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J. F. FARRINGTON

DUPLEX COMMUNICATION

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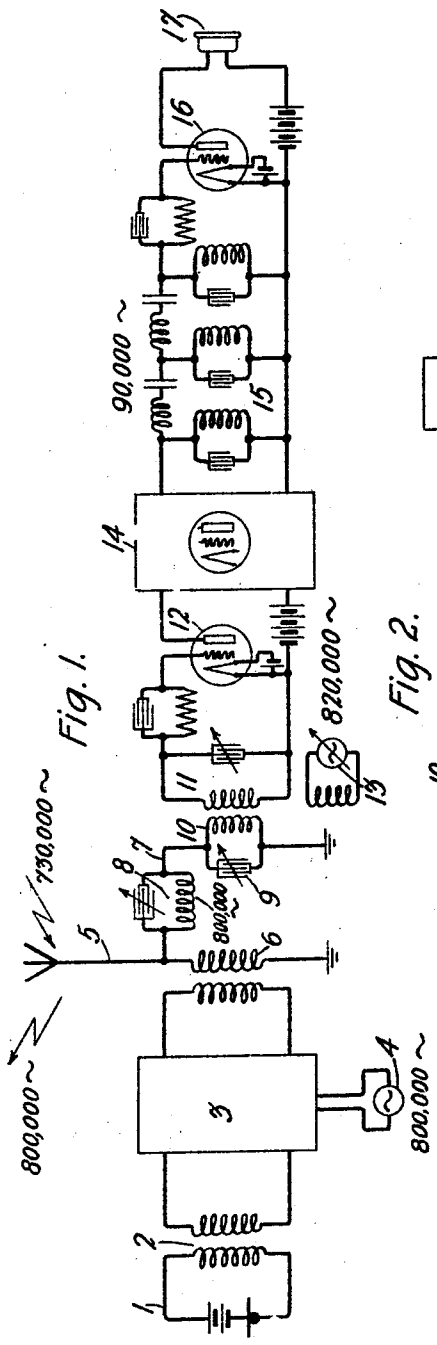


Fig. 1.

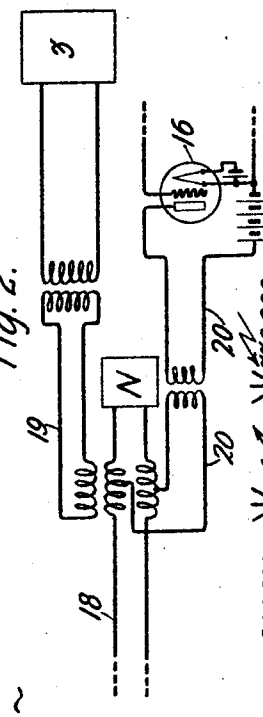


Fig. 2.

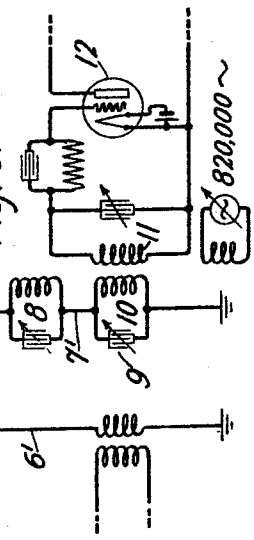


Fig. 3.

Inventor:
John F. Farrington.
by E. V. Griggs
Att'y.

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UNITED STATES PATENT OFFICE.

JOHN F. FARRINGTON, OF NEW YORK, N. Y., ASSIGNOR TO WESTERN ELECTRIC COMPANY, INCORPORATED, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

DUPLEX COMMUNICATION.

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This invention relates to carrier wave signaling circuits for two-way communication.

An object of the invention is to provide improved methods and systems of duplex radio communication employing one antenna system, or two antennæ systems placed so as to influence each other to a relatively large extent, whereby a conversation can be carried on between two persons at widely separated radio stations in the manner of ordinary telephone practice, that is, without the manipulation of any control or switch to change the circuit from talking to listening condition. Under certain conditions as for example, on board ship, the limited space available or other physical limitations often necessitates the employment of a single antenna for transmission and reception. Under such circumstances the present invention may be advantageously applied, but it is not limited in application to systems employing a single antenna for transmission and reception, but may be applied in systems where separate antennæ are used.

A further object of the invention is to produce a system which will facilitate two-way communication over a system comprising a telephone line connected to a radio system.

In carrying out the invention transmitting means are employed for impressing a modulated carrier wave of one frequency upon a transmitting antenna which receives waves of another carrier frequency from a distant communicating station. A local source of waves is combined with the incoming carrier waves to produce waves of an auxiliary carrier or beat frequency which are amplified, selectively separated from interfering waves and used to reproduce the signal. A trap circuit or its equivalent is used in the receiving branch of the antenna when one antenna is used, and in the receiving antenna when separate antennæ are used for transmission and reception to reduce the amount of locally transmitted energy transferred into the receiving circuit.

In connection with the following detailed description reference is made to the accompanying drawings wherein Fig. 1 is a circuit diagram of a station for two-way radio telephony employing a single antenna and embodying the improvements of the present invention; Fig. 2 is a diagram illustrating a manner of connecting the system of Fig. 1 or any equivalent system to a two-way low frequency telephone line; and Fig. 3 is a circuit diagram of a system having separate transmitting and receiving antennæ.

In Fig. 1 a microphone circuit 1 is connected to a transformer 2 of a radio transmitter 3 which is supplied with oscillations from a source 4. These elements indicate in a conventional manner any known form of apparatus for producing high frequency waves and modulating them in accordance with speech for purposes of radio transmission, such, for example, as that described in U. S. Patent to Colpitts, et al., No. 1,388,450, granted August 23, 1921. The waves produced by the transmitter circuit are impressed upon the antenna circuit 5 which constitutes a suitable radiating aerial having a connection to ground through the coil 6 which serves as a coupling coil. The antenna circuit has a branch path 7 which includes a loop resonant circuit 8 tuned to prevent waves of the outgoing frequency from traversing the path 7. The path 7 also includes a variable condenser 9 and a coil 10 in parallel which serve as tuning elements for the branch path 7. The coil 10 also serves to couple the branch path to the receiver circuit now to be described. The receiver circuit comprises a tuned circuit 11 coupled to the coil 10. The circuit 11 is included in the input circuit of a thermionic detector 12 of a conventional type. The circuit 11 is a simple form of selective circuit for selecting the incoming high frequency. Greater selectivity may be secured by using more complicated forms of selective circuits such as well-known types of band filters. The device 13 comprises a local source of waves of radio frequency which are supplied to the input circuit of the detector 12 by introducing them into the circuit 11. Sources 4 and 13 may conveniently be the type of vacuum tube oscillation generator described in U. S. Patent to Hartley No. 1,356,763, granted October 26, 1920, and capable of having the frequency varied to any desired value within a desired working range. If, however, it is desired to work at fixed wave lengths, then it is not essential that the elements 4 and 13 be variable as to frequency. Any other suitable source of continuous radio frequency oscillations may be substituted for the sources 4 and 13. For example, the oscillations may be different harmonics of a single base frequency from

which they are derived by one or more harmonic producers of a well-known type.

The output circuit of detector 12 is connected to a single or plural stage amplifier 14, which feeds into the selective circuit 15. The essential characteristic of this selective circuit is that it must discriminate between waves of different frequencies to the extent and in the manner hereinafter indicated. It may comprise any combination of elements necessary to accomplish this result. Preferably, however, it is in the form of a recurrent sectional network designed to pass a band of frequencies corresponding to the auxiliary carrier and one or both accompanying side bands which result from modulation and to exclude all materially different frequencies. Greater selectivity may be secured by placing another circuit similar to the circuit 15 between the detector 12 and the amplifier 14. The output terminals of circuit 15 are connected to a detector 16 with which is associated a telephone receiver 17 or equivalent device.

In operation the person talking into the microphone or the circuit 1 and listening at the receiver 17 will be enabled to communicate with a person at a distant station. The incoming and outgoing carrier waves will preferably differ by an amount greater than the highest frequencies of speech. The source 13 will produce undamped waves of such frequency that they will combine with the incoming carrier waves to produce a combination frequency wave which can be separated from any combination frequency waves produced by the beating together of the incoming and outgoing carrier waves and any combination frequency wave produced by the modulated outgoing carrier wave and waves from the local source. A typical set of frequency values is: outgoing carrier frequency, 800,000; incoming carrier frequency 730,000; source 13, 820,000; difference frequency or auxiliary carrier 90,000. These are the frequencies indicated on the drawing. Many other combinations of frequencies might be used, thus for example, outgoing carrier, 800,000; incoming carrier frequency 810,000; local source 780,000; and auxiliary carrier frequency, 30,000 or 1,590,000. It is an important consideration that the present method permits the employment of outgoing and incoming carrier waves differing from each other in frequency by a relatively small amount, which is often desirable. Good selectivity requires, in the case where both the local and distant transmitters are transmitting both side frequencies of their respective modulated waves, that the incoming and outgoing carrier waves differ by an amount at least twice the value of the highest frequencies which modulate the carrier waves. With ordinary types of selective circuits a somewhat greater frequency separation than this is necessary but numerous combinations of wave lengths may be utilized in which the frequency difference is considerably less than ten per cent of either the incoming or outgoing carrier frequency. Nevertheless, this invention is not limited to cases of small frequency difference of the outgoing and incoming carrier waves but may be advantageously employed where the difference is considerably greater than ten per cent. The circuit 15 is designed to pass the auxiliary carrier frequency together with its upper or lower side band or both and to exclude waves of other frequencies from the detector 16. The loop circuit 8 is adjusted to prevent too much energy of the outgoing carrier wave frequency from traversing the branch path 7 and hence entering the receiving circuit. Elements 9 and 10 are adjusted to tune the whole antenna network to the incoming carrier wave frequency, thus selectively receiving the incoming waves.

With sufficiently selective circuits and proper shielding of the receiver from the transmitter a system such as described herein is an anti-side tone system, i. e., sounds impressed upon the microphone of the circuit 1 will not be heard in the receiver 17. In practice, however, some side tone may be present owing to the fact that shielding and selectivity are not perfect. By designing the system so that the side tone is reduced to a small volume as compared to the volume of the incoming signal, true duplex operation is available as distinguished from two-way systems wherein the transmission in the two directions alternates.

The present system can be easily changed to operate in accordance with the method described in applicant's application Serial No. 326,986, filed September 27, 1919, in which the outgoing and incoming carrier waves are combined to produce an intermediate frequency carrier wave. To do this the generator 13 is stopped or disconnected from the input circuit of detector 12, and either the outgoing carrier wave frequency or the transmission band of the selective circuit 15 is changed so that the auxiliary carrier frequency produced by the beating together of the outgoing and incoming carrier waves will freely pass thru the circuit 15 to the detector 16. The circuit 8 and the elements 9 and 10 may also need readjustment.

Furthermore, the present system when utilizing the waves from the source 13 may cooperate with a distant station which operates to combine its incoming and outgoing carrier waves to produce an auxiliary carrier wave of intermediate frequency. Thus, let it be supposed that a distant cooperating station is similar in circuit arrangement to the present station with the exception that source 13 is omitted. The local station ra-

diates a carrier wave having a frequency of 800,000 cycles per second and the distant cooperating station radiates a wave having a frequency of 730,000 cycles per second. At the distant station the outgoing and incoming carrier waves beat together to produce an auxiliary carrier wave having a frequency equal to the difference of 800,000 and 730,000, i. e., 70,000 cycles per second. If the source 13 at the local station has a frequency of 820,000 cycles per second then the auxiliary carrier frequency which is selected by the circuit 15 at the local station will be of 90,000 cycles frequency.

Fig. 2 illustrates the connection of a low frequency telephone line 18 to the system of Fig. 1 whereby a subscriber at the remote end of the line may communicate over the radio system. The line 18 is balanced by the balancing network N and is connected to the output circuit of the detector 16 and to the input circuit of the radio transmitter 3 by conjugately related paths 19 and 20. Path 19 transfers speech frequency waves incoming over the telephone line to the radio transmitter 3 and path 20 conveys speech frequency waves from the output circuit of the device 16 to the line 18. The conjugate relation of connections 19 and 20 prevents local circulation of power or singing through the radio system. When a radio system is thus connected to a line it is desirable that the side-tone in the radio circuit be as small as possible. This is an advantage of the present arrangement. It permits a high degree of suppression of side-tone.

Fig. 3 illustrates the application of the invention to a system employing separate antennæ 6′ and 7′ for transmission and reception respectively. These antennæ may comprise aerial structures so closely related that they react strongly on each other. This would be the case for example, with two antennæ mounted on the same vessel. They may, however, be more remote from each other so that their mutual reaction will be less strong. The antenna 7′ may be strongly directional so as to receive efficiently from the distant station, but inefficiently from the local transmitting antenna 6′. The circuit 8 constitutes adjustable means for making the antenna circuit of high impedance to currents of the outgoing wave frequency. The elements 9, 10 function to tune the antenna 7′ to resonance at the incoming wave frequency. The other elements of the system are of the same kind and function as described in connection with Fig. 1.

In all the arrangements described additional amplifiers may be introduced at any point in the system. Additional selective circuits may also be provided at any point in the system to discriminate against undesired frequencies.

Having described the invention in detail the novel features believed to be inherent therein are defined in the appended claims.

What is claimed is:

1. A two-way radio transmission system comprising an antenna, means for impressing a wave to be radiated on said antenna, a receiving circuit connected to said antenna, rejector means individual to the frequency of the outgoing wave for materially reducing the amount of energy of said wave which is impressed upon said receiving circuit, a local source of waves connected to said receiving circuit, means for combining waves from said local source with incoming carrier waves present in said receiving circuit to produce waves of auxiliary carrier frequency, and means for deriving the signal currents to be received from said waves of auxiliary carrier frequency.

2. The method of duplex radio telephony by means of a single antenna structure serving both for radiation and reception, comprising impressing outgoing carrier waves on said antenna structure, receiving incoming waves in said antenna structure, selecting said incoming waves to at least the partial exclusion of said outgoing waves, combining the incoming waves with waves from a local source to produce an auxiliary carrier wave having a frequency different from any frequency obtained by combining the incoming and outoging carrier waves, and selecting and detecting said auxiliary carrier wave to reproduce the signal.

3. A radio transmission and reception circuit comprising a conductor system for radiating outgoing wave energy and absorbing incoming wave energy, a transmitting system for impressing carrier waves of the given frequency to be radiated on said conductor system, a receiving circuit connected to said system, the connection including a circuit, anti-resonant to the radiated frequency, for allowing incoming waves to reach said receiving circuit while reducing the amount of energy of the radiated frequency supplied thereto, a locally controllable source of waves of a frequency other than said radiated frequency, means for combining waves from said source with incoming waves to produce waves of an auxiliary carrier frequency, selective means for separating waves of said auxiliary carrier frequency from accompanying interfering waves, and means for deriving an incoming signal current from the separated waves.

4. A duplex transmission system comprising a source of waves to be transmitted, a radiating antenna comprising a path to ground coupled to said source, a branch path to ground, impedance means in said branch path offering high impedance to waves of the frequency to be radiated, tuning means in said path for tuning said antenna system as a whole to waves of a different frequency

which are to be received, and means for coupling a receiver circuit to said branch path.

5. A duplex transmission system comprising a source of waves of one frequency to be radiated, a transmitting antenna comprising a path to ground coupled to said source, a branch path to ground including impedance means for offering high impedance to waves of the frequency to be radiated, tuning means in said path for tuning said antenna system as a whole to waves of a second frequency to be received, means for coupling a receiver to said path and means for supplying to said receiver waves of a third frequency to combine with the received waves to produce waves of a fourth frequency having such a value as will allow their separation from waves of the first, second and third mentioned frequencies or any troublesome combination frequency resulting therefrom.

6. The method of two-way radio transmission by means of a single antenna structure which comprises transmitting waves of one carrier frequency over said antenna structure, receiving incoming waves of another carrier frequency, combining waves of a third frequency with the incoming waves to produce waves of a fourth frequency which is sufficiently different from the sum or difference of the first and third mentioned frequencies to allow separation therefrom by selective circuits, and selecting and detecting said fourth frequency wave to reproduce the signal.

7. The method of two-way radio transmission by means of a single antenna structure which comprises transmitting waves of one carrier frequency over said antenna structure, receiving incoming waves of another frequency differing from the first frequency by less than ten per cent of the value of either, combining waves of a third frequency with the received incoming waves to produce waves of a fourth frequency differing from any frequency obtained by combining the first frequency waves with the second or third frequency waves, and selecting and detecting the fourth frequency wave to reproduce the signal.

8. The method of two-way radio transmission by means of a single antenna structure which comprises transmitting waves of one carrier frequency over said antenna structure, selectively receiving incoming waves of another carrier frequency over said antenna, combining waves of a third frequency with the received waves to produce waves of a fourth frequency which is sufficiently different from a frequency equal to the differences of the frequencies of the two first mentioned wave frequencies to allow separation by selective circuits, and selecting and detecting said fourth frequency wave to reproduce the signal.

In witness whereof, I hereunto subscribe my name this 19th day of June A. D., 1922.

JOHN F. FARRINGTON.