

April 12, 1927.

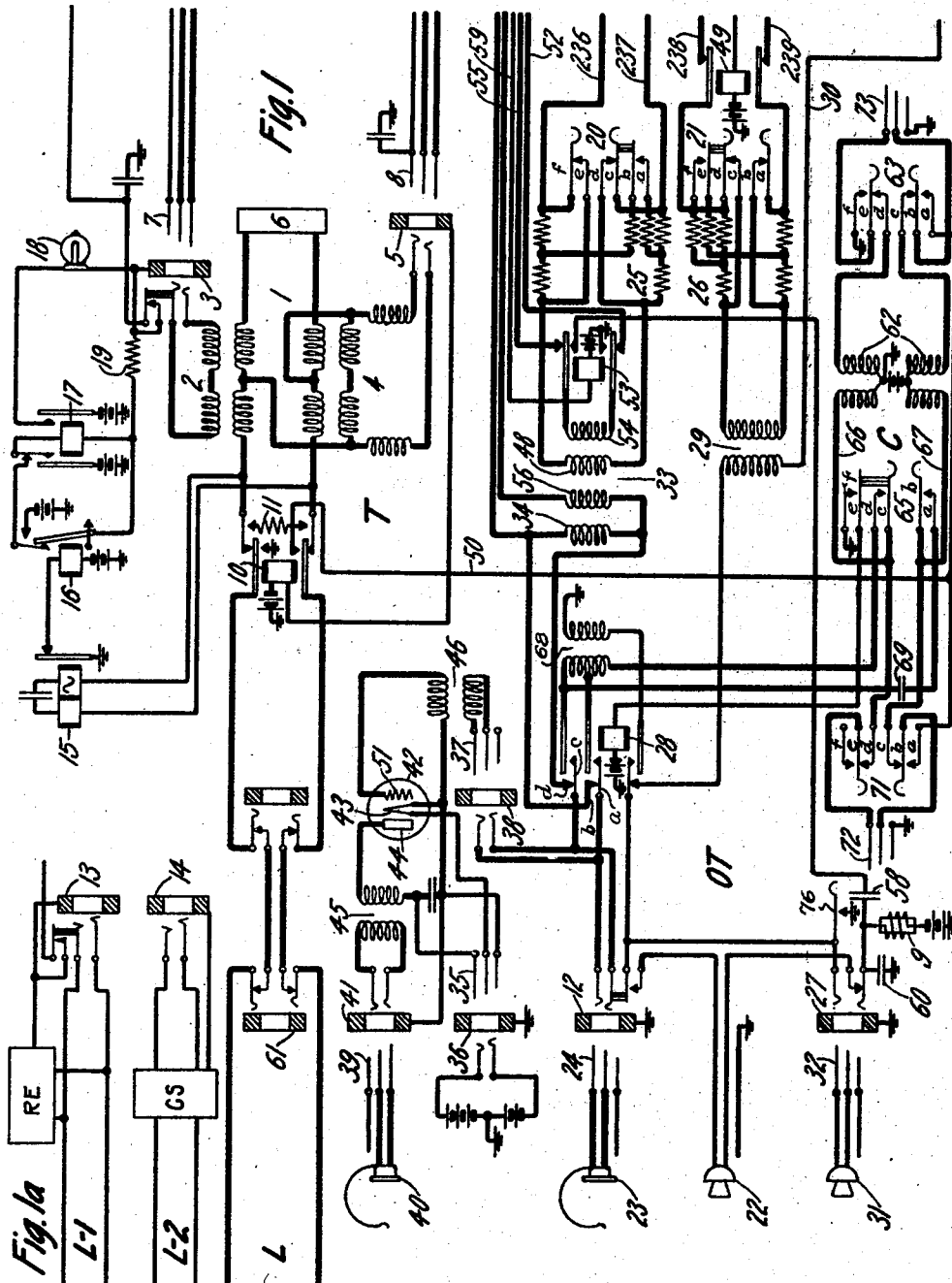
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1,624,672

COMMUNICATION SYSTEM

Filed Dec. 17, 1924

5 Sheets-Sheet 1



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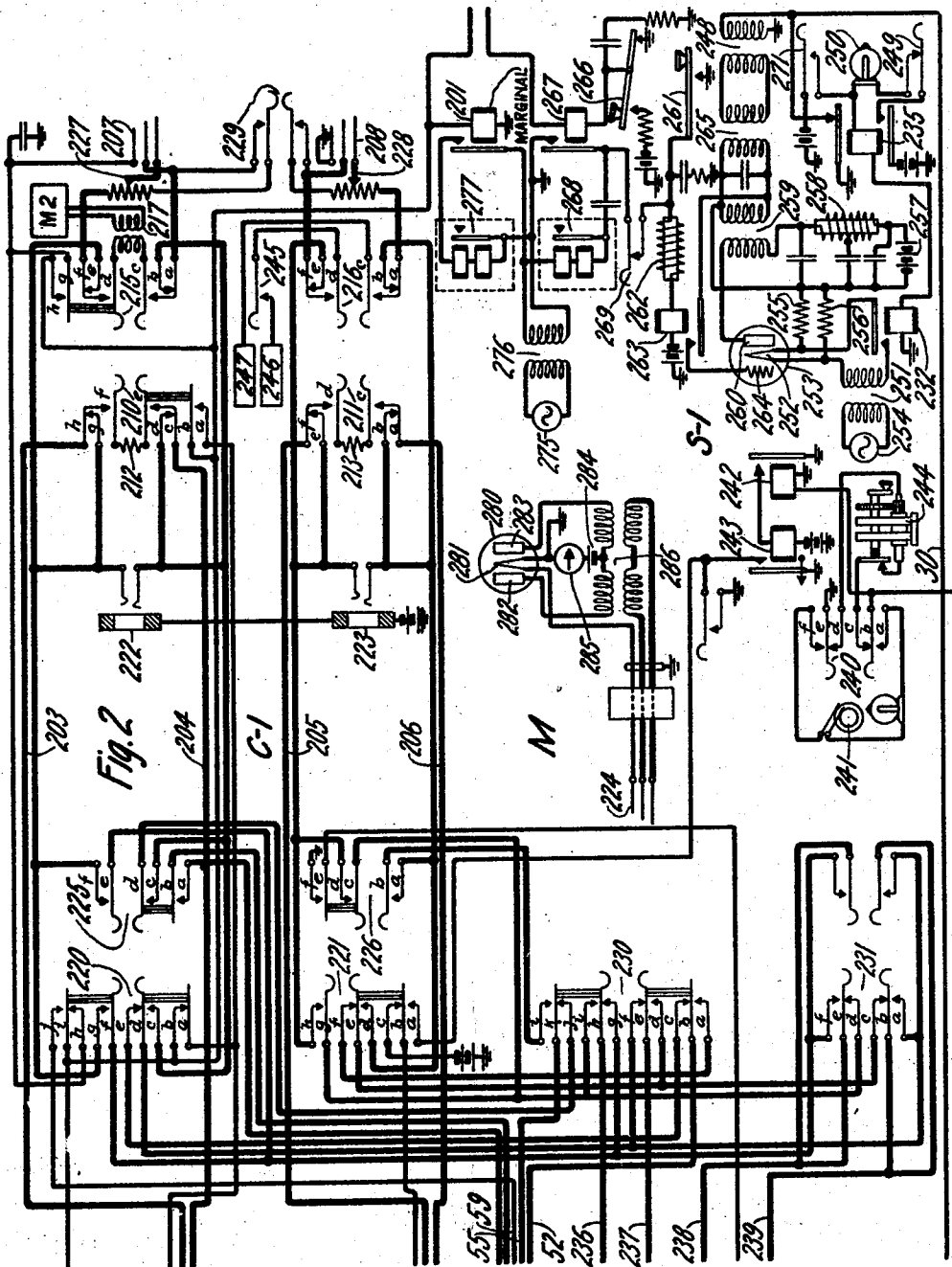
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5 Sheets-Sheet 2



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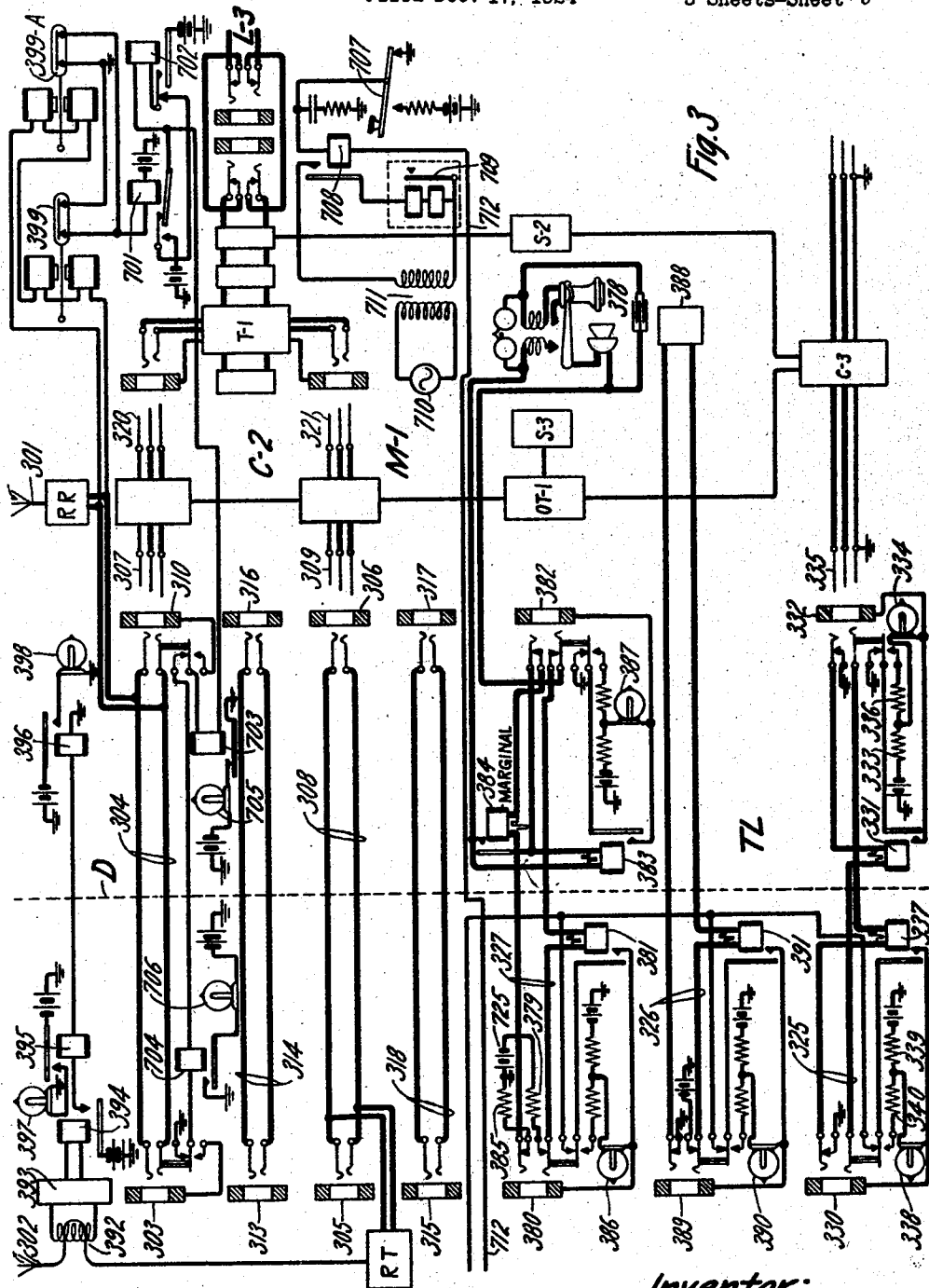
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COMMUNICATION SYSTEM

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5 Sheets-Sheet 3



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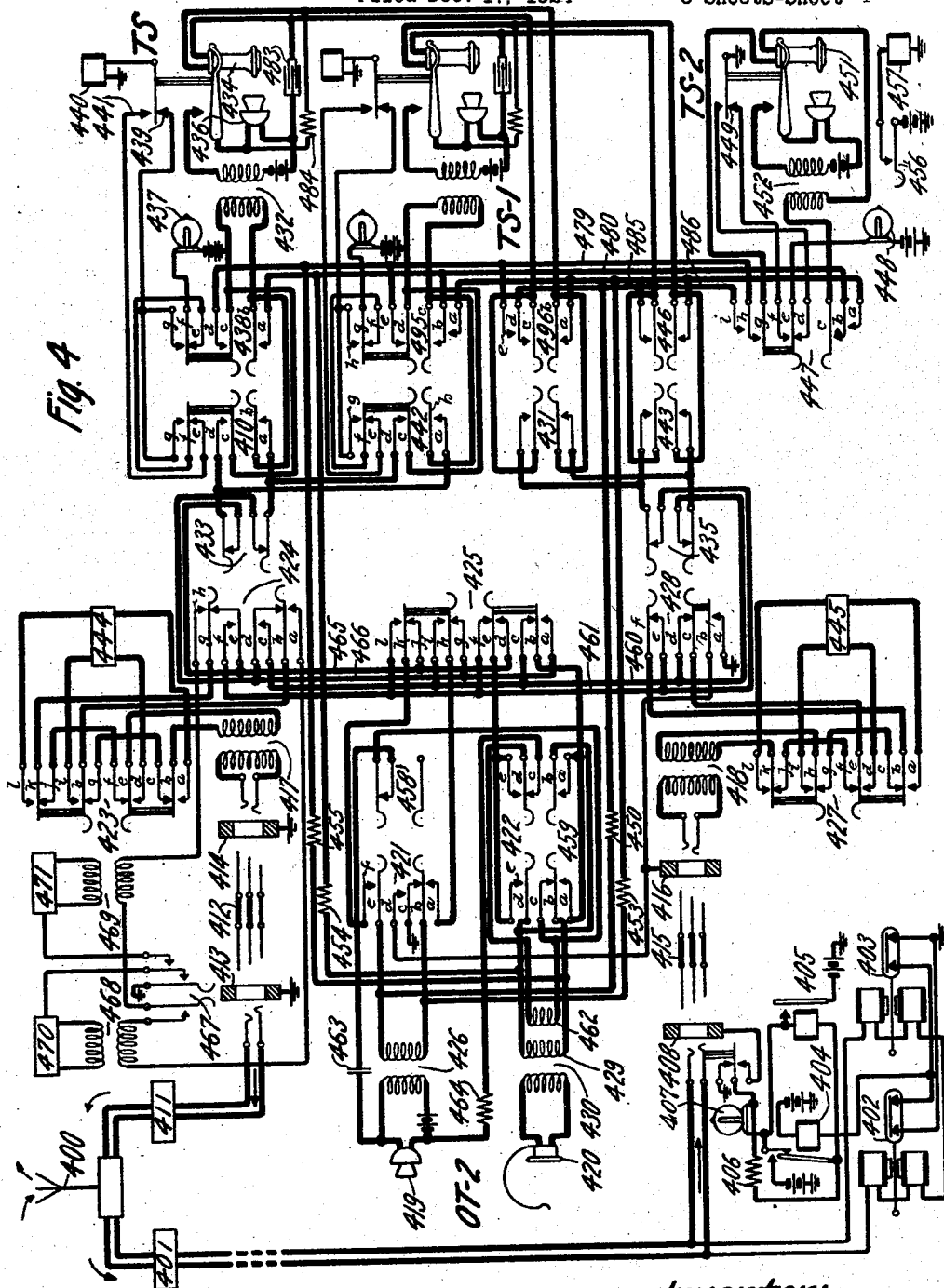
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COMMUNICATION SYSTEM

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5 Sheets-Sheet 4



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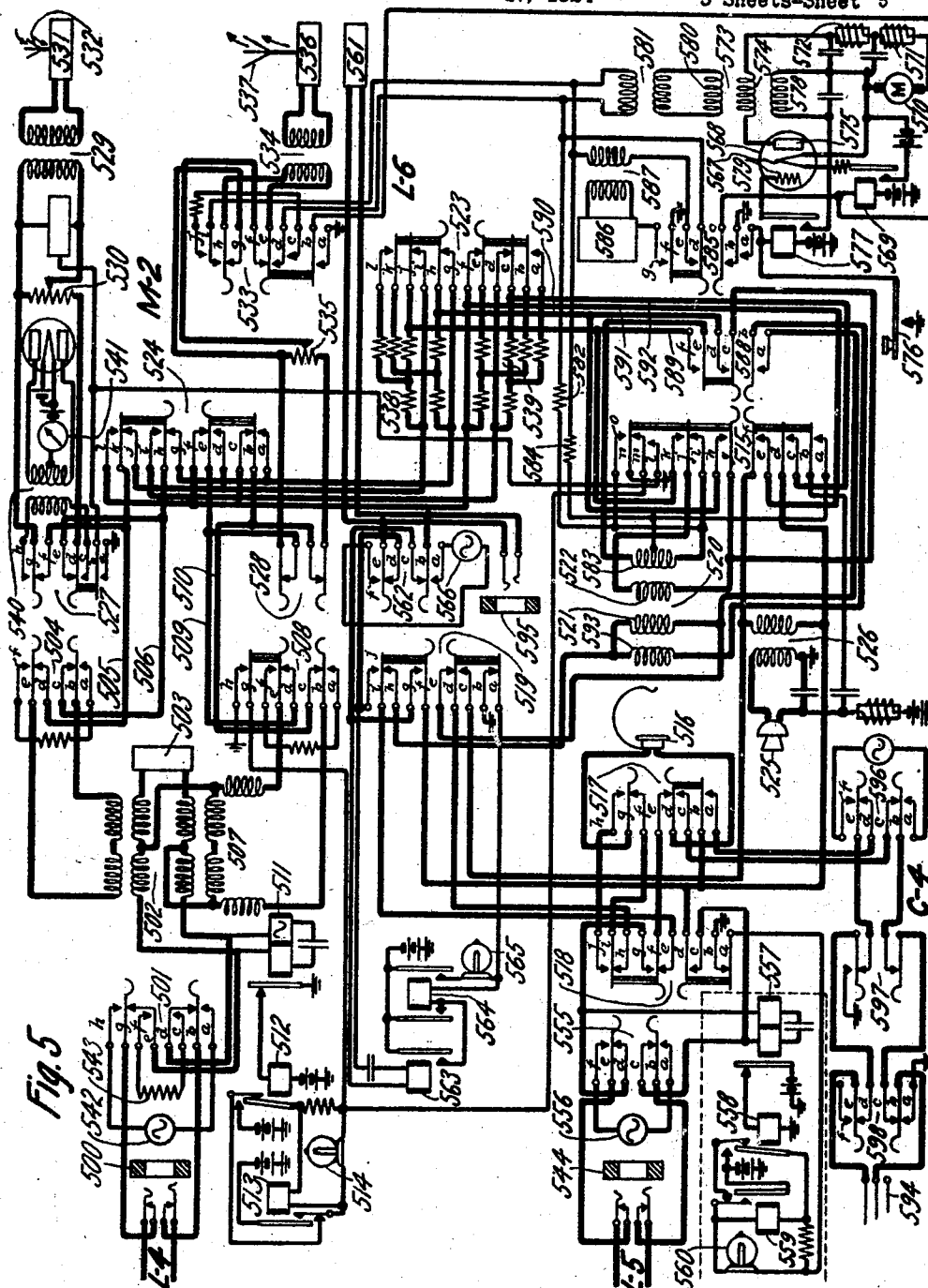
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COMMUNICATION SYSTEM

Filed Dec. 17, 1924

5 Sheets-Sheet 5



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UNITED STATES PATENT OFFICE.

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COMMUNICATION SYSTEM.

Application filed December 17, 1924. Serial No. 756,403.

This invention relates to communication systems and more particularly to systems of radio-wire communication.

The object of this invention is to provide a system whereby land lines or wire circuits may be joined to radio systems for the optional handling of either telephone or telegraph messages.

A feature of the invention is the employment of an improved system involving a plurality of switching equipments respectively located at separate points relative to radio transmitting and receiving sets and arranged in such a manner that the establishment and control of radio-wire connections may rest either with a single switching point or the control may be divided between a plurality of such points, and further, that such joint control may be on either of several different plans, as a parallel relation or a series relation or a combination of parallel and series relations relative to the circuits of the switching facilities at the different points.

Another feature is the provision for reciprocal control of the call and supervisory signals relative to radio channels and wire circuits or channels.

Another feature is the provision of an arrangement for the wire side of a connection whereby either two-wire or four-wire working may be resorted to, while equipment automatically responsive to the handling of traffic may render receiving and sending devices of an attendant's equipment effective with circuits ancillary to and differing from the main channels of a connection.

Another feature is the provision of an arrangement whereby any switching point may serve either as a terminating station or as a repeater station relative to the handling of communications over wire or radio channels or on mixed connections relative to wire and radio working or on wire-to-wire communications.

Another feature is the provision of improved means for supplying so-called side tone relative to a transmitter and receiver of a telephone set when these instruments may be respectively associated with electrically isolated circuits usually present in four-wire working.

Another feature is the provision of an improved signaling arrangement whereby

a single visual signaling device is employed both as a calling signal and as a clearing-out signal.

Another feature is the provision of a circuit arrangement wherein an incoming line is provided with a visual signal device at each of two operator's boards and means actuated when the call is answered from one board for retiring both signals, and means for reoperating only the signal at the board where the call is answered when the calling party disconnects.

Another feature is the provision of an arrangement whereby the receiver may be applied to either side of a four-wire circuit for communication purposes, the impedance of the circuit being increased when the receiver is employed for monitoring purposes.

Another feature is the provision of a circuit arrangement involving compensating means in the operator's set which renders the voice currents impressed on the amplifiers by the operator of substantially the same intensity as those which would be impressed from the transmitting end, that is, this resistance in effect sets the operator back to the transmitting end and makes it unnecessary to adjust the gain device before and after the operator calls.

Another feature is the provision of a connection from the low frequency oscillator used for telegraphing to the operator's set so that the operator may hear in the receiver the code of low frequency oscillations which are impressed on the carrier wave.

Another feature is the provision of an improved system to prevent false signals from the land lines from operating the calling signals.

Another feature is the provision of a circuit arrangement whereby low frequency oscillations are impressed on high frequency oscillations from either one of two points connected in a direct current circuit.

Another feature is the provision of two alternating current relays in the signaling circuit tuned to respond to different frequencies, preferably within the voice range, and a signal operated only on the simultaneous response of both relays.

Another feature is the provision of a monitoring set including an induction coil having a high impedance primary winding connected across the cord being monitored,

an amplifier being connected to the secondary winding, whereby transmission is not impaired.

Another feature is the provision of an arrangement whereby the operator may modulate the carrier waves by voice currents or low frequency telegraph waves without changing the transmitting circuit, the circuits being so arranged that when the telegraph key is in the operated position, the talking transmitting circuit is in operative relation with the radio transmitter.

Another feature is the provision of a circuit for eliminating the ringing key in the cord circuit and consists in providing a common relay associated with the signaling generator, and a relay in each line circuit, the common relay being actuated upon the operation of the generator, and the relay in the line taken for use being operated due to the conjoint actuation of the common relay and the talking key of the cord used. A related feature is the provision of a circuit arrangement for applying signaling current to the line over a path independent of the cord used and at a point beyond the terminating equipment of said line, said equipment being of a character opaque to such low frequency signaling currents.

Another feature is the provision of a circuit arrangement involving the application of a substantially zero resistance ground, to the high frequency currents used in radio transmission, to one of the strands of the cord circuits to prevent interference.

Another feature is the provision of a circuit arrangement for communicating systems using four-wire circuits, the receiver and transmitter being connected respectively to the two sides of the circuit for affording side tone without physically connecting the two sides of the four-wire circuit, consisting in providing means for directing a portion of the energy from the transmitter to the receiver without establishing a path whereby an appreciable amount of energy is transferred between the two sides of the four-wire circuit.

Another feature relates to communicating systems using four-wire circuits wherein two of the wires are used for transmitting and two for receiving, consisting in the provision of manually controlled switches for utilizing either of said pairs for local telephone conversations.

Other features of the invention will appear from the following description together with the appended drawings in which:—

Fig. 1 shows the terminating equipment T, line L, equipment OT of and in connection with an operator's telephone set, a cord circuit C of the two wire type, Fig. 1^a shows line circuits L—1 and L—2 for

four wire working which may be used in place of the two wire line L of Fig. 1.

Fig. 2 shows a four wire circuit C—1, telephone signaling equipment, telegraph signaling equipment S—1, and a system M for measuring the strength of voice and telegraphic currents.

Fig. 3 shows equipment RT of a radio transmitting system with circuit facilities corresponding to a radio receiving system RR and a trunk and line equipment TL while equipments L—3, T—1, OT—1, C—2, S—2, S—3 and M—1 may be considered, respectively, as corresponding with equipments L, T, OT, C, S, S—1 and M of Figs. 1 and 2.

Fig. 4 shows the radio equipment for a ship; while

Fig. 5 shows the equipment for a second radio station with the equipments of either Figs. 1, 2 and 3 or other stations having equipment similar to the system of Fig. 4.

In describing this system the equipments of Fig. 2 and that portion of equipment of the radio system to the left of line D (Fig. 3) may be considered present at a radio wire station at which radio transmitting equipment RT is present while the equipment at the right side of line D may be considered as located at a radio wire receiving station.

The line circuit L (Fig. 1) may be considered as extending to a distant toll or long distance telephone switchboard and through which connections may be established with other land lines. This two wire circuit terminates in a repeating coil 1 of the hybrid type having a secondary winding 2 joined to a jack 3 while the bridge points of the coil 1 are connected to an autotransformer 4, which in turn is connected to a jack 5. The purpose of the autotransformer is to increase the impedance of the circuit from the bridge points of coil 1 to correspond with the impedance of the secondary or output winding 2. The artificial line 6 serves as a balancing network for the line L. The relay 10 is controlled from a cord circuit as will be presently described, and serves for disconnecting the hybrid coil and for applying signaling current outward over the line circuit. During such operations, this relay also connects a resistance or network 11, corresponding to the network 6 to maintain a balanced condition at the hybrid coil, whereby the transfer of energy between the radio transmitting system and the radio receiving system is prevented when the line is disconnected from the hybrid coil, during a ringing period.

Called signals from the line L are received as follows. Ringing current incoming from the line L flows through the relay 15, which being energized, pulls up its arma-

ture to thereby open the circuit including the normally energized relay 16. The armature of relay 16 therefore falls off and completes a circuit including grounded battery, the winding of relay 17, resistance 19 and relay 201 (Fig. 2) which is connected to ground. The relay 17, being energized, actuates the two armatures associated with it. The left hand armature opens the circuit of the grounded battery previously closed and completes a locking circuit through a second grounded battery. The right hand armature of relay 17 completes a circuit including a third grounded battery, the signal lamp 18 and relay 201.

One side of the four wire cord circuit C—1 comprises main conductors 203 and 204 while the other side is formed by conductors 205 and 206. In this cord circuit, although separately shown, keys 210—211 may be considered as units forming a single key, while units 215—216, 220—221, 225—226 and 230—231 may be considered as similarly constituting single keys. The units 210—211 serve as a so-called splitting key for disconnecting the left-hand end of the cord circuit, while units 215—216 form a key to disconnect the right hand end or radio side of the cord circuit. Units 220—221 permit the operator's telephone set to be connected for talking on a circuit which may be used to establish a connection between the line and radio equipment. Units 225—226 form a key for monitoring and units 230—231 form a key whereby the operator's transmitter and receiver may be reversed or transposed relative to the two sides of the four wire cord circuit.

At the splitting key unit 210, the transformer 217 may be connected to a radio receiving system. During the period of a connection this key may be operated for the purpose of including a device M—2 which corresponds with the current indicating system M whereby when the radio side of a connection is disconnected, incoming voice or signaling current will be indicated in the system M—2. The resistance units or networks 212 and 213 will be connected to the respective sides of the four wire circuits connected to the line L when the key 210—211 is operated to disconnect the circuits in that direction. The purpose of these resistances is to maintain a balanced condition relative to the terminating equipment T of the line L during such periods. The jacks 222 and 223 are provided to permit the speech meter M to be connected by the plug 224 with either side of the four wire connection.

Key units 20—21 (Fig. 1) are also mechanically connected to form a single key which is used to control the connection of the transmission loss networks 25 and 26 with respect to the circuits at a point intermediate between an operator's telephone receiver 23

and the transmitters 22 or 31 and the respective sides of the cord circuit C—1. These networks permit a simulation of a condition whereby an associated operator's telephone circuit may, from a transmission standpoint, be positioned equivalent to the distant toll switchboard, assumed as present on the line circuit L. Therefore, following the establishment of a connection with a distant radio station or ship, gain controls 227 and 228 of the cord circuit C—1 may be set by the operator to determine a speech energy level which will be satisfactory when the connection is extended through or linked to the toll operator at the assumed distant point.

In establishing a connection between line and the radio link, plugs 7 and 8 are inserted in jacks 3 and 5 of the toll line L while plugs 207 and 208 are inserted in jacks 303 and 305 of the equipment of Fig. 3. Incoming radio waves incident upon the antenna 301 will be supplied to the radio receiving equipment RR in which they will be detected to reproduce speech currents. The detected speech currents will traverse the main conductors of the trunk 304, the main members of jack 303 and plug 207, main conductors 203 and 204 of the cord circuit, main members of jack 7 and plug 3 and the terminating equipment T of the toll line L.

Speech currents from the line L will traverse the main contact members of jack 5 and plug 8, main conductors 205 and 206 of the cord circuit, main contact members of plug 208 and jack 305, thence to the radio transmitting equipment RT. A speech modulated radio frequency wave will be supplied to and radiated from the transmitting antenna 302.

During the period of the connection just described, it may be desirable for the operator at the radio receiving station to be able to talk, monitor, signal, etc. This may be accomplished by associating a four-wire cord circuit C—2, including equipment similar to that of cord circuit C—1, with the radio transmitting and receiving apparatuses. The cord circuit C—2 may be connected either in parallel, in series, or in series multiple with the cord circuit C—1.

For a parallel connection of the receiving operator's set OT—1, with the cord circuit C—1; the plugs 307 and 309 of the cord circuit C—2 are inserted in the corresponding jacks 306 and 310.

To provide for four wire working on the land line side of a cord connection, the plugs 7 and 8 of the cord circuit C—1 should be inserted in jacks 13 and 14, Fig. 1^a, respectively, of the lines L—1 and L—2 which form a four wire circuit. Equipment corresponding with signal receiving equipment, constituted by relays 15, 16 and 17 and signal 18 of the line L, is provided at RE on line L—1, while CS on line L—2 represents

equipment similar to the signaling relay 10 and associated apparatus of line L.

The arrangement of a connection, whereby the switching equipment at the first or transmitting station may be in series or tandem with the switching equipment at the second or receiving station, is accomplished by inserting the plugs 207 and 208 of cord circuit C—1 in jacks 313 and 315 of trunk circuits 314 and 318, respectively. At the second station plugs 320 and 321 of the four-wire cord circuit C—2 are inserted in jacks 316 and 317 of the trunk circuits 314 and 318, while the opposite plugs 307 and 309 are inserted in the jacks 310 and 306, respectively, of the trunk circuits 304 and 308 associated with the radio receiving and transmitting systems. Under such an assumed connection, the matter of setting the gain control devices rests with either station. At the station to which such operations may be assigned, a key 229 (Fig. 2) may be operated for connecting the gain control devices 227 and 228 in circuit with the two sides of the four wire cord circuit.

For a connection, which may be referred to as a series multiple combination, the plug 207 is inserted in jack 313 of the trunk 314 while plug 208 is inserted in jack 305 of trunk 308. At the other station, plug 320 of the cord circuit C2 is inserted into jack 316 of the trunk 314 and plug 307 is inserted into jack 310 of trunk 304. When this connection is made, incoming voice currents from line L will traverse the lower side of the cord circuit C1 and the connection of the trunk 308 to the radio transmitting antenna 302, while voice currents arriving over the receiving antenna 301 will traverse the upper conductors of the four-wire cord circuit C2, trunk 314, thence over the upper side of the cord circuit C1 to the line L. Thus speech currents resulting from detecting the incoming radio waves will be transmitted in tandem through the cord circuits C2 and C1 to the toll line L, while currents from this line to the radio transmitting equipment will traverse only the circuits of the cord C1. The radio transmitting equipment however, will be accessible to the lower half or side of the cord circuit C2 at the second station, if desired, by inserting plug 309 into jack 306 of the trunk 308 connected to the radio transmitter.

In a converse manner, the transmitting equipment may be placed in series with one side of the cord circuits C1 and C2 at the respective stations, while the radio receiving circuits will be connected directly through the upper side of the cord circuit C1 to the line L. Bridged supervision on the incoming radio channel will be carried out during such periods at the second station by inserting plug 307 into jack 310 of the trunk 304. Referring to the equipment of the oper-

ator's telephone set (OT, Fig. 1) the telephone transmitter 22, which may be of the so-called switchboard type, will be energized by inserting plug 24 of the telephone receiver 23 into jack 12. This energizing circuit extends from grounded battery, through the winding of retardation coil 9, normal contacts of jack 27, transmitter 22, forward contacts of jack 12, lower normal contacts of relay 28, primary winding of induction coil 29, conductor 30, thence to ground through the normal contacts of relay 235 (Fig. 2).

When it is desired to use a breast transmitter 31, in place of the switchboard transmitter 22, plug 32 of the transmitter 31 may be inserted in jack 27. The separated contacts of jack 27 will then disconnect transmitter 22 and the energizing circuit for 31 may be traced from grounded battery, through retardation coil 9, lower main members of jack 27 and plug 32, transmitter 31, upper main members of this plug and jack, thence to ground through the circuit already traced by way of the lower normal contacts of relay 28.

The circuit for the operator's receiver 23 may be traced from the lower terminal of the winding 34 of transformer 33, upper normal contacts *cd* of relay 28, lower main members of jack 12 and plug 24, receiver 23, upper main members of plug 24 and jack 12, upper normal contacts *ab* of relay 28 to the upper terminal of winding 34.

A monitoring system, which when employed will inappreciably effect the transmission relative to the operator's receiver 23, may be obtained by inserting plug 35 into jack 36, plug 37 into jack 38, and plug 39 into jack 41. Current from grounded battery will traverse a circuit over the lower main members of jack 36 and plug 35 to filament 43 of a three element vacuum tube amplifier 42 to ground over the sleeve members of plug 35 and jack 36. Grounded battery also applies current through the upper members of jack 36, plug 35 and primary winding of transformer 45 to the plate element 44 of the tube 42. The telephone receiver 40 is connected by way of plug 39 and jack 41 to the secondary or output winding of transformer 45. The main members of jack 38 are connected in parallel to the leads of jack 12 which connect to receiver 23. Therefore, voice currents over the plug 37 will traverse a circuit through the primary winding of transformer 46, the secondary winding of this transformer is included in the input circuit of tube 42, which includes a grid element 51. When desired, the operator's receiver 23 may be disconnected from jack 12 and connected to jack 41 and used with the transmitter 31 in the regular handling of telephone connections, in place of the monitoring receiver 40. Under these

conditions, it is immaterial whether plug 24 is in jack 12, since the circuit for the transmitter 31, as already traced, is independent of the lower contacts of jack 12. These contacts merely serve to complete the circuit for the transmitter 22.

To connect the operator's receiver 23 and transmitter 31, with the respective sides at the cord circuit C1, the key formed of units 220—221 is operated. For the receiver, a circuit may be traced from the main conductor 203 of the cord, the upper normal contacts *hg* of key 210, the upper forward contacts *gf* of key 220, the upper normal contacts *gh* of key 230, conductor 236, the upper normal contacts *fe* of key 20, winding 48 of transformer 33, lower normal contacts *dc* of key 20, conductor 237, lower normal contacts *ef* of key 230, the lower alternate contacts *dc* of key 220, the lower normal contacts *dc* of key 210 to the opposite main conductor 204 of the cord circuit. For the transmitter 31, the circuit is traced from the main conductor 205, the upper normal contacts *ef* of key 211, the upper forward contacts *hg* of key 221, the upper normal contacts *de* of key 231, conductor 238, the upper normal contacts of relay 49, upper normal contacts *dc* of key 21, secondary winding of the induction coil 29, the lower normal contacts *ba* of key 21 and lower normal contacts of relay 49, conductor 239, the lower normal contacts *bc* of key 231, the lower alternate contacts *ed* of key 221 and the lower normal contacts *ab* of key 211 to the main conductor 206. With the circuits just traced, the receiver 23 will be connected in bridge on the upper side of the four-wire cord circuit, while the transmitter 31 will be similarly connected to the lower side of the four wire cord circuit.

In case the splitting key 210—211 is operated at this time, the operator's set will be connected to plugs 207 and 208 and may be used for communication over the radio circuits. If the splitting key is in its position to operate units 215—216, the radio side will be disconnected and the operator's set will be connected for use with the line "L."

Operation of the key formed of units 20—21 opens obvious connections which normally short circuit the series resistance units, while the forward contacts of the shunt resistance units are connected together to form a bridge path for the loss networks, which is of the conventional H type.

When it is desired to reverse the relation of the transmitter and receiver of the operator's set with respect to the sides of the four-wire cord circuit, the key formed of units 230—231 is operated, the key 220—221 being actuated. The circuit for the transmitter may now be traced from conductor 203, upper normal contacts *hg* of key 210, the upper forward contacts *gf* of key 220, upper

alternate contacts *fe* of key 231, conductor 238, and as already traced through the secondary winding of the induction coil 29, thence returning over conductor 239, the lower alternate contacts *ba* of key 231 and the lower alternate contacts *dc* of key 220 and the lower normal contacts *dc* of key 210 to the opposite conductor 204. The circuit for the receiver may be traced from conductor 205 over the upper normal contacts *fe* of key 211, upper alternate contacts *hg* of key 221, upper alternate contacts *ih* of key 230, conductor 236, thence as traced through the winding 48 of the transformer 33 returning over conductor 237, the lower alternate contacts *ed* of key 230, the lower alternate contacts *ed* of key 221, and the lower normal contacts *ba* of key 211 to the opposite main conductor 206.

The control described above, increases the flexibility of the connecting circuit, since it permits the transmitter and receiver of an operator's set to be interchanged with respect to the sides of the cord circuit C—1, whereby a single operator's set may be properly connected to talk, monitor or signal in either direction, whether the communication takes place from line to radio or from radio to line. This is a distinct advantage, especially when repeaters are used between the cord circuit and the distant radio system, or between the cord circuit and the four-wire terminating equipment of the two-wire line "L" or the circuits of the four-wire line formed of circuits L1 and L2. When using a connecting circuit of this type it will be obvious that the repeaters render the respective sides of the four-wire circuit opaque to currents in one direction. In talking from the operator's set in one direction over such a connecting circuit, the reversing key 230—231 will be in one position, while in order to talk in the opposite direction, it will be necessary to throw the reversing key to the opposite position.

Upon receiving a call signal from the line L, as indicated by the lighting of lamp 18 due to the locked position of relay 17, insertion of plug 7 into jack 3 will separate the normal contacts of this jack to disconnect ground and thereby effect the release of relay 17 to extinguish the signal 18.

The structure of the jack 3 and plug 7 are such that the normal contacts of the jack will separate prior to closure of the upper member of the plug 7 with the sleeve member of the jack, thereby permitting the release of relay 17. Following complete insertion of plug 7 into jack 3, a circuit, in substitution of the first path, is completed over the sleeve conductor of plug 7, the lower normal contacts of key 220 to ground through the winding of relay 201 (Fig. 2). This provides that during the period of a connection, an incoming call signal locks up

the relay 17 over the sleeve conductor of the connection and the lower normal contacts of key 220, so as to maintain the signal lamp 18 lighted. When the talking key 220—221 is operated in responding to such a signal, separation of the lower normal contacts of the unit 220 will open the locking circuit of the relay 17, thereby extinguishing signal 18.

To insure that the signal 18 will not be displayed due to inductive or surge effects in the conductors of line L, a slow release relay 16 is inserted between the alternating current relay 15 and the signal control relay 17. Relay 16 is normally energized over an obvious circuit which circuit is opened upon the operation of relay 15. Signaling current incoming over line L must hold relay 15 energized for a sufficient period to allow the contacts of relay 16 to assume the fully released position, in order to remove a short circuit about the winding of relay 17.

For signaling outward over the line circuit L, the plug 8 is inserted in jack 5 and the talking key 220—221 operated. Key 240 is then operated to apply signaling current from a source 241 to operate relay 242 which has a high impedance to signaling currents. Relay 242 causes the energization of relay 243 over an obvious circuit closure of the contacts of relay 243, connects ground to a circuit which extends through the lower alternate contacts *ab* of unit 221, the upper sleeve member of plug 8, shell of jack 5, and the winding of relay 10 to grounded battery. The upper armature of relay 10 connects ground to the upper main conductor of line L, while the lower armature connects the lower main conductor of the line to conductor 50 now connected over the lower alternate contacts *ab* of key 240 through the source 241 and the upper alternate contacts *ef* of the key 240 to ground, whereby current is supplied to line L from the source 241.

Where a continually operating source of alternating current, as the source 241, may not be available, the key 240 may remain in its normal position, and the hand generator 244 operated. One side of this generator is normally grounded through the upper normal contacts *de* of key 240, while the opposite side of the generator is connected over the lower normal contacts *cb* of this key to the conductor 50. Under these conditions the relay 242, connected from the conductor 50 to ground, will respond to current from the hand generator and effect the operation of relay 242, which in turn causes relay 243 to operate; whereby ground potential will be applied over the sleeve of the connection to energize relay 10, while energy from the hand generator over conductor 50 will be effective over the lower armature of relay 10 to supply ringing current to line L.

The operation of the current indicating

system M may be described as follows. Let it now be assumed that, during the period of the connection or while in preparation for a connection, the plug 207 of the cord C1 is connected to the trunk 304 of the radio receiving equipment RR. Insertion of the plug 224 into jack 222 establishes a circuit which may be traced from main conductor 203 over the normal contacts *hg* of key 210, upper main members of the jack 222 and plug 224, the primary winding of transformer 286, thence over the lower members of plug 224 and jack 222 and the lower normal contacts *dc* of key 210 to the opposite main conductor 204. The sleeve members of this jack and plug supply current from a grounded battery through filament 281 of a rectifier tube 280 to ground. The secondary winding of the transformer 286 is divided into two sections, the outer terminals of which are respectively connected to plate elements 282 and 283 of the tube, while a common midpoint of the secondary winding is connected through a counter potential cell 284 and a direct current meter 285, to one side of the filament circuit. Opposite half-waves of the incoming signal or voice currents will be respectively rectified in this tube to set up uni-directional currents through the meter 285. The purpose of the battery 284 is to neutralize residual current effects commonly referred to as "Edison effect" currents, and retain the needle of the instrument 285 normally at zero or at any other predetermined point or position on its associated scale. Therefore, with this stabilizing arrangement any response of the needle will be due only to such alternating currents as may arrive from the connected circuit. By transferring the plug 224 to the jack 223 similar readings of voice or other signaling currents may be made relative to the opposite side of the four-wire circuits. The current measuring system M is described more in detail in my Patent No. 1,404,311 dated January 24, 1922.

During the period of a connection, the operator may monitor by operating the monitoring key formed of units 225—226. A circuit for this purpose may be traced from the main conductor 203, upper normal contacts *hg* of key 210, upper forward contacts *fe* of key 225, upper normal contacts *gh* of key 230, conductor 236, normal upper contacts *fe* of key 20, winding 48 of transformer 33, lower normal contacts *dc* of key 20, conductor 237, lower normal contacts *ef* of key 230, lower normal contacts *de* of key 220, lower normal contacts *cb* of key 230, conductor 52, lower normal contacts of relay 53, winding 54 of transformer 33, upper normal contacts of relay 53, conductor 55, upper normal contacts *hj* of key 230, lower forward contacts *dc* of key 225, lower normal contacts *dc* of key 210 to the opposite

main conductor 204 of the cord circuit. The lower forward contacts of key 225 connect the winding 56 of the transformer 33, in parallel with the winding 34 as already traced. The latter winding is connected to the telephone receiver 23 of the operator's telephone set which will now be in a position to monitor on the upper side of the four-wire cord circuit, which may be assumed as connected to the trunk circuit 304 for the reception of voice currents transmitted from the radio equipment to the line L. When desired, receiver 40 may be employed for monitoring operations over the circuits already traced through amplifier 42 to the output windings 34 and 56 of the transformer 33.

During the monitoring period the transmitter of the operator's set will be rendered inoperative. For this purpose a circuit may be traced from ground through the upper forward contacts *ef* of the key 226 to grounded battery through the winding of relay 49. In responding, this relay opens the circuit of the secondary winding of the induction coil 29 of the operator's transmitter.

For monitoring on the opposite side of the four-wire cord circuit, the key units 225—226 are continued in the operated or monitoring position, while key units 230—231 are also operated. The circuit may now be traced from the main conductor 205 through the upper normal contacts *ef* of relay 211, the forward upper contacts *dc* of key 226, the upper alternate contacts *ih* of key 230, conductor 236, normal contacts *fe* of key 20, winding 48 of transformer 33, lower normal contacts *dc* of key 20, conductor 237, lower alternate contacts *ed* of key 230, lower normal contacts *ef* of key 221, lower alternate contacts *ab* of key 230, conductor 52, lower normal contacts of relay 53, winding 54 of transformer 33, upper normal contacts of relay 53, conductor 55, upper alternate contacts *kl* of key 230, lower forward contacts *ba* of key 226, lower normal contacts *ab* of key 211 to the opposite main conductor 206 of the cord circuit. With the circuits connected as described above, the operator's telephone receiver will be coupled by the transformer 33 for monitoring on the opposite, i. e. lower, side of the cord circuit; while the circuit of the operator's transmitter, although associated with the upper side of this cord circuit, will continue to stand open at the separated contacts of relay 49, which continues operated over the circuit already described.

Where repeater equipments are not present intermediate the cord circuit and the line L, transmission currents from the line L, as well as from the radio receiving equipment, will become effective in the operator's receiver when it is connected to the conductors 203 and 204 of the cord circuit for

monitoring purposes. These conductors, while forming the path proper for the currents to the wire side of the connection, may also be common to the voice currents from the line L, the proper or "through" path for which, however, is by way of the lower conductors 205 and 206 of the cord circuit to the radio transmitting equipment. At the hybrid coil the voice currents may divide, a portion flowing into the upper side of the four-wire circuit which includes conductors 203 and 204 of the cord circuit.

In case repeater equipments are present between the cord and the line L, the upper side of the four wire cord circuit will not be common to voice currents incoming from the line L, due to the repeaters being opaque to currents in that direction. Therefore, in order to monitor such currents, it is necessary to operate the reversing key 230—231 to transfer the operator's receiver to the lower side, formed by the conductors 205 and 206 of the cord circuit. In a converse manner, the presence of the repeaters serves to completely isolate these conductors with respect to transmission currents arriving from the radio receiving equipment, which currents in the main may be excluded by a sufficiently accurate condition of balance between the real line L and the artificial line 6.

When the operator's telephone set is in position for talking over the cord circuit C1, key units 220—221 being in their operated positions as already described, it is desirable that currents corresponding with the so-called side tone effects be present in the operator's receiver by currents produced by the operator's transmitter. These effects are produced in the present system by means of transformer 33 as will now be described.

In the talking position of the circuits, winding 34 of the transformer will be connected to receiver 23, while winding 48 will be connected in bridge on the conductors 203 and 204 of the cord circuit. A circuit may now be traced in half tapped relation from grounded battery, through retardation coil 9, condenser 58, upper alternate contacts of relay 53, winding 54 of transformer 33 and the lower alternate contacts of the relay to ground.

During the talking period, relay 53 is energized by current from grounded battery through the winding of this relay over lead 59, upper alternate contacts *ji* of unit 220 to ground through relay 201, as previously traced. Relay 201 is of the marginal type and does not respond at this time.

With the circuits traced above, it will be seen that condenser 58 and winding 54 of transformer 33, form a series path connected in parallel with condenser 60. This condenser is connected in shunt across the primary circuit of the operator's telephone set, and constitutes a path traversed by such

voice currents as may be set up when the transmitter is in use. Therefore, by employing a suitable capacity value for condenser 58, a predetermined amount of the voice currents, to serve as side tone may be set up in transformer 33 and will be supplied to the receiver 23 over the circuits already traced. Side tone effects are recognized requirements for proper transmission, as a speaker may thereby gauge the amplitude or energy of the voice.

On the four-wire circuit, where a relatively perfect balance obtains at the terminating equipment T of the line L with respect to the artificial line 6, no currents from conductors 205 and 206 will reach conductors 203 and 204 of the cord circuit. In like manner, in case plugs 7 and 8 of the cord circuit are employed with the four-wire, circuit formed of lines L1 and L2, voice currents from the operator's transmitter, when connected to conductors 205 and 206, will not reach the upper side of the cord circuit formed by conductors 203 and 204. Therefore, the necessity for providing the side tone feature will be evident.

Cord circuit C (Fig. 1) may also be employed with the toll line L. Plug 72 may be inserted in jack 61 and a connection established by plug 73 either to a trunk circuit 325, a line circuit 326 or a tandem circuit 327. The cord circuit C which is of the two-wire type may also be employed in establishing the connections between the circuits 325 and 327 or between other two-wire circuits not shown but present in the system.

In describing the two-wire circuits, it will be understood, as already mentioned, that the cord circuit equipment C3 (Fig. 3) may be a duplicate of the cord circuit C. Assuming that a call has originated over the trunk circuit 325 by the insertion of plug 73 of the cord circuit C into jack 330 of trunk 325, a circuit may be traced from grounded battery, lower right hand winding of repeating coil 62, lower normal contacts *ab* of ringing key 63, center or ring members of plug 73 and jack 330, relay 331 and thence to ground through the upper normal contacts of jack 332 at the opposite end of the trunk circuit.

The response of relay 331 completes a circuit from grounded battery over resistance 333, signal 334, contacts of relay 331 to ground through the lower normal contacts of jack 332. Plug 73 in jack 330 effects separation of the normal contacts of the jack and by closure of the lower contacts, current from grounded battery traverses a resistance 339, signal 338 and thence over the local or sleeve members of jack 330 and plug 73 to ground. At this time signal 338 serves as a guard or supervisory signal.

In response to this call, a plug 335 of the cord circuit C3 may be inserted into

jack 332. This effects separation of the normal contacts of jack 332 and closure of the lower alternate contacts, thereby connecting a resistance unit 336 in parallel with and shunting signal 334. Ground over the sleeve members of the jack 332 and plug 335 being provided by the cord circuit, in substitution of the ground at the lower normal contacts of jack 332.

Since the cord circuit C3 is a duplicate of the cord circuit C, current will be supplied from grounded battery of cord C—3 over the center or ring conductors of the plug 335 and jack 332 to the winding of relay 337, the upper or tip members of jack 330 and plug 73 through the upper right-hand winding of repeating coil 62 to ground. The corresponding grounded battery, present in the cord C, will cause current to traverse relay 331 to ground through the repeating coil of the cord C3 to maintain relay 331 energized. Resistance 340 will now be connected by the forward contacts of jack 330 and contacts of relay 337 to ground over the sleeve members of the connection to the cord C, thereby extinguishing signal 338.

In establishing the operator's telephone set with the two-wire cord circuit C, key 65 will be operated. The upper contacts *ef* of this key provide a ground connection for the circuit through relay 28 to grounded battery, thereby effecting response of the relay 28. A circuit is established which may be traced as follows from the upper main conductor 66 of the cord C by way of the second upper forward contacts *cd* of key 65, left hand winding of repeating coil 68, condenser 69 and lower forward contacts *ab* of key 65 to the opposite conductor 67 of the cord.

When the relay 28 operates, a circuit is established which may be traced as follows. From ground over the primary winding of repeating coil 68, lower alternate contacts of relay 28, transmitter 31 and retardation coil 9 to grounded battery, while another circuit extends in half tap relation from the upper terminal of the secondary winding of induction coil 68 by way of the upper alternate contacts of relay 28, receiver 23 and next upper alternate contacts of relay 28 to an intermediate half tap point on the secondary winding of induction coil 68. The separated contacts of relay 28 disconnect the transformer 33 and also induction coil 29 employed for four-wire working, as already described. For the circuits just traced, the forward contacts of relay 28 connect transmitter 22 and receiver 23 to operate by way of induction coil 68 in two-wire relation to the circuits of the cord circuit C.

The signal at either end of the trunk circuit 325 may be flashed by the removal and

re-insertion of the plug at the opposite end of the trunk, while removal of a plug will cause the signals at each end of the circuit to be energized. To render this clear, removal of plug 73 from the jack 330 effects the release of relay 331, thereby disconnecting the shunting resistance 336 to permit the illumination of signal 334 by current from grounded battery through resistance 333, signal 334, sleeve members of jack 332 and plug 335 to ground on the cord circuit C3. In case the plug 73 is now re-inserted in jack 330, re-operation of relay 331 will re-apply resistance unit 336 in parallel with the circuit just traced for the signal 334, thereby causing this signal to be extinguished.

From the description just given, it will be apparent that a single relay having a single forward contact, as the relay 331, in association with jack 332 and cord circuit C—3 will serve either as a line or supervisory signal control relay in the handling of telephone traffic over the trunk circuit 325. In a reciprocal manner, a corresponding relay 337 may serve as a line or supervisory signal control relay for calls originating at jack 330.

Assume now that a call has originated at a station such as 378, on tandem circuit 327. In initiating the call, removal of the receiver from its switchhook at station 378 completes a circuit which may be traced from grounded battery 725 over resistance unit 379, first lower normal contacts of jack 380, relay 381, first lower normal contacts of jack 382, thence through the instrument at station 378, through relay 383, upper normal contacts of jack 382, marginal relay 384, upper normal contacts of jack 380 and resistance unit 385 to ground. Due to the presence of resistances 379 and 385 in the circuit just traced, the marginal relay 384 will not respond. However, relays 381 and 383 will respond to complete circuits similar to those described for trunk circuit 325, whereby signals 386 and 387 will be energized.

This call may be answered either at the switchboard of the radio transmitting equipment or at the switchboard which is associated with the radio receiving equipment.

Assuming that the call is answered at the transmitting station, plug 73 of cord circuit C will be inserted into jack 380. The lower group of contacts of jack 380 effect disconnection of grounded battery through the winding of relay 201 (Fig. 2) and establish a shunt on signal 386 as already described for the call over trunk circuit 325. Separation of the first lower normal contacts of jack 380 opens the circuit over which current is supplied through resistance units 379 and 385, current and ground being now substituted by way of repeating coil 62 of

the cord circuit to the main conductors of the tandem trunk 327.

The direct current resistance of the windings of repeating coil 62 is relatively low compared with resistances 379 and 385. Hence, under an increased flow of current from the cord circuit C through the distant station 378, the marginal relay 384 will respond. The contacts of this relay establish a shunt path around relay 383 which will now release and disconnect signal 387. When the receiver is restored to its switchhook at station 378, cessation of current through the main conductors of the line will effect release of relays 384 and 381. Release of relay 381 removes the shunt path around signal 386 and connects grounded battery therethrough to the sleeve conductor of plug 23, to effect display of the signal which at this time is a disconnect indication.

Assuming now that the call received from station 378 is to be answered at the switchboard of the radio receiving station, lamps 386 and 387 will be lighted, as explained above and the call will be answered by inserting plug 335 of the cord circuit C3 into jack 382. The upper and first upper normal contacts of this jack now disconnect the circuit from the distant jack 380, thereby effecting the release of relay 381 to extinguish signal 386 at the latter point, while battery over the ring conductor of the cord circuit C3 will traverse the circuit through the instrument at station 378, returning through relay 383 over the tip members of the connection to ground on the repeating coil of cord C3. Circuit changes, due to the presence of plug 335 in jack 382 and the operated position of relay 383, serve to shunt the lamp 387. On disconnection at station 378, relay 383 will be released, thereby effecting removal of the shunt path and permitting signal 387 to be displayed.

Let it now be assumed that an operator at OT (Fig. 1) desires to call station 388 of line 326. Plug 73 will be inserted into jack 389 thereby disconnecting ground and battery from the main conductors of this line due to separation of the normal contacts of the jack. A signal 390 will be lighted at this time by current from the grounded battery through the associated resistance unit, signal 390 and sleeve members of the plug and jack to ground on the cord circuit C. Operation of ringing key 63 and hand generator 244, serve to apply ringing current over conductor 50, lower alternate contacts of key 63, ring members of the connection, thence over line 326 through the instrument which may be similar to the instrument shown at station 378, thence returning over the tip side of this connection to ground through the upper alternate contacts of key 63. Upon response

at station 388, flow of direct current through the repeating coil of the cord circuit will effect the response of relay 391 to effect shunting of signal 390. Under flashing or disconnect operations as station 388, relay 391 will be alternately energized and de-energized to respectively display or extinguish the signal 390 in a manner similar to that already described for flashing and disconnect operations in the trunk circuit 385.

When desired, the jack 61 of the line L may be employed for so-called patching of this line to come primarily under the control of the switching equipment at the distant radio station, or this line may be patched directly to the circuits 325—327 for service therewith. A patching cord, not shown, but well known in the art, may be associated with jack 61 of the toll line and with jack 315 of the trunk circuit 318. In turn, a second patching cord may be associated from jack 317 to the jack adjacent the plug 321 thereby providing that the line L may terminate at the duplicate equipment T—1 at the radio receiving station. This prepares circuits so that the four-wire cord circuit C—2 may be employed for establishing connections between the land line L and the radio transmitting and receiving equipment in the manner already described for connections established at the other switchboard. Similar combinations relative to parallel, series or tandem or combinations of parallel and series connections may be carried out relative to the two switchboards in a similar but inverse manner to the arrangements already described.

In connection with the radio transmitting system, a coil 392 may be positioned adjacent the electromagnetic equipment of the transmitting circuits, or of an inductive turn, as shown in the antenna lead. As shown, the coil 392 may connect to suitable amplifier-rectifier equipment 393 for causing the relay 394 to respond during the periods that energy is supplied to the antenna. This results in the application of current from grounded battery over an obvious circuit through relays 395 and 396 to energize the respective signals 397 and 398 at the two switching points. The display of these signals indicates to operators at the respective stations that the radio transmitting system is energized for use.

A call signal, incoming over the radio side, may comprise two alternating currents of different frequencies as modulations of the carrier wave. Upon detection of the incoming wave by the radio receiving equipment, an impulse of current comprising the two different frequency currents will become effective to cause two correspondingly tuned relays 399 and 399—A to respond.

Simultaneous separation of the normally closed contacts of these relays releases relay 701 which is normally energized over an obvious circuit. Relay 701 in releasing applies current from grounded battery through relay 702, relay 703, normal contacts of jack 310, relay 704 to ground through the normal contacts of jack 303. Response of relays 703 and 704 apply grounded battery through obvious paths to respectively energize signals 705 and 706.

The call may be answered at either switching equipment and, assuming that response is made at the first switchboard, insertion of plug 207 of the cord C—1 into the jack 303 effects the separation of the normal contacts of this jack to disconnect the circuit through relays 702, 703 and 704. However, these relays were held energized, following the response of the relay 702, by current from a grounded battery connected over the alternate contacts of the relay 702. This battery having been thereby substituted for the battery initially connected over the contacts of relay 701. When the plug 207 is fully seated in jack 303, a circuit will be prepared from ground through relay 201, upper normal contacts of key 220, upper sleeve members of plug 207 and jack 303, thence over the now closed alternating contacts of jack 303 to the circuit already traced through relays 704, 703 and 702. Therefore, during the period of a connection, a subsequent call signal will effect the response of the relays 399 and 399—A to cause the re-operation of the relays 702, 703 and 704 to display signals 705 and 706 as already described.

In responding to such a signal, operation of the talking key formed of units 220—221 disconnects the circuit to ground through relay 201 at the upper normal contacts of the key 220, effecting release of relays 702, 703 and 704 thereby restoring the signals 705 and 706 to normal, or non-operated position.

For call signaling over the radio link, the plug 208 is inserted in jack 305, key 215—216 of cord circuit C—1 is now operated, followed by the operation of a master signaling key 245. Current from sources 246 and 247 will flow over the main conductors of the plug 208, jack 305, to the radio transmitting equipments TR and a carrier wave modulated by the current from the sources 246 and 247 will be supplied to and radiated from the antenna 302.

At a distant point, such as at a station equipped as shown in Fig. 4, the called signal modulated wave will be received by an antenna 400, detected by the receiving equipment 401, and the detected currents will be supplied to the two correspondingly tuned alternating current relays 402 and 403. Simultaneous operation of these relays opens

the connection to ground of a circuit including the relay 404 which is normally energized over an obvious circuit. On release, the latter relay connects grounded battery to a circuit through relay 405, resistance 406 and the normal contacts of jack 408 to ground. When the relay 405 responds, its contacts connect a second grounded battery, in substitution of the first mentioned battery, over the contacts of relay 404 to retain relay 405 energized and also to supply current through signal 407 and the normal contacts of the jack 408 to ground.

For telegraph operation, key 271 of the equipment S-1 (Fig. 2) may be momentarily operated, thereby applying current from grounded battery through relays 235 and 232 to ground. In responding, separation of the upper contacts of relay 235 disconnects a normally closed path in shunt to the output winding of transformer 248. On closure of the lower contacts of relay 235, grounded battery is applied through normal contacts of key 249, signal 250 and relays 235 and 232 to retain these relays energized. The contacts of relay 232 connect the secondary winding of the transformer 251 to energize the cathode or filament 252 of a three-element vacuum tube 253, the primary winding of this transformer being energized from a source 254. From an intermediate half-tap point connecting units 255 and 256 connected in series to form a bridge across the filament 252, a circuit may be traced through "B" battery 257, retardation coil 258, the primary winding of an output transformer 259 to the plate element 260 of the tube 253. The condensers shown connected from the retardation coil to points of the plate circuit serve to establish a condition of resonance relative to a certain frequency, which in the present case may be assumed as one thousand cycles per second.

Upon closure of key 261, grounded battery is connected through relay 263, retardation coil 262, key 261 to ground. The response of relay 263 closes a circuit which may be traced from the filament 252 by way of resistances 255 and 256, through the secondary winding of transformer 259 and contacts of relay 263 to the grid element 264 of tube 253. The latter circuit forms a so-called "feed back" to produce and maintain the production of oscillations in the tube circuit. These oscillations are supplied to transformer 248 by way of an intermediate transformer 265.

Assuming now that the plug 208 is present in jack 305 with the talking key units 220-221 in their operated positions, alternating current of one thousand cycles per second will be supplied from ground through the right hand winding of transformer 248, conductor 30, the primary wind-

ing of repeating coil 29, lower normal contacts of relay 28, thence through transmitter 31 to ground through the condenser 60. As already described, the operated position of key 221 connects the secondary winding of induction coil 29 and with conductors 205 and 206. It therefore follows that each closure of the telegraph key 261 will result in an impulse of alternating current, which traverses the connection over the plug 208 and jack 305, to the radio transmitting equipment RT from which it will be supplied as a modulation of the carrier wave to the antenna 302. The right hand winding of transformer 248 is of low ohmic or direct current resistance, therefore, it is substantially immaterial whether this winding is in series with the battery supply of transmitter 31, as already traced through the winding of induction coil 29. Accordingly, during the periods when relays 235 and 232 are energized as indicated by the display of signal 250, the operator may either talk or telegraph over the radio transmitter; i. e., during periods when the telegraph key 261 is at rest the transmitter 31 may be employed for talking, while upon cessation of talking the key 261 may be operated for telegraphing.

Similar equipment at a distant radio station may be operated for telegraph signaling, the signals being received by way of the antenna 301 and radio receiving equipment RR. After detection in the receiver RR the signal impulses will be transmitted by way of jack 303 and plug 207 to the conductors 203 and 204 of the cord circuit C-1, through the key 220 which connects the receiver 23 for reception of such incoming telegraphic signals, without other manipulation on the part of the operator. A key 76 may be operated if desired to apply ground to the transmitter circuit and thereby shunt the transmitter 31 for the alternating telegraph signal currents. This key may also be employed as a transmitter cut-out key at any time in the handling of telephone traffic.

The system of direct current telegraph, employed with the present system, will now be described. A pole changer or telegraph key 707, line relay 708, and a vibrator sounder 709, controlled by the line relay and energized from an alternating current source 710 by way of a transformer 711, may form one station on a line conductor 712, while a similar key 266, line relay 267 and sounder 268 may be present at a second station on the line 712. Operation of the key 707 applies grounded battery over the line 712 to ground through the normal contacts of key 266 to cause the line relays 708 and 267 to respond to respectively operate the sounders 709 and 268 when signals are transmitted from the right hand to the left hand

station. In a reciprocal manner, operation of the key 266 serves to transmit signals from the left hand to the right hand station. The sounder 268 is supplied with energy from the alternating current source 275 by way of a transformer 276, which also supplies energy for the sounder 277.

When desired the Morse line 712 may be connected to control the system for transmitting telegraph signals over the radio channel. This may be effected by operation of key 269. Assuming the latter key is in its operated position and sending under way from key 707, each closure of the contacts of the line relay 267 establishes a circuit from ground by way of key 269, retardation coil 262 and the winding of relay 263 to grounded battery, causing the latter relay to respond and control the feed-back circuit of the oscillator 253 in the same manner as that already described for controlling it from the telegraph key 261. Further, assuming that plug 208 is present in jack 305, direct current signals from the Morse line 712 will be translated into alternating current impulses at 1000 cycles per second which will be supplied by way of the transformer 248, induction coil 29, talking key 221 and the connection previously described to the radio transmitting apparatus and antenna 302.

The arrangement whereby busy test operations may be carried out by means of the cord circuit C may be described by assuming that the talking key 65 of this cord is in its operated position. Relay 28 will now operate due to grounded battery through the relay to ground through the upper forward contacts of the key 65 as already described in transferring the operator's receiver 23 and transmitter 31, respectively, from the transformer 33 and induction coil 29, to control through the induction coil 68.

Assume now that the upper or tip member of plug 72 is applied to the sleeve of the jack 330 in performing a busy test operation. Current from grounded battery, through the resistance 339 and signal 338 to the shell or sleeve member of the jack 330, will traverse the tip strand of the cord circuit as connected by way of the upper normal contacts of the ringing key 71 to ground through the upper left hand winding of repeating coil 62. This current effects a change of potential level between the main conductors 66 and 67 of the cord circuit, which becomes effective through the condenser 69 and the secondary winding of the repeating coil 68 to cause a click in the telephone receiver 23. In the present instance this click may be taken as an indication that the line 325 is idle.

In the event that a cord, similar to the cord circuit C, is connected to a jack associated with the jack 330 on the line 325,

ground potential from the sleeve conductor of such cord circuit to the shell of the jack, will prevent flow of current from grounded battery, as described when the tip of the plug 72 is inserted into jack 330. In such a case, absence of a click in the telephone receiver is an indication that the line 325 is busy.

Where it may be desirable, the order of the busy test indications may be reversed, that is, for an idle condition of a circuit no click will be present, while for a busy line, a click will be heard in the operator's telephone receiver when the tip of a plug is touched to the shell of a jack on a line or trunk which is busy. This may be done by reversing battery and ground for the sleeve or local circuit of a cord and jack. For example, on the trunk 325 the resistance 339 may be connected to ground instead of to a battery, while the sleeve strand of the cord C may be connected to battery instead of to ground. Again the winding of the auxiliary signal relay 201 may be connected to battery instead of being grounded, as shown.

The equipment for a ship or similar station (Fig. 4) may comprise an antenna connected to a receiving equipment 401 and also to a transmitting equipment 411. In establishing connection of a telephone set to the radio transmitting and receiving apparatuses a cord 412 is used to connect jacks 413 and 414, and similarly a cord 415 is used to connect conductors 408 and 416. Over the main jacks of the respective cords and the main contacts of the jacks, with which they are associated, the output and input windings of transformers 417 and 418 will be respectively connected to the radio transmitting and radio receiving equipments. To connect an operator's telephone equipment OT2, comprising a transmitter 419 and receiver 420, with the radio equipment a talking key, formed of units 421 and 422, is operated.

For the transmitter a circuit may now be traced from the upper terminal of the right hand or primary winding of the transformer 417, lower normal contacts *bc* of a key 423, upper normal contacts *gh* of this key, lower normal contacts *bd* of key 424, conductor 466, upper normal contacts *gh* of key 425, lower forward contacts *ab* of the key 421, the secondary winding of induction coil 426, upper forward contacts *ef* of key 421, upper normal contacts *kj* of the key 425, conductor 465, upper normal contacts *eg* of the key 424, the upper normal contacts *lj* of the key 423, the lower normal contacts *fe* of this key to the lower terminal of the primary winding of transformer 417.

For the receiver a circuit may be traced from the upper terminal of the secondary winding of the transformer 418 over the upper normal contacts *hg* of key 427, lower

normal contacts *cb* of this key, upper normal contacts *fe* of key 428, lower normal contacts *fe* of key 425, upper forward contacts *ed* of key 422, winding 429 of transformer 430, lower forward contacts *ba* of key 422, lower normal contacts *bc* of key 425, lower normal contacts *dc* of key 428, lower normal contacts *ef* of key 427, the upper normal contacts *jk* of this key to the lower terminal of the secondary winding of the transformer 418.

Voice currents from the transmitter 419 will be supplied through the repeating coil 426, over the circuits traced above, to the radio transmitting equipment 411 and voice modulated carrier waves will be supplied to the antenna 400. Voice or signaling modulated carrier waves incident upon the antenna 400 will be supplied to and translated in the radio receiving equipment 401 to produce voice or signal currents which will be supplied over the circuits traced above, including the transformer 430, to the receiver 420.

Communication, by means of the ship equipment described above, may be effected with another ship having a similar equipment, or communication with a land station similar to the station shown on Fig. 3, or with stations including equipment similar to that shown in Fig. 5, to be hereinafter described.

A connection for a communication over the radio channel may be made to different telephone stations aboard ship. To illustrate how this may be done, an extension of the connection to station TS will be traced. A key formed of groups 410 and 431 when operated complete a circuit which may be traced as follows. From the upper terminal of the secondary winding of induction coil 432 at the station TS over the upper forward contacts *ed* of key 410, upper normal contacts of key 433, upper normal contacts *eg* of the key 424, thence over the circuit already traced through the contacts *kj* and *fe* of key 423 to the lower terminal of the primary winding of the transformer 417. The connection from the lower terminal of the secondary winding of the induction coil 432 extends over the lower forward contacts *ba* of key 410, lower normal contacts of key 433, lower normal contacts *db* through the key 424 thence to contacts *hg* and *cb* of the key 423 already traced to the upper terminal of the primary winding of the transformer 417.

From the right hand terminal of the telephone receiver 434 a path extends over the upper forward contacts of key 431, upper forward contacts of the key 435, upper normal contacts *ef* of the key 428, thence through contacts *bc* and *gh* of the key 427 already traced to the upper terminal of the secondary winding of the transformer 418.

From the left hand terminal of receiver 434 a path extends over the lower forward contacts of key 431, lower normal contacts of key 435, lower normal contacts *dc* of the key 428 thence through contacts *ef* and *jk* of key 427 to the lower terminal of the secondary winding of the transformer 418. When the receiver 434 is removed from the switchhook at the station TS, the transmitter 436 will be connected to such speech currents to the radio transmitter 411, from which a speech modulated carrier wave is supplied to the antenna 400, the receiver 434 will be connected to receive speech currents to the radio receiver, which is connected to the antenna 400.

When the receiver is replaced on the switchhook at the station TS, during a period of a communication, a circuit will be completed as follows. From grounded battery through a signal device or lamp 437, the upper normal contacts *fe* of key 438, upper alternate contacts *fg* of key 410, normal contacts 439 under control of the switch-hook thence to ground through an audible signal device 440. Signal 437 indicates to the operator that disconnect has taken place at the station TS and therefore, the key 410—431 may be restored to normal.

Assuming that the circuit is in normal condition and a call is initiated at the station TS. Removal of the receiver 434 from the switchhook establishes a circuit from ground through a signal 440, contacts 441 of the switchhook mechanism, the upper normal contacts *ef* of key 410, the upper normal contacts *ef* of key 438, thence through signal 437 to grounded battery. Display of the signal 437 serves as a line signal for this call, while the signal 440 may be continuously energized until response to the call has been made by the operation of key 410—431. When the circuits are in normal condition already traced and receiver 434 is replaced, the path for the lamp 437 will be transferred by the upper contacts of the key 410 for control through the contacts 439 of the switchhook mechanism. This again gives the disconnect signal and key 410—431 is returned to normal position. The equipment at the station TS1 is a duplicate of the equipment at the station TS and is under the control of a key formed of units 442 and 443. The instrument at this station may be connected for service through the radio equipments.

Equipments represented by 444 and 445 may be used to insure secrecy of the communication over radio channels. Assuming that a station equipped as shown in Fig. 4 is in communication with another ship or station similarly equipped, the devices 444 will operate to mutilate in a predetermined manner the voice or signaling currents outgoing over the sending radio channel. At

the distant vessel an equipment, corresponding with that at 445 will operate to restore the signals or speech currents to their normal condition of intelligibility before they are supplied to the receiving devices.

The key formed of units 423—427 is used to connect or disconnect the equipments 444 and 445, for secrecy communications, between the telephone set and the radio terminal apparatus. Assuming now that these keys are in their operated positions, a circuit will be provided from the upper terminal of the secondary winding of the transformer 417 over the lower alternate contacts *ba* of key 423 through the apparatus 444, upper alternate contacts *lk* of key 423, the upper normal contacts *ge* of the key 424, thence to the conductor 465 which may lead to the operator's transmitter 420 or to the transmitter of the stations TS or TS1, over the circuits already traced. The lower terminal of this winding of the transformer 417 is connected through the lower alternate contacts *ed* of key 423, equipment 444, upper alternate contacts *ih* of the key 423, thence through the lower normal contacts *bd* of key 424 to conductor 466 which may be connected to either the transmitter 420 or the station TS, TS1.

For the equipment 445 a path extends from the upper terminal of the secondary winding of transformer 418 over the upper alternate contacts *hi* of key 427, equipment 445, lower alternate contacts *de* of key 427, lower normal contacts *cd* of key 428 to the conductor 460, while the lower terminal of this transformer winding is connected over the upper alternate contacts *kl* of key 427, the equipment 445, lower alternate contacts *ab* of key 427, thence through the upper normal contacts *fe* of key 428 to the opposite conductor 461, whereby either the operator's receiver 420 or the receivers of the stations TS, TS1 may be connected thereto according to the positions in which the various switches already described may have been placed.

A key 447 under control of the operator serves for establishing communication with the station TS2 at which may be located the devices 444, 445 of the secrecy system as well as power and other equipments for the radio system. In initiating a call from the station TS2 removal of the receiver from the switchhook at that point applies ground over contacts of the switchhook mechanism, the normal contacts *de* of key 447, thence through signal 448 to grounded battery. In response to this signal, the key 447 is operated. When this is done the circuit of the signal device 448 will be switched to the now separated contacts 449 of the switchhook mechanism where the circuit will stand open. A circuit may now be traced from the upper terminal of the secondary winding

of the induction coil 426 of the operator's set, resistance unit 450, upper contacts *ih* of key 447, receiver 451 at station TS2, secondary winding of an induction coil 452, the lower group of forward contacts *cb* of key 447, resistance unit 453, the lower terminal of the secondary winding of the coil 426. A second circuit may be traced from the upper terminal of the winding 429 of transformer 430, resistance 454, the lower contacts *bc* of the key 447, thence through the induction coil 452, receiver 451, the upper contacts *gh* of key 447, resistance unit 455, to the lower terminal of the winding 429 of the transformer 430. With the circuits just traced the transmitter 419 and receiver 420 of the operator's equipment will be connected for communication with the equipment at the station TS2. When the receiver is restored to its switchhook at the latter point, ground is applied through the contacts 449 to supply current to the signal lamp 448 which is lighted, thereby indicating a disconnect condition; whereupon the key 447 will be restored to its normal position.

A key 456 at the operator's position and a signal 457 at station TS2 serve as a means for calling from the first to the latter point.

In case it is desired to reverse the relation of the operator's transmitter and receiver with respect to the outgoing and incoming radio channels, a key 425 may be operated. In its operated position and assuming that the key formed of units 421—422 is in its operated position, a circuit for the transmitter may be traced as follows. From the upper terminal of the secondary winding of the induction coil 426, upper forward contacts *ef* of the key 421, upper alternate contacts *kl* of the key 425, upper normal contacts *ef* of the key 428, thence through normal contacts *bc* and *gh* of the key 427 as already traced to the upper terminal of the right hand winding of transformer 418. From the lower terminal of the secondary winding of the coil 426 the connection extends over the lower forward contacts *ba* of the key 421, the upper alternate contacts *hi* of the key 425, lower normal contacts *de* of the key 428, thence through normal contacts *ef* and *jk* of key 427 to the lower terminal of the winding of the transformer 418. From the upper terminal of the winding 429 of the transformer 430, a path extends through the upper forward contacts *ed* of key 422, lower alternate contacts *ed* of key 425, upper normal contacts *eg* of key 424, thence through normal contacts *kj* and *fe* of the key 423 to the lower terminal of the right hand winding of the transformer 417. The lower terminal of the winding 429 of the transformer 430 is connected over the lower forward contacts *ba* of key 422, lower alternate contacts *ba* of key 425, lower normal contacts *db* of key 424, thence through nor-

mal contacts *hg* and *cb* of key 423 to the upper terminal of the winding of the transformer 417. In this position of the circuits it will be clear that the transmitter 419 stands connected to the lower channel through the transformer 418 while the receiver 420 stands connected to the upper channel through the transformer 417.

For monitoring on the connection just described, a key formed of units 458—459 is moved to its operated position. A path from conductor 461 of the speech circuit connected to the incoming radio channel may be traced over the lower normal contacts *fe* of key 425, upper alternate contacts *ed* of key 459, winding 462 of the transformer 430, lower normal contacts of the key 422, winding 429 of the transformer 430, lower forward contacts *ba* of key 459, lower normal contacts *bc* of key 425, to the opposite conductor 460 of the speech circuit associated with the incoming radio channel. The windings 429 and 462 of the transformer 430 are connected in series across the incoming radio channel to form a bridge to which the receiver 420 is coupled for monitoring. The increased impedance due to addition of the winding 462 at this time results in a condition of substantially zero loss as regards the incoming transmission.

When monitoring on the circuit just described the key 458 serves to disconnect a side tone circuit, in a manner to be described hereinafter. Again, operation of the reversing key 425 serves to transfer the circuits of the receiver 420 from the conductors 460 and 461 of the incoming side of the radio channel to conductors 465 and 466 which, as already traced, constitutes part of the speech circuit associated with the outgoing radio channel, thereby permitting the operator to monitor on either the incoming or outgoing channel.

During periods when the operator's telephone set is in the talking position, a side tone circuit from the transmitter 419 to the receiver 420 is provided over a path from the upper terminal of the transmitter 419 by way of a condenser 463, normal contacts of key 458, winding 462 of the transformer 430, upper normal contacts *dc* of the key 459, and resistance unit 464 to the lower terminal of the transmitter. The winding 462 in this instance serves to supply receiver 420 with a predetermined amount of voice current from the transmitter 419. During the monitoring period, as already described the winding 462 is disconnected relative to the side tone circuit and connected with the winding 429 of the transformer to form a high impedance bridge path across a speech circuit of the radio channel.

Call signaling may be effected by operating a key formed of the units 424—428 and a key 467. Operation of these keys completes

a circuit which may now be traced as follows. From the upper terminal of the right hand winding of the transformer 417 through the normal contacts *bc* and *gh* of the key 523, the lower alternate contacts *ba* of the key 424, secondary winding of a transformer 468, left hand contacts of the key 467, the secondary winding of transformer 469, upper alternate contacts *hg* of the key 424, thence through normal contacts *kj* and *fe* of the key 423 to the opposite terminal of the winding of the transformer 417. 470 and 471 represent alternating current sources, which for convenience may be similar to the oscillator system S1 (Fig. 2). The current supplied by sources 470 and 471 will be of respectively different frequencies and on arriving at a distant station, similar to the station shown in Fig. 3 or the station being described and illustrated in Fig. 4, are used to energize two relays, corresponding with either relays 399 and 399a or 402 and 403, to control a signal device as already described in connection with the signal receiving system of Figs. 3 and 4.

When the station TS is connected over four wire circuits to the radio transmitting and receiving equipments, voice currents for side tone effects may traverse a relatively high impedance circuit formed by a condenser 483 and resistance unit 484 connected from the terminals of the transmitter 436 in bridge on the main leads of the receiver 434. A corresponding resistance and condenser serve the same purpose for side tone effects when a four wire is used to connect the station TS1 to the radio apparatuses.

A group connection between stations TS, TS1 and TS2 may be had by operation of the keys formed of units 438, 446, 495 and 496 and also 447. When these keys are operated, the instruments will all be connected common to the conductors 479 and 480 for so-called conference communication. At such times the operators' transmitters 419 and 420 may also be included in such a connection over circuits already traced to conductors 479, 480, 485 and 486.

The radio-wire system shown in Fig. 5 may be used at a station which is adapted for communicating with other land lines for telephony, or may be used for communication by radio with ship stations or other land stations of the type described above. A line circuit L4 is connected through a jack 500, a signaling key 501, one pair of terminals of the series winding of a hybrid coil transformer 502, the other pair of the terminals of the series winding being connected to an artificial line or network 503 which electrically balances the line L—4. The upper output winding of the hybrid coil 502 is connected through a splitting key 504 to conductors 505 and 506. The bridge points of the hybrid coil 502 are connected

to an auto-transformer 507, the output terminals of which are connected through a splitting key 508 to conductors 509, 510.

For an incoming call signal from line L4, alternating current will energize the relay 511 to open the circuit of a normally operated relay 512 which in turn completes an energizing circuit for the relay 513. Upon operating, relay 513 completes a self-locking circuit and also an energizing circuit for the signal lamp 514, the circuit of which extends through upper normal contacts *mn* of a key 515 to ground.

In responding to this call a key formed of units 504—508 and key 515 are operated. From the upper terminal of receiver 516 of an attendant's telephone set, a path extends over the upper normal contacts *gf* of key 517, upper normal contacts *ih* of key 518, lower normal contacts *de* of key 519, winding 521 of transformer 520, upper normal contacts *hi* of key 519, upper normal contacts *ef* of key 518, lower normal contacts *ed* of the key 517, to the lower terminal of the receiver 516. From the upper terminal of winding 522 of the transformer 520 a path may be traced over the upper alternate contacts *jk* of key 515, upper normal contacts *ji* of the key 523, the upper normal contacts *jk* of the key 524, conductor 505, upper normal contacts *de* of key 504 to one terminal of the upper output winding of the coil 502. The opposite terminal of the latter winding is connected through the lower normal contacts *bc* of key 504, conductor 506, upper normal contacts *hg* of key 524, upper normal contacts *gh* of key 523, third upper forward contacts *hg* of key 515 to the lower terminal of winding 522 of the transformer 520.

For the operator's transmitter 525 a circuit may be traced from the upper terminal of the secondary winding of a repeating coil 526, third lower forward contacts *fe* of key 515, second lower normal contacts *fe* of key 523, normal contacts *fe* of key 524, conductor 509, upper normal contacts *de* of key 508, to the right hand terminal of the auto-transformer 507. The left hand terminal of this transformer is connected over the lower normal contacts *bc* of key 508, conductor 510, lower normal contacts *bc* of key 524, lower normal contacts *de* of key 523, lower forward contacts *ed* of key 515 to the lower terminal of the secondary winding of the induction coil 526.

With the circuits traced above, the two-wire line circuit L4 is now transformed through the hybrid coil 507 into a four-wire circuit one side of which is connected with the operator's telephone receiver 516 and the other side to the transmitter 525. Therefore, assuming that a key formed of units 527—528 is in its normal position, this four-wire circuit will also be connected to radio

receiving and transmitting channels 532 and 537.

The connection to the radio receiver may be traced from the conductor 505, upper normal contacts *fg* of key 527, left hand winding of transformer 529, gain control device 530, lower normal contacts *de* of the key 527, to conductor 506. The right hand winding of the transformer 529 is connected to the output circuits of a radio receiving system, shown at 531, and which is connected to the antenna 532.

The radio transmitter is connected over a path which may be traced from conductor 509, upper normal contacts of key 528, lower normal contacts *gh* of key 533, left hand winding of the transformer 534, upper normal contacts *ef* of the key 533, gain control device 535, lower normal contacts of key 528, to the opposite conductor 510. The right hand winding of the transformer 534 is connected to radio transmitting equipment represented by 536 for supplying signal modulated waves to the antenna 537.

Key 523 is provided to connect loss networks 538 and 539, respectively, into the circuit of the operator's receiver 516 and transmitter 525 for the purpose of introducing a predetermined loss into the circuit of the operator's set during the preparation of a radio or wire connection. When the key 523 is operated the impedance elements constituting these networks are connected together to provide units which are of the conventional H type.

The key 524 serves as a reversing key for transposing the relation of the operator's telephone transmitter and receiver with respect to the two sides of the four-wire circuits, the necessity for doing this being similar to that already discussed in connection with the systems shown in Figs. 2 and 4.

The key formed of units 504—508 may be operated for disconnecting the circuits associated with the lines L4 from its circuits of the radio channels, while permitting the latter to be connected to the operator's telephone set. Networks 538 and 539 serve to maintain a normal impedance condition for the circuits of the hybrid coil at this time. In a converse manner, when the key formed of units 527—528 are operated, the radio channels will be disconnected, while the circuits of the line L4 will be available for use with the operator's set.

While the radio channels are disconnected the radio receiving equipment 531 will be connected over the upper and lower alternate contacts *gh* and *ed* of key 527 to the input winding of transformer 540, the output winding of this transformer being connected to a current indicating system which may be similar to the speech level meter shown in Fig. 2. This is to prevent isolation of the radio channels, so that voice, signaling or

telegraphic currents, resulting from a modulated carrier wave received by the antenna 532 which may arrive during the time that the keys 527 and 528 are in operated positions, will actuate the instrument 541 of the receiving system.

In turn, if desired, the secondary winding of the transformer may also be connected in substitution of the network 538, to the upper and lower alternate contacts of the key 504 to connect the detector system M2 to the line L4 during periods that the key 504 is in its operated position.

To transmit call signals outwardly over the line L4, the key 501 is operated to establish a current circuit over obvious paths from the source 542 to the line, while the inner sets of alternate contacts *fe* and *de* of this key connect a network 543 for preserving a balanced relation of the circuits through the hybrid coil 502. This balance insures that currents over the incoming radio channel may not be transferred through the hybrid coil and be transmitted outwardly over the sending radio channel. It may be mentioned that unless this precaution relative to signaling is observed, the incoming radio currents may result in operation of the circuit breakers or otherwise interfere with the apparatus of the radio transmitting system.

For communicating over a second line L5, routed through a jack 544 and a ringing key 555, the key 518 may be operated. From the upper conductor of the line L5 a path extends over the upper normal contacts of the jack 544, upper normal contacts *ed* of key 555, upper forward contacts *gf* of key 518, lower normal contacts *ed* of key 517, operator's receiver 516 upper normal contacts *gf* of key 517, upper alternate contacts *ij* of key 518, secondary winding of induction coil 526, lower forward contacts *de* of key 518, lower normal contacts *cb* of key 555, lower normal contacts of the jack 544 to the lower conductor of the line L5.

With the circuit connections described above, the receiver 516 and transmitter 525 are connected by way of the induction coil 526 on a so-called two-wire basis for service with the line L5. The four-wire equipment which includes the transformer 520 having been disconnected by separation of contacts of the key 518. The key 555 serves to control the supply of current from the source 556 for signaling over the line L5, while signaling current incoming over the line will energize the relay 557 to disconnect a normally energized relay 558, whereby a relay 559 will respond and thereafter be locked-up to energize a signal device 560 over a circuit from ground, the lower normal contacts *ab* of the key 518, the signal device, winding of relay 559 to battery and ground. When the latter key is operated, in responding to

such a call, the ground connection is opened and the relay 559 is deenergized to open the circuit through the signal 560.

For communication over a line L6, extending to a station 561, incoming ringing or signaling current from the latter point will traverse the normal contacts *bc* and *de* of a ringing key 562, and the winding of a relay 563 bridged on this line. Response of the latter relay closes a circuit from grounded battery through relay 564 to ground through the lower normal contacts *ab* of the key 519. When relay 564 responds, it self-locks independently of relay 563 to energize a signal device 565 through the same grounded contacts of key 519.

In responding to this call the operator actuates key 519 to open the ground connection for relay 564 which releases and extinguishes signal 565. Operation of relay 519 completes a talking circuit which may now be traced as follows: From the upper conductor of the line L6 over the normal contacts *ed* of the key 562, upper alternate contacts *ji* of the key 519, the upper normal contacts *ef* of the key 518, the lower normal contacts *ed* of the key 517, the receiver 516, upper normal contacts *gf* of key 517, upper normal contacts *ih* of key 518, lower alternate contacts *de* of key 519, secondary winding of the induction coil 526, upper forward contacts *fg* of key 519, lower normal contacts *cb* of key 562 to the lower conductor of the line L6. This places the transmitter 525 and receiver 516 by way of the induction coil 526 in two-wire relation for talking over circuit L6. To transmit call signals outwardly over the latter line, the key 562 is operated to disconnect the receiving equipment and to connect a source of alternating current 566 to the line.

For telegraphic or similar signaling communication over the outgoing radio channel key 533 is operated. The lower contacts *ab* of this key connect ground to the circuit including the relay 569 and grounded battery. Relay 569 responds to connect an "A" battery to energize the filament 567 of a vacuum tube oscillator 568. A direct current generator 570 is connected from the filament 567 of the oscillator by way of retardation coils 571 and 572 and a winding 574 of a transformer 573 to its plate 575 to supply energizing current to the oscillator. The frequency of the current supplied by the oscillator is determined by a tuned circuit comprising the retardation coils and associated condensers shown.

A telegraph key 576 controls a relay 577 over an obvious circuit. The latter relay serves to connect a winding 578 of the transformer 573 to the grid element 579 of the tube. The circuit, including the winding 578, constitutes a feed back path over which oscillating energy is supplied to the grid.

The output winding 574 of the transformer 573, is coupled to the winding 580 connected to an output transformer 581. Oscillations are supplied to the radio transmitting apparatus 536 through the secondary of transformer 581 over a circuit which may be traced as follows: From the left hand terminal of the secondary winding of the transformer 581, over the third lower forward contacts *de* of the key 533, left hand winding of the transformer 534, upper alternate contacts *hi* of key 533 to right hand terminal of the secondary winding of the transformer 581. With the circuits just traced, closures of the key 576 will cause impulses of current to be supplied through the transformer 534, to the radio transmitter, and signal modulated waves will be supplied to and radiated from the sending antenna 537.

A tone circuit for producing an audible signal in the receiver 516 during such telegraphic sending may be traced from the left hand terminal of the output winding of transformer 581, resistance 582, the winding 583 of the transformer 520, thence over a path from an intermediate point on the winding 583 through a resistance unit 584 to the opposite terminal of the winding of the transformer 581. Since, over the circuits already traced, the receiver 516 is normally connected through the winding 521 of the transformer 520, the alternating current impulses supplied to the radio transmitter will also be supplied to this receiver to produce a monitoring or side tone effect for the transmitted telegraphic signaling currents.

To transmit call signals outwardly over the radio channel, key 585 is operated. The lower contacts *ab* of this key grounds one terminal of the winding of relay 577 the other terminal of which is connected to grounded battery, and also grounds one terminal of the winding of relay 569 the other terminal of which is connected to grounded battery. Response of the latter relay closes the filament circuit of the oscillator tube 568 while operation of the relay 577 closes the feed back or control circuit to the grid 579 of the tube 568. A second oscillator system 586, similar to the one comprising the tube 568, is provided. This oscillator is controlled through the upper contacts *fg* of key 585 to energize relays, corresponding with the relays 577 and 569, whereby this second system is caused to generate oscillations of a frequency different from 568. An output transformer 587, due to closure of the upper forward contacts *ed* of the key 585, is connected across the leads extending from the secondary winding of the output transformer 581 of the first oscillator, as previously traced. Thus the two currents, which are of different frequencies, traverse the circuit connected to the radio transmitter to modulate the outgoing carrier wave and,

after detection at the distant station, become effective to operate relays corresponding with relays 399, 399—A, or relays 402 and 403, of the systems, respectively shown in Figs. 3 or 4, to actuate associated signal devices.

As already described, conductor 505 is extended to a conductor 589, the conductor 506 is extended to a conductor 590, conductor 509, is extended to conductor 591, and conductor 510 is extended to conductor 592. To monitor on the connection of the type described above, the key 588 is operated to provide a circuit which may be traced as follows: From conductor 589 over the upper forward contacts *fe* of the key 588, winding 583 of the transformer 520, upper normal contacts *ij* of key 515, winding 522 of the transformer 520, upper forward contacts *cd* of key 588 to conductor 590. The lower forward contacts *ab* of the key 588 connect the lower terminals of the windings 521 and 593 of the transformer 520, together. The receiver 516 is normally connected across on the winding 521, over the circuits already traced. Therefore, during a monitoring period the windings 521 and 593, which serve as secondary windings for the windings 522 and 583, are connected in series with each other across the main conductors 505 and 506. The secondary winding of the induction coil 526 for the transmitter 525 will be disconnected at contacts of the keys 515, 519, 517 and 518, therefore the transmitter will be ineffective at this time.

Operation of the reversing key 524 will transfer circuits for the receiver 516 from the conductors 505 and 506 to conductors 509 and 510 of the outward or opposite side of the connection for the purpose of monitoring thereon.

A cord circuit C4 is adapted for either communication or for testing the circuits of the present system. Plug 594 may be inserted in jack 500 of the line L4, jack 544 of the line L5, or jack 595 of the line L6. A key 596 serves for applying signaling current from a source associated with this cord, while keys 597 and 598 serve to disconnect one conductor of a connection while grounding the opposite conductors, as may be desired in testing with a distant point or station. For talking outwardly over this cord circuit, key 517 is operated to complete a circuit which may be traced as follows. From the upper conductor of the plug 594 over the upper normal contacts *ed* of keys 598, 597 and 596, lower forward contacts *ab* of key 517, the secondary winding of the induction coil 526, the upper forward contacts *hg* of key 517, receiver 516, next lower forward contacts *de* of key 517, thence through the lower normal contacts *cb* of key 596, lower contacts of 597 and lower

normal contacts *cb* of 598 to the lower or ring conductor of the plug 594.

What is claimed is:

1. In a signaling system, radio transmitting and receiving stations, signal responsive means at the receiving station, a circuit including a pair of relays, one at each of said stations operated upon the actuation of said signal responsive means, a visual signal at each station actuated by the operation of its corresponding relay, means actuated upon answering a call at either station to deenergize both relays, a circuit for the relay at the station where the call is answered prepared upon the answering of the call, and means for closing said circuit upon disconnection to actuate said visual signal as a clearing-out signal.

2. In a signaling system, radio transmitting and receiving stations, a subscriber's line, at each station a switchboard wherein said line terminates, a lamp at each switchboard for said line lighted by the initiation of a call in said line, means actuated by the answering of the call at either of said boards for extinguishing both lamps and preparing a circuit at the board where the call is answered to light a corresponding lamp as a disconnect signal.

3. In a signaling system, radio transmitting and receiving stations, a subscriber's line, at each station a switchboard at which said line terminates, a relay for said line at each of said switchboards, a lamp controlled by each relay, means actuated by the answering of the call at one board for releasing both relays and preparing a circuit for the relay at the switchboard where the call is answered, and means actuated when the subscriber disconnects for closing said prepared circuit to operate said relay to light said lamp as a disconnect signal.

4. In a signaling system, radio transmitting and receiving stations, a subscriber's line, at each station a switchboard at which said line terminates, a lamp at each switchboard for said line lighted by the initiation of a call in said line, means actuated by the answering of the call at either of said boards for extinguishing both lamps, and preparing a circuit at the switchboard where the call is answered to light a corresponding lamp as a disconnect signal, a talking key, means controlled by said talking key actuated by the operator in response to said disconnect signal for extinguishing said disconnect signal.

5. In a communication system, radio transmitting and receiving stations, telephone lines, a central office at which said lines may be connected to said stations, two-wire and four-wire cord circuits at said station, equipment common to both types of cord circuits, and means for automatically conditioning said common equipment to op-

erate with either type of cord circuit upon such cord circuit being taken for use.

6. In a communication system, radio transmitting and receiving stations, telephone lines, a central office at which said lines may be connected to said stations, two-wire and four-wire cord circuits at said station, an induction coil common to said cord circuits, and means automatically actuated in taking either type of cord circuit for use, for adapting said induction coil to operate with such cord circuit.

7. In a communication system, radio transmitting and receiving stations, telephone lines, a central office, a cord circuit for connecting said telephone lines to said stations, an induction coil in said cord circuit, monitoring and talking keys for said cord circuits, means actuated upon the operation of said talking key for including a winding of said induction coil in the circuit, and means actuated upon the operation of the monitoring key for including high impedance windings of said coil in the circuit.

8. In a communication system, radio transmitting and receiving stations, telephone lines, a central office, a cord circuit for connecting said lines to said stations, a monitoring set including an induction coil, a high impedance primary winding, means for connecting said high impedance winding to said cord circuit, and means associated with the secondary winding for amplifying the current in a receiver of said set associated with said amplifying means.

9. In a communication system, radio transmitting and receiving stations, line circuits adapted for connection to said stations, cord circuits, an operator's telephone equipment, keys for connecting said equipment to the cords, a generator common to said cords, a relay in the line circuit and a common relay associated with the generator, an energizing circuit whereby said common relay may be closed upon the operation of said generator, a circuit whereby said relay in the line may be closed on the conjoint operation of said generator and said key, said relay thereupon connecting said generator to the line.

10. In a communication system, radio transmitting and receiving stations, line circuits adapted for connection to said stations, cord circuits, an operator's telephone equipment, keys for connecting said equipment to the cords, a generator common to the cords, a relay in the line circuit and a common relay associated with the generator, an energizing circuit whereby said common relay may be closed upon the operation of said source, a circuit whereby said relay in the line may be closed on the conjoint operation of said generator and said key, said relay thereupon connecting said generator to the

line, said circuit from said generator to the line being independent of the cord circuit.

11. In a communication system, radio transmitting and receiving stations, line circuits adapted for connection to said stations, cord circuits, an operator's telephone equipment, a talking key for each cord circuit for connecting said operator's equipment to the corresponding cord, a constant source of signaling current common to said cord circuits, a relay in each line circuit, a relay associated with said source and common to said cord circuits, a key for energizing the relay associated with said source, and a circuit for the relay of the line taken for use closed by the conjoint operation of the relay associated with the source and the talking key of the cord circuit taken for use.

12. In a communication system, radio transmitting and receiving stations, line circuits adapted for connection to said stations, a terminating equipment for each line opaque to low frequency currents, cord circuits, signaling apparatus associated therewith, and means for connecting the same to a line circuit over a path independent of the cord circuit used and at a point beyond the terminating equipment.

13. A radio signaling system including a four-wire communicating circuit, cord circuits, a receiver and a transmitter, means for including said instruments in the respective sides of the four-wire cord circuits, means for directing a portion of the energy from the transmitter to the receiver without establishing a path whereby an appreciable amount of energy is transferred between the two sides of the four-wire circuits.

14. In a signaling system, a radio transmitting station, telephone lines, cord circuits for connecting said telephone lines with the sending equipment of said radio transmitting station, at least one of the strands of said cord circuits being provided with a substantially zero resistance ground to the high frequency currents of the radio transmitting equipment.

15. In a signaling system, a radio transmitting station, a radio receiving station, a source of low frequency oscillations at one of said stations, a relay thereat, a direct current circuit including said relay and leading to the other of said stations, a key at said second station for controlling said relay, a source of high frequency oscillations adapted to be modulated by said low frequency oscillations, and a key at said first station for also controlling said relay.

16. In a communication system, an incoming and an outgoing radio circuit each involving two wires, a pair of substations, means for interconnecting said stations over a circuit including one of said pairs of wires composing one side of the radio circuit.

17. In a signaling system, a radio trans-

mitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting station or radio receiving station to make connections between outlying radio stations and said wire connected subscribers' stations, a second means under the control of said operator to permit said operator to transmit signals to either the outlying radio stations or the wire stations with the same strength as the signals from the radio station to the wire station or vice versa.

18. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting station or the radio receiving station to make connections between distant radio stations and said wire connected subscribers' stations, a key under the control of said operator arranged to insert resistance in the circuit of the operator's transmitter and receiver to give the same effect to the operator's signals as if said operator were at either the distant radio station or at the wire connected subscriber's station.

19. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting station or the radio receiving station to make connections between distant radio stations and said wire connected subscribers' stations, code signal sending apparatus, means to produce in said operator's receiver audible sounds corresponding to the transmitted code signals.

20. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting station or the radio receiving station to make connections between distant radio stations and said wire connected subscribers' stations, code signal sending apparatus, a low frequency oscillator controlled by said code signal to effect modulation of the carrier wave and connected through the transmitting operator's set to produce in said operator's receiver audible sounds corresponding to the transmitted code signals.

21. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting

station or the radio receiving station to make connections between distant radio stations and said wire connected subscribers' stations, an operator's telephone set, code signal sending apparatus connected in circuit with the transmitter of said set, and means to permit said operator to talk or transmit radio code signals over the outgoing radio equipment without changing the transmitting circuit.

22. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means to enable an operator at either the radio transmitting station or the radio receiving station to make connections between distant radio stations and said wire connected subscribers' stations, an operator's telephone set, code signal sending apparatus including a telegraph key connected in circuit with the transmitter of said operator's set to permit said operator to transmit radio code signals, and when said key is in the unoperated position to permit

said operator to talk over the transmitting circuit without further altering the circuit.

23. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means for receiving signals from said wire connected subscribers' stations and means for preventing temporary surges of alternating current from operating said signal receiving means.

24. In a signaling system, a radio transmitting station and a radio receiving station, wire connections between said stations and between said stations and wire connected subscribers' stations, means for receiving signals from said wire connected subscribers' stations including a slow release relay which will cause the signal to be given only after such signal has persisted an appreciable length of time.

In witness whereof, I hereunto subscribe my name this 4th day of December, A. D. 1924.

HENRY W. O'NEILL.