L. ESPENSCHIED.
WIRELESS DUPLEX SIGNALING SYSTEM.
APPLICATION FILED MAY 15, 1916.

1,256,889. **Patented Feb. 19, 1918.**

3 SHEETS—SHEET 1.

Fig. 1

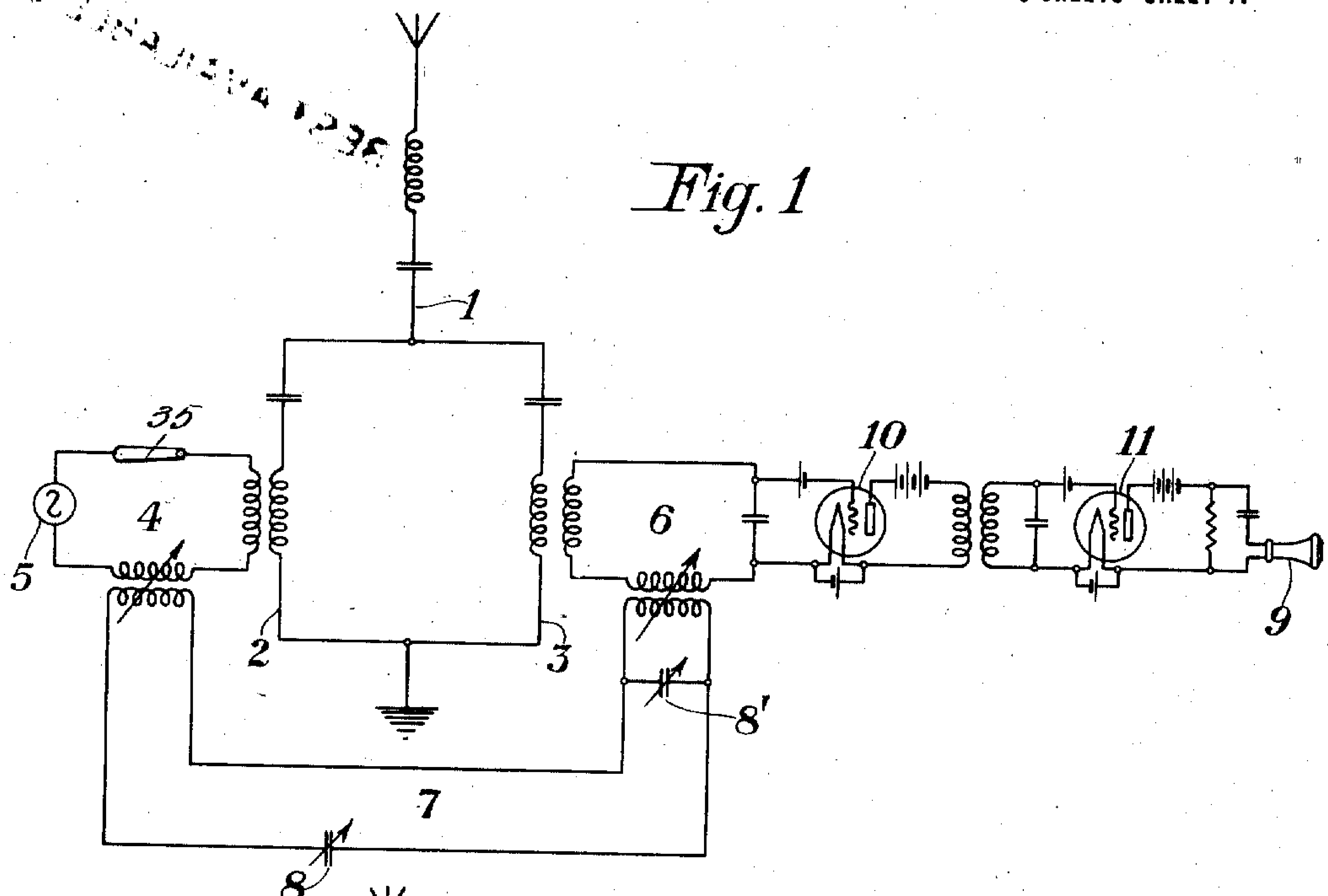
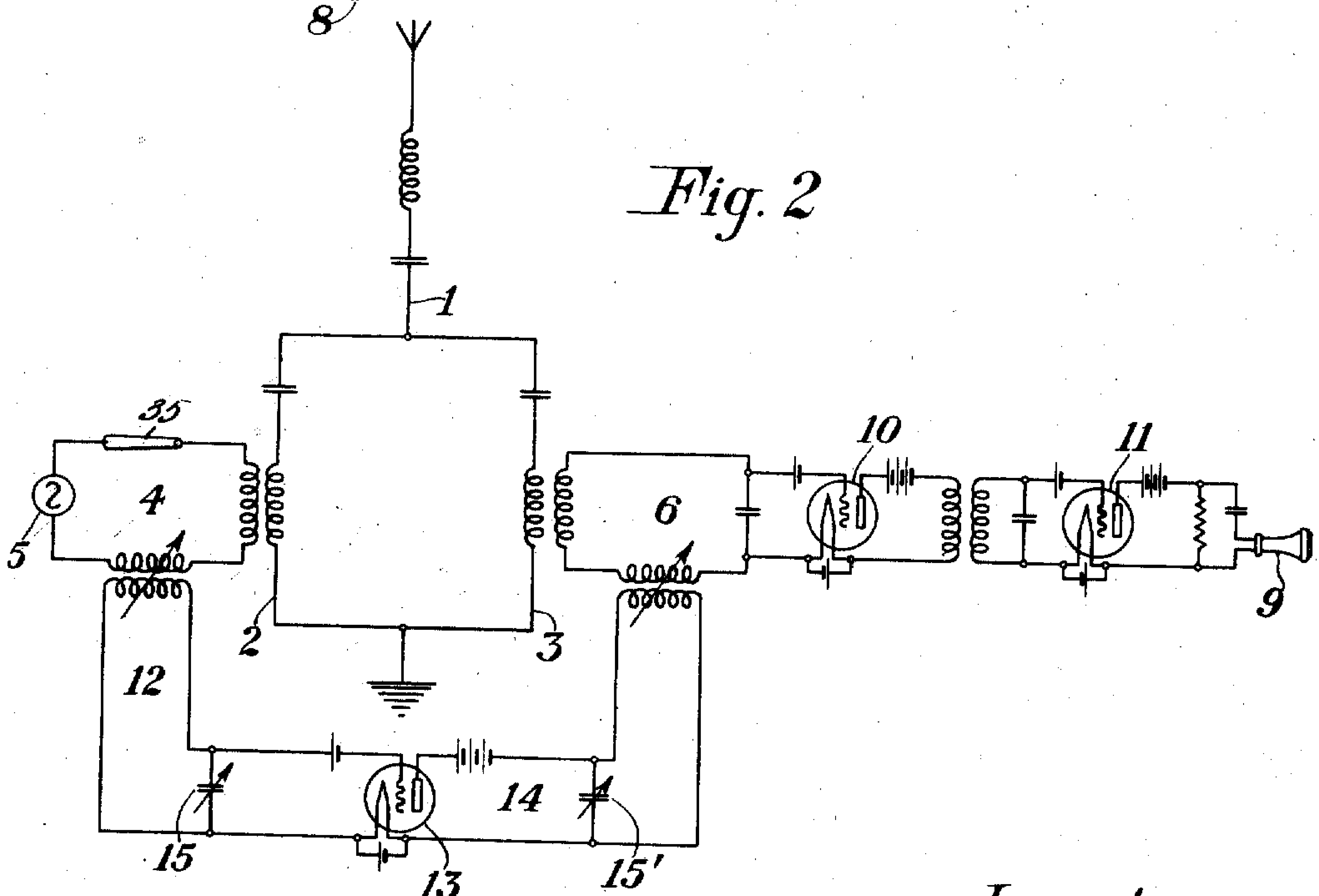


Fig. 2



Inventor:
L. Espenschied
per Thomas D. Lockwood
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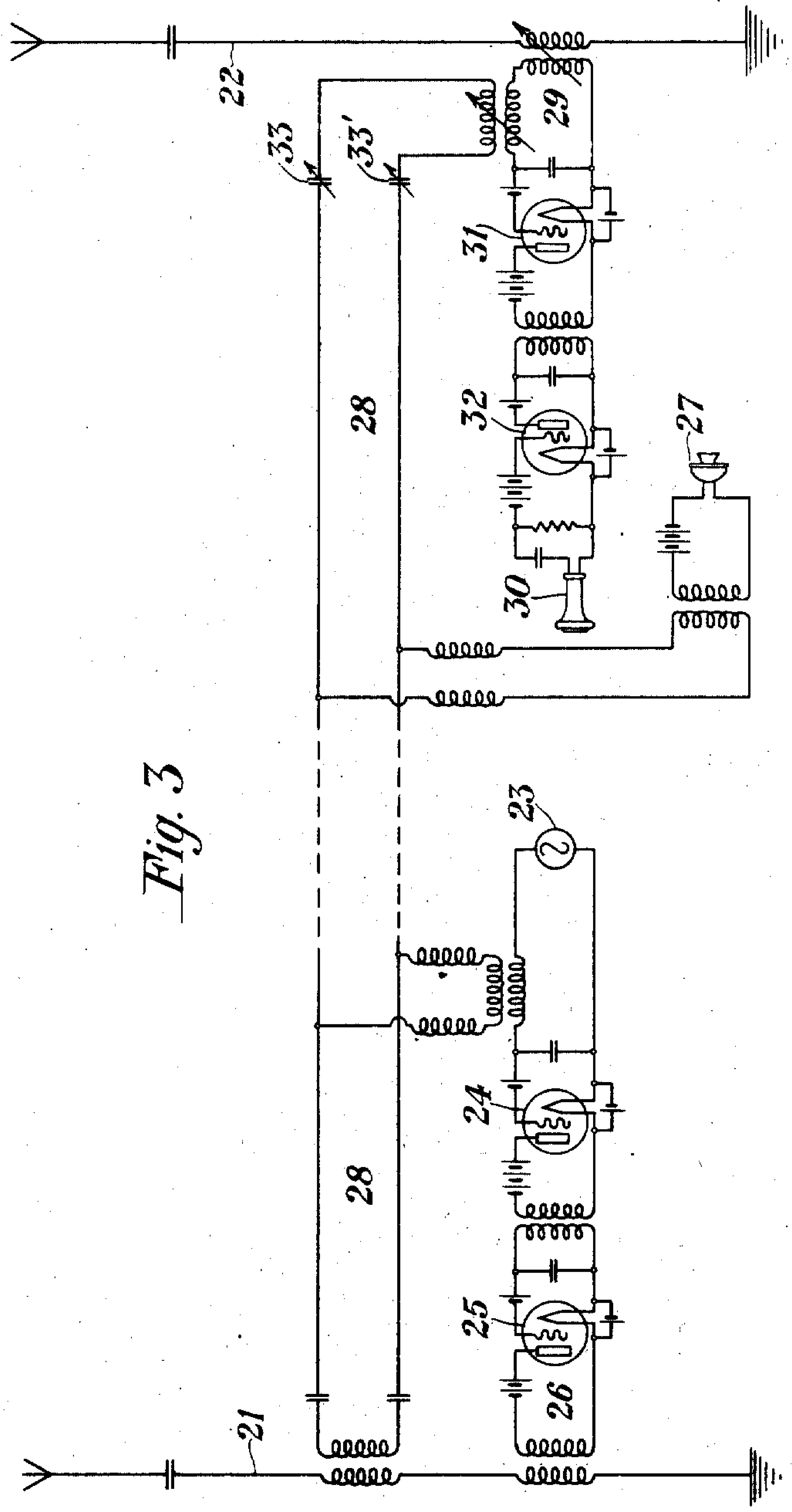

Fig. 3

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3 SHEETS—SHEET 3.

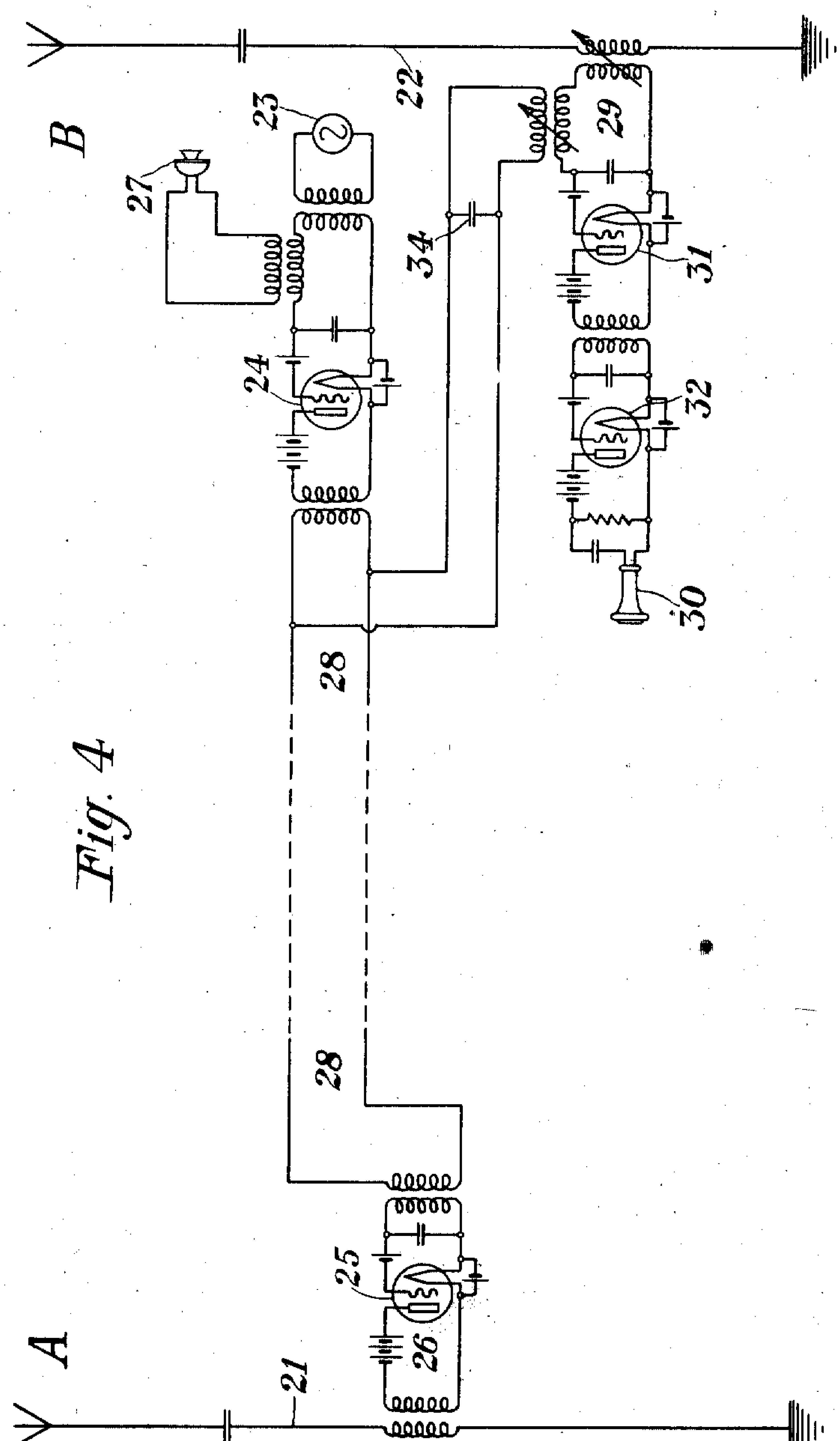

Fig. 4

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UNITED STATES PATENT OFFICE.

LLOYD ESPENSCHIED, OF HOLLIS, NEW YORK, ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

WIRELESS DUPLEX SIGNALING SYSTEM.

1,256,889. Specification of Letters Patent. Patented Feb. 19, 1918.

Application filed May 15, 1916. Serial No. 97,565.

To all whom it may concern:

Be it known that I, LLOYD ESPENSCHIED, residing at Hollis, Long Island, in the county of Queens and State of New York, have invented certain Improvements in Wireless Duplex Signaling Systems, of which the following is a specification.

This invention relates to a wireless signaling system and more particularly to a wireless duplex signaling system. Its object is to provide a system for the simultaneous transmission and reception of signals and in particular to provide means for duplex communication between two stations.

For successful duplex operation it is necessary that the receiving arrangements be effectively protected from interference by the transmitting arrangements at the same station; that is, protected from what is known as "side tone". It is well known that in wireless telegraph and telephone systems the magnitude of the transmission current is enormously greater than that excited in the antenna by the received waves, the relative magnitude of the former with respect to the latter being of the order of one million to one. This enormous ratio renders inapplicable to wireless systems methods of transmission interference elimination which are successfully employed in ordinary wire telegraph and telephone systems. The wireless system is, however, differentiated in two important respects from the ordinary wire system; first, signals are transmitted on high frequency carrier waves of definite frequencies, this fact permitting of the employment of different frequencies for transmission and reception, and, secondly, resonant tuned circuits may be employed, thus rendering the receiving system selective with respect to the waves it is desired to receive.

In my present invention I provide for successful duplex operation by employing carrier waves of different frequency for transmission and reception and by neutralizing the inductive action of the transmitting system proper on the receiving system by means of balancing circuits.

My invention is best understood by reference to the accompanying drawings in which Figures 1, 2, 3 and 4 is each a diagram of a system embodying the invention.

Referring to Fig. 1, 1 is an antenna for the simultaneous transmission and reception of signals. Antenna 1 includes two parallel branches 2 and 3, transmitting circuit 4 being coupled to branch 2, while the receiving arrangements are coupled to branch 3. By virtue of said parallel branches, the antenna system has two degrees of freedom and is therefore resonantly responsive to two different frequencies. It is contemplated that signals be transmitted at one of said frequencies and received at the other of said frequencies. The transmitting arrangement proper is conventionally represented as a high frequency generator 5, which generates waves of the frequency of transmission, a translating device 35 being provided to control the transmission of oscillations. Details of the transmitting arrangements are not shown. A receiving oscillation circuit 6 is coupled to branch 3, said receiving oscillation circuit being tuned to the frequency of reception and preferably offering a high impedance to currents of the transmission frequency. Coupled to circuit 4 and circuit 6 is a balancing circuit 7 which includes condensers 8 and 8′. The function of said circuit is to neutralize with respect to circuit 6 the effect of the transmission current flowing in branch 3. Circuit 7 and branch 3 must therefore balance at the transmitter frequency both as regards magnitude and phase of current in their effects on circuit 6. The balance as regards magnitude may be controlled by adjustment of the couplings between circuits 7 and 4 and circuits 7 and 6 while by adjustment of condensers 8 and 8′ the phase of the current in circuit 7 may be controlled. It is then clear that by proper adjustments of the above-mentioned circuit variables, circuit 6 may be be rendered approximately free from interference due to transmission currents.

As regards the reception of waves which it is desired to receive and to which oscillation circuit 6 is tuned, it is clear that the balancing action of branch 3 and circuit 7 with respect to circuit 6 no longer obtains since said balance is adjusted only for the frequency of transmission and since also, as regards the received waves, antenna 1 is the driving circuit. Oscillation circuit 6 therefore oscillates resonantly in response to the waves received from the distant communicating station and receiver 9 is thereby energized through amplifier 10 and detector 11 which are both preferably of the vacuum tube type.

Referring to Fig. 2 the arrangement shown is similar to that illustrated in Fig. 1, differing only in the balancing circuit arrangement. Coupled to circuit 4 is a circuit 12 to which is connected the input side of a vacuum tube amplifier 13. The output circuit 14 of said amplifier is coupled to circuit 6. The operation of this arrangement in balancing the transmission interference in receiving circuit 6 is similar to that of the arrangement of Fig. 1, the arrangement of Fig. 2 being more flexible in that the magnitude of the balancing current in circuit 11 may be controlled by amplifier 10, thus permitting of nicer balancing adjustments. Adjustment of phase relations may be obtained by varying the capacity of condensers 15 and 15'.

Fig. 3 is a diagram of a wireless telephone system for the simultaneous transmission and reception of speech signals in which separate antennæ are employed for the transmission and reception. Referring to said figure, 21 is the transmitting antenna and 22 the receiving antenna. Antenna 21 is tuned to the frequency of transmission, that is to the frequency of the carrier wave generated by high frequency generator 23, while antenna 22 is tuned to the frequency of the signals to be received, that is to the reception frequency. The transmitting system proper comprises the generator 23, a modulating device 24, preferably of the vacuum tube type and an amplifier 25 whose output circuit 26 is coupled to antenna 21. Telephonic waves generated by transmitter 27 are transmitted by line 28 to modulator 24 in which they are combined with the carrier wave generated by generator 23 to produce modulated high frequency waves.

Line 28 is also coupled to antenna 21 and is therefore excited by the high frequency waves in said antenna and transmits high frequency current to the receiving antenna station as well as audio-frequency current to the transmitter. High frequency waves of similar form are also radiated from antenna 21 and excite oscillations in antenna 22 which interfere with the reception of the desired signals. In the present organization I contemplate balancing in their effects on receiving oscillation circuit 29 the high frequency waves transmitted by wire line 28 and those transmitted wirelessly to antenna 22. As shown both line 28 and antenna 22 are coupled to oscillation circuit 29 and by a proper adjustment of relative couplings and of condensers 33 and 33' the resultant induction in circuit 28 may be substantially eliminated as regards the effects originating at the transmitting station. Oscillation circuit 29 is further protected against transmission interference by being tuned to the frequency of reception and offering a relatively high impedance to the frequency of transmission.

As regards the reception of signals antenna 22 is strongly responsive while antenna 21 is weakly responsive. The balance between the inductive effects of line 28 and antenna 22 on circuit 29 does not therefore obtain as regards the signals to be received. Further oscillation circuit 29 is resonantly responsive to said signals, and receiver 30 connected to said circuit through detector 31 and amplifier 32 responds to said signals.

Fig. 4 is a diagram illustrating an arrangement which is similar in general to that shown in Fig. 3. Corresponding component parts of Figs. 3 and 4 are designated by the same numerals. Referring to Fig. 4 transmitting station A and receiving station B are connected by wire line 28. Generator 23 and modulator 24 are located at receiving station B; modulated high frequency waves are transmitted by line 28 to transmitting station A where they are amplified by amplifier 25 and then radiated by antenna 21. Line 28 is coupled to receiving oscillation circuit 29 which is also coupled to receiving antenna 22. By a proper adjustment of coupling, and of phase by means of condenser 34, interference, as regards transmitted effects may be eliminated from circuit 29, leaving it free to oscillate resonantly to the waves it is desired to receive.

What is claimed is:

1. In a system for the simultaneous transmission and reception of signals, a circuit tuned to one frequency for transmission, a circuit tuned to another frequency for reception, a transmitting apparatus, means for associating the same with said first circuit, a receiving apparatus, means for associating the same with said second circuit, a balancing circuit and means for coupling said balancing circuit to the means for associating said transmitting and receiving apparatus with the tuned circuit so as to render said receiving apparatus free from interference by the transmitted energy.

2. In a system for the simultaneous transmission and reception of signals, a circuit tuned to one frequency for transmission, a circuit tuned to another frequency for reception, a transmitting apparatus, a circuit for connecting the same with said first tuned circuit, a receiving apparatus, a circuit for connecting the same with said second tuned circuit, and means to neutralize the effect of transmitted energy upon the receiving apparatus, said means being connected to said connecting circuits and through said connecting circuits with said tuned circuits.

3. In a system for the simultaneous transmission and reception of signals, an element tuned to transmission frequency, a second element tuned to reception frequency, a

transmitting apparatus, means to associate the same with the first element, a receiving apparatus, means to associate the same with the second element, and an auxiliary circuit coupling the means for associating the transmitting and receiving apparatus with said elements, said auxiliary circuit being provided with means to overcome the effect of transmitted energy upon the receiving apparatus.

4. In a system for the simultaneous transmission and reception of signals, an element tuned to transmission frequency, a second element tuned to reception frequency, a transmitting apparatus, a circuit for coupling the same to the first element, a receiving apparatus, a circuit for coupling the same to the second element, and an auxiliary circuit connecting the coupling circuits, said auxiliary circuit being provided with means including an amplifier to overcome the effect of transmitted energy upon the receiving apparatus.

5. In a system for the simultaneous transmission and reception of signals, an antenna circuit provided with two paths, a transmitting apparatus associated with said first path, a receiving apparatus associated with said second path, and an auxiliary circuit coupling the transmitting and receiving apparatus, said auxiliary circuit being provided with means to overcome the effect of transmitted energy upon the receiving apparatus.

6. In a system for the simultaneous transmission and reception of signals, an antenna circuit provided with two paths, a transmitting apparatus associated with said first path, a receiving apparatus associated with said second path, and an auxiliary circuit coupling the transmitting and receiving apparatus, said auxiliary circuit being provided with means including an amplifier to overcome the effect of transmitted energy upon the receiving apparatus.

7. In a system for the simultaneous transmission and reception of signals, a circuit tuned to transmission frequency, a circuit tuned to reception frequency, a transmitting apparatus, means for connecting the same with said first circuit, a receiving apparatus, means for connecting the same with said second circuit, and an auxiliary circuit coupled to said connecting means and connected through said connecting means to said tuned circuits, said auxiliary circuit comprising means to overcome the effect of transmitted energy upon the receiving apparatus.

8. In a system for the simultaneous transmission and reception of signals at different frequencies the combination of an antenna system reasonantly responsive to two frequencies, a transmitting circuit arrangement coupled to one element of said antenna system, a receiving circuit arrangement coupled to another element of said antenna system and a balancing circuit coupled to both said transmitting circuit arrangement and said receiving circuit arrangement, and means included in said balancing circuit whereby the receiving circuit arrangement is substantially free from interference by the transmitted energy.

9. In a wireless system for the simultaneous transmission and reception of signals at different frequencies the combination of an antenna system resonantly responsive to the frequency of transmission and the frequency of reception; a transmitting circuit arrangement coupled to one element of said antenna system; a receiving circuit arrangement coupled to another element of said antenna system; a balancing circuit coupled to both said transmitting circuit arrangement and said receiving circuit arrangement; an amplifier in said balancing circuit and means for controlling the phase of the circuit in said balancing circuit.

10. A wireless signaling system for the simultaneous transmission and reception of signals comprising an antenna including two parallel branches, said antenna being resonantly responsive to two frequencies; a transmitting arrangement coupled to one of said branches; a receiving arrangement coupled to the other of said branches; a balancing circuit coupled to said transmitting arrangement and said receiving arrangement; and means included in said balancing circuit for neutralizing as regards phase and magnitude the transmission interference in said receiving arrangement.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses, this 4th day of May, 1916.

LLOYD ESPENSCHIED.

Witnesses:

RALPH W. WOLF,
FRED'K S. ROBINSON.