration of R235, the three relays R230, R220 and R210 restore in the order named and in an obvious manner. The last-mentioned relay, upon restoring, interrupts, at RA214, the path short-circuiting the winding of R225, permitting this relay to reoperate. At RA212 and RA213, the relay R210 opens a point in the simplex holding circuit for R955, causing this latter relay to restore to interrupt, at RA957, a further point in its holding circuit and to open, at RA956, a point in the operating circuit for R950. The relay R950, upon restoring, opens, at RA951, a point in the dotted line portion of the circuit for energizing R200, causing the last-mentioned relay to restore. When R200 restores it causes the transmitter 240 to again impress its carrier output on the transmission line conductor 100 and the receiver 845 responds to the received carrier by causing the restoration of R860, whereby the ringing operation is arrested.

At RA212 and RA213 and their respective associated upper contacts, the relay R210 re-completes the circuit for normally energizing the relay R330 and, at RA210, the relay R210 opens a point in the alternative circuit for maintaining R380 energized for the duration of the call just described. At RA217, the relay R210 opens a point in the operating circuit for R955 and, at RA215, it removes ground from the control conductor C324, thereby to initiate the release of the operated switches 315 and 310 in a manner which will be apparent from the foregoing description. When ground is removed from the control conductor noted, battery is applied thereto through the resistor 296 to mark the link line 321 as idle in the bank contacts of the connector switches to which this line extends.

The manner in which a call initiated at the substation 846 is routed by way of the carrier current equipment transmission line conductor 100, the repeater 320 and the automatic switching equipment of the distant automatic exchange to a substation, such, for example as the substation A, associated with a line terminating at this exchange, is in all respects identical to the mode of operation of the apparatus illustrated in Figs. 1 to 3, inclusive, to establish a connection between the operator's station 102 and the substation A on a call initiated at the operator's station. It is pointed out that a call is initiated at the substation 846 by actuation of the calling key comprising the springs 822 to the off-normal position to complete an obvious circuit for energizing R810, which relay corresponds to the relay R110 illustrated in Fig. 1. Following the operation of the relay R810, the circuit elements illustrated in Figs. 8, 9 and 3 operate in the exact manner and in the same sequence as described above for the corresponding elements shown in Figs. 1, 2 and 3. In view of this fact, it is deemed unnecessary further to explain the manner in which the apparatus operates to extend a connection from the substation 846 to one of the automatic subscribers' substations. Also, the manner in which a connection established to one of the automatic exchange lines on a call initiated at the substation 846, is released at the end of the conversation is the same as that set forth above with reference to Figs. 1, 2 and 3 and need not be repeated.

Referring now to Fig. 10, there is illustrated a modified circuit arrangement which may be substituted for the arrangement of Fig. 8 in the

system formed by combining the apparatus shown in Figs. 8 and 9 with the apparatus shown in Fig. 3. The essential difference between the arrangement shown in Fig. 10 and that shown in Fig. 8 is that, in the last-mentioned arrangement, a separate source of direct current must be provided for energizing the relays R810, R820, R825, R830, and R835 located at the substation proper. This substation may be remotely located with respect to the carrier current equipment shown to the right of Fig. 8, and, hence, the provision of a source of current for energizing the enumerated relays may be rather expensive. In the Fig. 10 arrangement, on the other hand, the control relays and the carrier current equipment are assembled as a unit and are located at the point where the carrier current equipment is coupled to the transmission line. If desired, alternating current relays may be used throughout. Alternatively, direct current relays may be provided, together with a rectifier arranged to supply voltage of the proper potential for energizing the control relays.

The mode of operation of the system formed by combining the apparatus illustrated in Fig. 10 with that shown in Figs. 9 and 3 is identical with that described above with reference to the system formed by combining Figs. 8, 9 and 3 on a call incoming to the telephone substation terminating the line 1009. The somewhat different arrangement of the control relay circuit connections alters slightly the mode of operation of these relays on a call initiated at the substation terminating the line 1009. The relay equipment provided at the substation terminating the line 1009 must perform three functions in setting up a connection on a call initiated at this substation. The first function to be performed is the interruption of the carrier output of the transmitter 1040 to cause a switch seizing pulse to be delivered over one of the carrier channels to the repeater 320, whereby a loop circuit is established from this repeater to certain of the automatic switches provided in the distant automatic exchange. The second function of the control relays is that of converting impulses dialed at the calling substation into interrupted carrier current impulses which are repeated to the repeater pulsing relay R350, and are in turn repeated by this relay to the seized impulse responsive switching equipment in the automatic exchange. The third and final function to be performed by the control relays shown in Fig. 10 is that of causing the carrier output of the transmitter 1040 to be interrupted during the release of the connection for the purpose of initiating the release of the repeater 320 and the operated switch train by way of which the connection is routed. All three of the enumerated functions are performed by the relay equipment shown in Fig. 10. Thus, when the calling key comprising the springs 1022 is closed, a simplex circuit including the line 1009 is completed for energizing the relay R1010, which relay, upon operating, causes the sequential operation of the three relays R1015, R1020 and R1030 in an obvious manner. When the relay R1030 operates, it completes, at RA1032, an obvious path for short-circuiting the winding of R1025 and, at RA1031, a circuit extending from ground at RA1026 for energizing R1050. The resulting operation of R1050 causes the carrier output of the transmitter 1040 to be interrupted, so that a switch seizing pulse is transmitted to the repeater 320 in a manner which will be obvious in

view of the preceding description. This pulse is terminated through the restoration of the slow-to-release relay R1025, which restores shortly following the operation of R1030. Thus, the first function as pointed out above is discharged.

It will be noted that the impulsing springs of the impulsing device 1007 are included in the simplex circuit over which the relay R1010 is held energized. Hence, during operation of the impulsing device 1007, the relay R1010 follows the impulses. During the open circuit period of each impulse the relay R1010 restores to complete an alternative circuit for energizing R1050, this circuit extending from ground at RA1012 by way of RA1031 and the winding of R1050 to battery. Thus, R1050 is caused to operate for a portion of each impulsing cycle and, upon operating, causes the carrier output of the transmitter 1040 to be interrupted. Hence, it will be seen that the dialed impulses are converted into carrier current impulses through the operation of the relay R1050 and that the second function as outlined above is also performed by the relay equipment.

During the release of the connection and when the calling key comprising the springs 1022 is restored to its normal position, the operating circuit for R1010 is interrupted, causing this relay to restore to complete, at RA1012, the above-traced alternative circuit for energizing R1050 and to interrupt, at RA1011, the operating circuit for the slow-to-release relay R1015. The resulting operation of R1050 causes the carrier output of the transmitter 1040 to be interrupted so that a switch release pulse is transmitted by way of one carrier channel to the operated repeater 320. The duration of the switch release pulse is determined by the combined restoring periods of the two slow-to-release relays R1015 and R1020 and the relay R1030, which three relays restore in the order named following the restoration of R1010. Thus, when R1020 falls back, it interrupts, at RA1021, the operating circuit for R1030 which immediately restores to open, at RA1031, the above-traced alternative circuit for energizing R1050. The last-mentioned relay, upon restoring, causes the transmitter 1040 to again impress its carrier output on the transmission line conductor 100, thus ending the switch release pulse transmitted to the repeater 320 in the distant automatic exchange. When R1030 restores, it also interrupts, at RA1032, a point in the path short-circuiting the winding of R1025, permitting this latter relay to be energized over an obvious circuit including the resistor 1037. Following the operation of R1025, the apparatus is entirely released. Thus, the third function of the relay equipment is performed. The manner in which the apparatus illustrated in Figs. 9 and 3 responds to the switch seizing pulse, the interrupted carrier impulses and the switch release pulse, all transmitted by way of one of the carrier channels, is exactly the same as the response of the apparatus shown in Figs. 2 and 3 to the similar pulses transmitted from the operator's telephone station 102, and described previously.

The manual office equipment shown in Fig. 1, as modified by the addition of the two relays shown in Fig. 6, may be combined with the automatic exchange and associated carrier equipment formed by combining the apparatus illustrated in Figs. 9 and 3 to form a unified system. The purpose of providing the two relays R600

and R610 illustrated in Fig. 6 in combination with the other relay equipment associated with the operator's telephone station 102 is to prevent a ringing operation from being performed after a call to the operator's station has been answered. In this regard, it is pointed out that the two relays R600 and R610 are only used when the dotted line wiring as shown in Fig. 9 is provided in the repeater circuit. The manner in which a connection is routed from one of the automatic subscribers' substations through the automatic switching equipment provided in the automatic exchange, the repeater 320, the carrier current equipment, and the transmission line conductor 100 to the operator's station 102 will readily be apparent from the preceding description. If, after the relay R160 operates to project ringing current over the line 109 and cause the operation of the drop 106, the operator fails to answer the call within a reasonable time interval, the calling party may desire to resignal the operator. To this end, the calling subscriber actuates the impulsing device provided at the calling substation to cause the repeated operation of the line relay R235 and the sustained operation of the relay R950 for the duration of the digit. When the relay R950 operates at the beginning of this additional digit, it completes the above-noted alternative circuit for energizing R200. When the last-mentioned relay operates, it causes the carrier output of the transmitter 240 to be interrupted. The resulting response of the receiver 145 causes the relay R160 to operate to again project ringing current over the line 109. This ringing current manifests itself by causing the drop 106 to buzz in a conventional manner, thereby audibly to signal the operator. Instances may occur when the operator inserts the plug terminating her telephone set into the answer jack 105 to answer the incoming call only an instant before the additional ringing operation is started, in which case ringing current would normally be conducted through the receiver of her telephone set to be reproduced as a loud and objectionable buzz for the duration of the ringing operation. To obviate this difficulty, the two relays R600 and R610 are arranged to function as ring cutoff apparatus. More particularly, when the operator inserts the plug terminating her telephone set in the answer jack 105, ground as extended through the cord circuit is impressed on the sleeve contact of the jack 105 to complete a circuit extending by way of the dotted line conductor C603 for energizing R600. The relay R600 is provided with an armature RA602 which strikes a weighted contact spring RC602' immediately the winding of R600 is energized. The spring RC602' starts vibrating when struck by the armature RA602 and only settles into constant engagement with RA602 at a predetermined interval thereafter. During the period of its vibration, the armature RC602' intermittently engages RA602, thereby intermittently to complete the operating circuit for the slow-to-operate relay R610. Due to the slow-to-operate characteristic of the last-mentioned relay, it does not operate until RC602' settles into constant engagement with RA602. Immediately R600 is energized, a circuit is completed at RA601 for energizing R150, this circuit extending from battery by way of the resistor 132, C604, RA601, RA611, C605, the simplex circuit comprising the two conductors of the line 109 and the winding of R150 to ground. Upon

operating, the relay R150 causes the carrier output of the transmitter 140 to be interrupted.

On the type of call here being considered, that is, a call incoming to the operator's station 102, the relay R210 and the relay R955 are operated at the time the carrier is interrupted in response to the operation of R150. The receiver 245 responds to the interruption of the carrier output of the transmitter 140 by completing the operating circuit for R260, which relay, upon operating, interrupts, at RA261, the above-traced holding circuit for R955. When R955 restores, it opens, at RA957, a further point in its holding circuit and, at RA956, a point in the circuit for energizing R950. Thus, the relay R950 is caused to restore to interrupt, at RA951, the circuit for energizing R200, which latter relay, upon restoring, reconditions the transmitter 240 to transmit its carrier output to the receiver 145. The receiver 145 responds to the received carrier by opening the operating circuit for R160. Thus, the ringing operation is interrupted almost immediately after the operator plugs into the answer jack 105 to answer the incoming call. Shortly following the restoration of R160 in the manner just described, the vibrating contact spring RC602' of the relay R600 settles into engagement with RA602 and the slow-to-operate relay R610 operates. Upon operating, the relay R610 interrupts, at RA611, a point in the above-traced circuit for energizing R150, causing the last-mentioned relay to restore to recondition the transmitter 140 to transmit a carrier to the receiver 245. The receiver 245 responds to this carrier by opening the operating circuit for energizing R260, which relay, upon restoring, reprepares, at RA261, the holding circuit for R955. It will be noted, however, that the holding circuit for R955 is now open at RA957 and the operating circuit for this relay is open at the armature RA927. Thus, R955 is prevented from reoperating to reprepare the operating circuit for R950. When R950 restores, the operating circuit for R200 is held open at RA951 and, hence, the apparatus is prevented from projecting ringing current over the line 109 during the release of the connection and when the calling subscriber hangs up. It will be noted that the relay R600 functions to cause the restoration of R955 in any case when the operator answers a call incoming to the station 102. Thus, there is precluded the possibility of a ringing operation being performed when the operator's telephone set is still connected to the line 109. Aside from the above, the operation of the system formed by the combination of the apparatus illustrated in Figs. 1, 9 and 3 is exactly the same as previously described.

It will be apparent that the re-ring cutoff arrangement illustrated in Fig. 6 may, if desired, be incorporated in the substation circuit shown in Fig. 8. Thus, if the circuit for energizing the relay R600 is arranged to be completed by the hook switch provided at the substation 846 when a call to this substation is answered, the same ring cutoff operation is achieved. Also, if the substation circuit illustrated in Fig. 8 is modified in this manner, the ringing operation, which ordinarily occurs during the release of the connection when a calling subscriber at a distant substation hangs up, is prevented.

While there have been described what are at present considered to be the preferred embodiments of the invention, it will be understood that various modifications may be made therein, and

it is intended to cover in the appended claims all such modifications as fall within the true spirit and scope of the invention.

What is claimed is:

5 1. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including
10 said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, an automatic exchange, a plurality of lines extending to said exchange, means including an impulse responsive automatic switch for setting up connections between said lines, means responsive to the initiation of a call on said telephone line for arresting for a time interval the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for completing a connection to said automatic switch, means responsive to switch control impulses transmitted over said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said automatic switch thereby to cause said automatic switch to select a called one of said lines, and means including said automatic switch for completing a talking loop including said two carrier channels between said telephone line and said called line.

2. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, an automatic exchange, a plurality of lines extending to said exchange, means including an impulse responsive automatic switch for setting up connections between said lines, means responsive to the initiation of a call on said telephone line for arresting for a time interval the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for completing a connection to said automatic switch, means responsive to switch control impulses transmitted over said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said automatic switch thereby to cause said automatic

switch to select a called one of said lines, means including said automatic switch for completing a talking loop including said two carrier channels between said telephone line and said called line, means operative when said talking loop is interrupted at the calling end thereof for arresting for a time interval longer than said first-mentioned time interval the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said automatic switch.

3. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, means including an impulse responsive switch for setting up connections between said lines, said switch being accessible to said link line, means responsive to the initiation of a call on said telephone line for arresting for a time interval the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switch to be assigned to the use of said link line, means responsive to switch control pulses transmitted over said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said switch thereby to cause said switch to select a called one of said lines, and means including said link line and said switch for completing a talking loop including said two carrier channels between said telephone line and said called line.

4. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, means including an impulse responsive switch for setting up connections between said lines, said switch being accessible to said link line, means responsive to the initiation of a call on said tele-

phone line for arresting for a time interval the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switch to be assigned to the use of said link line, means responsive to switch control pulses transmitted over said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said switch thereby to cause said switch to select a called one of said lines, means including said link line and said switch for completing a talking loop including said two carrier channels between said telephone line and said called line, means operative when said talking loop is interrupted at the calling end thereof for arresting for a time interval longer than said first-mentioned time interval the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to said last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said automatic switch.

5. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, an automatic exchange, a plurality of lines extending to said exchange, means including an impulse responsive switch for setting up connections between said lines, a repeater coupled to the transmitter and receiver at the other of said points and including a link line having access to said switch, means responsive to the initiation of a call on said telephone line for arresting for a time interval the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for conditioning said repeater for audio frequency energy transmission and for causing said switch to be assigned to the use of said link line, means responsive to switch control impulses transmitted over said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said switch thereby to cause said switch to select a called one of said lines, means including said switch for completing a talking loop including said two carrier channels between said telephone line and said called line, means operative when said talking loop is interrupted at the calling end thereof for arresting for a time interval

longer than said first-mentioned time interval the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to said last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said repeater and said automatic switch.

6. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line coupled to the transmitter and receiver at said one point, a link line adapted to be coupled to the transmitter and receiver at said other point, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment in said exchange, said automatic switching equipment being accessible to said link line and having access to each of said plurality of lines, means responsive to the creation of a calling condition on said telephone line for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switching equipment to be assigned to the use of said link line, means responsive to impulses transmitted by way of said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said automatic switching equipment to select a called one of said plurality of lines, and means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission.

7. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line coupled to the transmitter and receiver at said one point, a link line adapted to be coupled to the transmitter and receiver at said other point, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment in said exchange, said

automatic switching equipment being accessible to said link line and having access to each of said plurality of lines, means responsive to the creation of a calling condition on said telephone line

5 for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling

10 said link line to the transmitter and receiver at said other point and for causing said switching equipment to be assigned to the use of said link line, means responsive to impulses transmitted by way of said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said automatic switching equipment to select a called one of said plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission, and means including one of said channels for transmitting dial tone, busy tone and ring-back tone signals, produced as an incident of the operation of said switching equipment, by way of one of said channels to said telephone line.

8. In a telephone system, a power transmission

35 line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative

40 and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line coupled to the transmitter and receiver at said one point, a link

45 line adapted to be coupled to the transmitter and receiver at said other point, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment in said exchange, said automatic switching equipment being accessible to said link line and having access to each of said plurality of lines, means responsive to the creation of a calling condition on said telephone line for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switching equipment to be assigned to the use of said link line, means responsive to impulses transmitted by way of said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said automatic switching equipment to select a called one of said plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission, means including one of said channels for transmitting dial tone, busy tone and ring-back tone signals, produced as an incident of the operation of said switching equipment, by way of one of said channels to said telephone line, means operative when the calling condition on said telephone line is terminated for again arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said automatic switching equipment to select a called one of said plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission, means including one of said channels for transmitting dial tone, busy tone and ring-back tone signals, produced as an incident of the operation of said switching equipment, by way of one of said channels to said telephone line.

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automatic switching equipment being accessible to said link line and having access to each of said plurality of lines, means responsive to the creation of a calling condition on said telephone line for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switching equipment to be assigned to the use of said link line, means responsive to impulses transmitted by way of said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said automatic switching equipment to select a called one of said plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission, means operative when the calling condition on said telephone line is terminated for again arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said automatic switching equipment.

9. In a telephone system, a power transmission

15 line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative

20 and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line coupled to the transmitter and receiver at said one point, a link

30 line adapted to be coupled to the transmitter and receiver at said other point, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment in said exchange, said automatic switching equipment being accessible to said link line and having access to each of said plurality of lines, means responsive to the creation of a calling condition on said telephone line for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said switching equipment to be assigned to the use of said link line, means responsive to impulses transmitted by way of said telephone line for correspondingly arresting the carrier output of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said automatic switching equipment to select a called one of said plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said selected called line in the respective two directions of audio frequency energy transmission, means including one of said channels for transmitting dial tone, busy tone and ring-back tone signals, produced as an incident of the operation of said switching equipment, by way of one of said channels to said telephone line, means operative when the calling condition on said telephone line is terminated for again arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said automatic switching equipment.

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10. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line adapted to be coupled to the transmitter and receiver at one of said points, an automatic exchange including a first impulse responsive automatic switch having access to said telephone line, a plurality of lines extending to said exchange and having access to said switch, a link line adapted to be coupled to the transmitter and receiver at the other of said points, a second automatic exchange including a second impulse responsive automatic switch accessible to said link line, a plurality of lines extending to said second exchange and accessible to said second automatic switch, said first automatic switch being controllable by way of a calling one of the lines extending to the first-named exchange to seize said telephone line, means responsive to the seizure of said telephone line for arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for operatively coupling said link line to the receiver at said other point and for causing said second automatic switch to be assigned to the use of said link line, means responsive to switch control impulses transmitted over said calling line and said telephone line for correspondingly arresting the operation of the transmitter at said one point, whereby interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for causing said second automatic switch to select a called one of the said second-named plurality of lines, means including said transmitters and receivers for providing two independent carrier channels for transmitting audio frequency energy between said telephone line and said called line in the respective two directions of transmission, means operative when the calling condition of said telephone line is terminated for again arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said second automatic switch.

11. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line adapted to be

coupled to the transmitter and receiver at said one point, an automatic exchange including a first impulse responsive automatic switch having access to said telephone line, a plurality of lines extending to said exchange and having access to said switch, a link line adapted to be coupled to the transmitter and receiver at the other of said points, a second automatic exchange including a second impulse responsive automatic switch accessible to said link line, a plurality of lines extending to said second exchange and accessible to said second automatic switch, said first automatic switch being controllable by way of a calling one of the lines extending to said first-named exchange to seize said telephone line, means responsive to the seizure of said telephone line by said first switch for momentarily arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrested carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point and for causing said second automatic switch to be assigned to the use of said link line, means responsive to impulses transmitted by way of the calling line for correspondingly arresting the carrier output of the transmitter at said one point in accordance with the transmitted impulses, whereby corresponding interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for transmitting corresponding impulses to said second automatic switch, whereby said second switch is caused to select a called one of the lines extending to said second exchange, and means including said transmitters and receivers for providing two independent carrier channels having different carrier frequencies for transmitting voice frequency energy between the calling and called lines.

12. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, the transmitters at both of said points normally being operative and the transmitter at one of said points having an output carrier frequency different from the output carrier frequency of the transmitter at the other of said points, the receiver at said one point being responsive only to the output carrier of the transmitter at said other point and the receiver at said other point being responsive only to the output carrier of the transmitter at said one point, a telephone line adapted to be coupled to the transmitter and receiver at said one point, an automatic exchange including a first impulse responsive automatic switch having access to said telephone line, a plurality of lines extending to said exchange and having access to said switch, a link line adapted to be coupled to the transmitter and receiver at the other of said points, a second automatic exchange including a second impulse responsive automatic switch accessible to said link line, a plurality of lines extending to said second exchange and accessible to said second automatic switch, said first automatic switch being controllable by way of a calling one of the lines extending to said first-named exchange to seize said telephone line, means responsive to the seizure of said telephone line by said first switch for momentarily arrest-

ing the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for operatively coupling said link line to the transmitter and receiver at said other point for causing said second automatic switch to be assigned to the use of said link line, means responsive to impulses transmitted by way of the calling line for arresting the carrier output of the transmitter at said one point in accordance with the transmitted impulses, whereby corresponding interrupted carrier pulses are transmitted to the receiver at said other point, means controlled in accordance with the response of the receiver at said other point to said interrupted carrier pulses for repeating corresponding impulses to said second automatic switch, whereby said second switch is caused to select a called one of the lines extending to said second exchange, means including said transmitters and receivers for providing two independent carrier channels having different carrier frequencies for transmitting voice frequency energy between the calling and called lines, means operative when the call is terminated for again arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to said last-mentioned arrest of the carrier output of the transmitter at said one point for releasing said second automatic switch.

13. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic switch having access to said link line, means for causing said automatic switch to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, and means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device.

14. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and

receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, and means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device.

15. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, and means controllable by way of said calling line for causing the transmitter at said other point to transmit a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said telephone line.

16. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being con-

trollable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, means controllable by way of said calling line for causing the transmitter at said other point to transmit a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said telephone line, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named control pulse for terminating said second control pulse, thereby to discontinue the projection of ringing current over said telephone line.

17. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic switch having access to said link line, means for causing said automatic switch to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, and means operative during the release of said control means for causing the transmitter at said other point to transmit a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said telephone line.

18. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for

setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, means controllable by way of said calling line for causing the transmitter at said other point to transmit a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said telephone line, and means operative during the release of said control means for causing the transmitter at said other point to transmit an additional control pulse by way of said one carrier channel, whereby ringing current is again projected over said telephone line.

19. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic switch having access to said link line, means for causing said automatic switch to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, said control means being conditioned, following the seizure of said link line by said switch, to cause the transmitter at said other point to transmit an additional control pulse by way of said one channel during the release of said control means, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named pulse for preventing any further control pulses from being transmitted by way of said one carrier channel.

20. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and re-

ceiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, and means controllable by way of said second telephone line for causing the transmitter at said other point to project a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said first-named telephone line.

21. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, means controllable by way of said second telephone line for causing the transmitter at said other point to project a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said first-named telephone line, and means operative during the release of said control means for causing the transmitter at said other point to transmit an additional control pulse by way of said one carrier channel, whereby ringing current is again projected over said first-named telephone line.

22. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way

of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, means controllable by way of said second telephone line for causing the transmitter at said other point to project a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said first-named telephone line, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named pulse for terminating said second control pulse, thereby to discontinue the projection of ringing current over said first-named telephone line.

23. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, said control means being conditioned, following its operation, to cause the transmitter at said other point to transmit an additional control pulse by way of said one channel during the release of said control means, means operative when a call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named pulse for preventing any further control pulses from being transmitted by way of said one carrier channel.

24. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said line, a two-way repeater coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said repeater, said equipment being accessible to said repeater,

said automatic switch being controllable by way of a calling one of said plurality of lines to seize said repeater, control means included in said repeater and responsive to the seizure of said repeater by said switch for completing a talking loop, including said carrier channels, between the calling line and said telephone line and for causing the transmitter at said other point to transmit a control pulse by way of one of said channels, means responsive to said control pulse for projecting ringing current over said telephone line, means responsive to the creation of a calling condition on said telephone line for causing the transmitter at said one point to transmit a control pulse by way of the other of said channels, means included in said repeater and responsive to said last-named control pulse for causing a portion of said switching equipment to be assigned to the use of said repeater, means responsive to impulses transmitted by way of said telephone line for causing the transmitter at said one point to transmit corresponding carrier impulses by way of said other carrier channel, and means responsive to said carrier impulses for repeating said impulses to said switching equipment, whereby said switching equipment is caused to select a called one of said plurality of lines.

25. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for causing the transmitter, at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, and means responsive to switch control pulses transmitted by way of said calling line for causing the transmitter at said other point to transmit a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said telephone line.

26. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the re-

spective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, means responsive to switch control impulses transmitted by way of said second telephone line for causing the transmitter at said other point to project a second control pulse by way of said one carrier channel, whereby said last-named means is caused to again project ringing current over said first-named telephone line, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named pulse for terminating said second control pulse, thereby to discontinue the projection of ringing current over said first-named telephone line.

27. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for momentarily arresting the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said telephone line to energize said signal device, means responsive to switch control impulses transmitted by way of said calling line for again momentarily arresting the carrier output of the transmitter at said other point, and means controlled in accordance with the response of the receiver at said one point to the last-mentioned arrest of the carrier output of the transmitter at said other point for again projecting ringing current over said telephone line.

28. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters

and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point, means controllable by way of said second telephone line for causing the transmitter at said other point to transmit a control pulse by way of said one carrier channel, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named control pulse for terminating said first-named control pulse, thereby to discontinue the projection of ringing current over said first-named telephone line.

29. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point, means controllable by way of said second telephone line for arresting for a time interval the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said first-named telephone line to energize said signal device, means operative when the call is answered at said telephone station for arresting momentarily the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for reinitiating the operation of the transmitter at said other point to transmit its carrier output, and means controlled in accordance with the response of the receiver at said one point to the resumed carrier output of the transmitter at said other point for discontinuing the projection of ringing current over said first-named telephone line.

30. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and

located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point, means controllable by way of said calling line for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said telephone line to energize said signal device, means operative when the call is answered at said telephone station for causing the transmitter at said one point to transmit a control pulse by way of the other of said carrier channels, and means responsive to said last-named control pulse for terminating said first-named control pulse, thereby to discontinue the projection of ringing current over said telephone line.

31. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point, means controllable by way of said calling line for arresting for a time interval the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said telephone line to energize said signal device, means operative when the call is answered at said telephone station for momentarily arresting the carrier output of the transmitter at said one point, means controlled in accordance with the response of the receiver at said other point to

the momentary arrest of the carrier output of the transmitter at said one point for reinitiating the operation of the transmitter at said other point to transmit its carrier output, and means controlled in accordance with the response of the receiver at said one point to the resumed carrier output of the transmitter at said other point for discontinuing the projection of ringing current over said telephone line.

32. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for momentarily arresting the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said first-named telephone line to energize said signal device, said control means being conditioned, following its operation, to again momentarily arrest the carrier output of the transmitter at said other point, means operative when a call is answered at said telephone station for momentarily arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for preventing the carrier output of the transmitter at said other point from thereafter being arrested.

33. In a telephone system, a power transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and receiver at the other of said points, an automatic switch having access to said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for momentarily arresting the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said telephone line to energize said signal device, said control means being condi-

tioned, following the seizure of said link line by said switch, to again momentarily arrest the carrier output of the transmitter at said other point, means operative when the call is answered at said telephone station for momentarily arresting the carrier output of the transmitter at said one point, and means controlled in accordance with the response of the receiver at said other point to the arrest of the carrier output of the transmitter at said one point for preventing the carrier output of the transmitter at said other point from thereafter being arrested.

34. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for causing the transmitter at said other point to transmit a control pulse by way of one of said carrier channels, means responsive to said control pulse for projecting ringing current over said first-named telephone line to energize said signal device, and means operative during the release of said control means for causing the transmitter at said other point to transmit an additional control pulse by way of said one carrier channel, whereby ringing current is again projected over said first-named telephone line.

35. In a telephone system, a transmission line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a second telephone line adapted to be coupled to the transmitter and receiver at the other of said points, control means for operatively coupling said second telephone line to the transmitter and receiver at said other point and for momentarily arresting the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said first-named telephone line to energize said signal device, and means operative during the release of said control means for again momentarily arresting the carrier output of the transmitter at said other point whereby said last-mentioned means is again operated to cause ringing current to again be projected over said first-named telephone line.

36. In a telephone system, a power transmis-

- sion line, a source of commercial frequency current connected to said line, carrier current transmitters and receivers coupled to said line and located at two separated points, means including
- 5 said line, said transmitters and said receivers for providing two independent carrier channels of different carrier frequencies for transmitting audio frequency energy between said points in the respective two directions of transmission, a
- 10 telephone line coupled to the transmitter and receiver at one of said points, a telephone station including a signal device connected to be energized by way of said telephone line, a link line adapted to be coupled to the transmitter and
- 15 receiver at the other of said points, an automatic exchange, a plurality of lines extending to said exchange, automatic switching equipment for setting up connections between said lines and including an automatic switch having access to said
- 20 link line, said automatic switch being controllable by way of a calling one of said plurality of lines to seize said link line, control means responsive to the seizure of said link line by said switch for operatively coupling said link line to the transmitter and receiver at said other point and for momentarily arresting the carrier output of the transmitter at said other point, means controlled in accordance with the response of the receiver at said one point to the arrest of the carrier output of the transmitter at said other point for projecting ringing current over said telephone line to energize said signal device, and means operative during the release of said control means for again momentarily arresting the carrier output of the transmitter at said other point, where- by said last-named means is operated to cause ringing current to again be projected over said telephone line.

CLARENCE ERNEST LOMAX. 20