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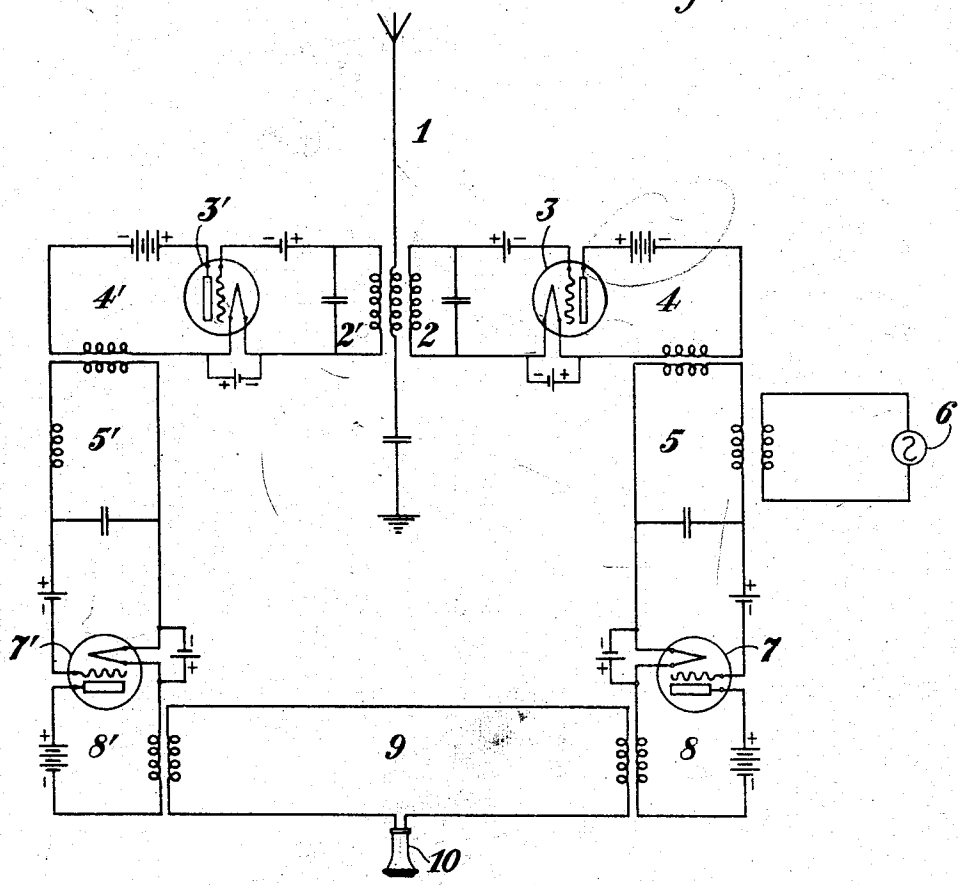
J. R. CARSON.

WIRELESS RECEIVING SYSTEM.
APPLICATION FILED JAN. 7, 1916.

Patented Oct. 30, 1917.
2 SHEETS—SHEET 1.

1,244,697.

Fig. 1



Witnesses:

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James E. Lynch

Inventor:

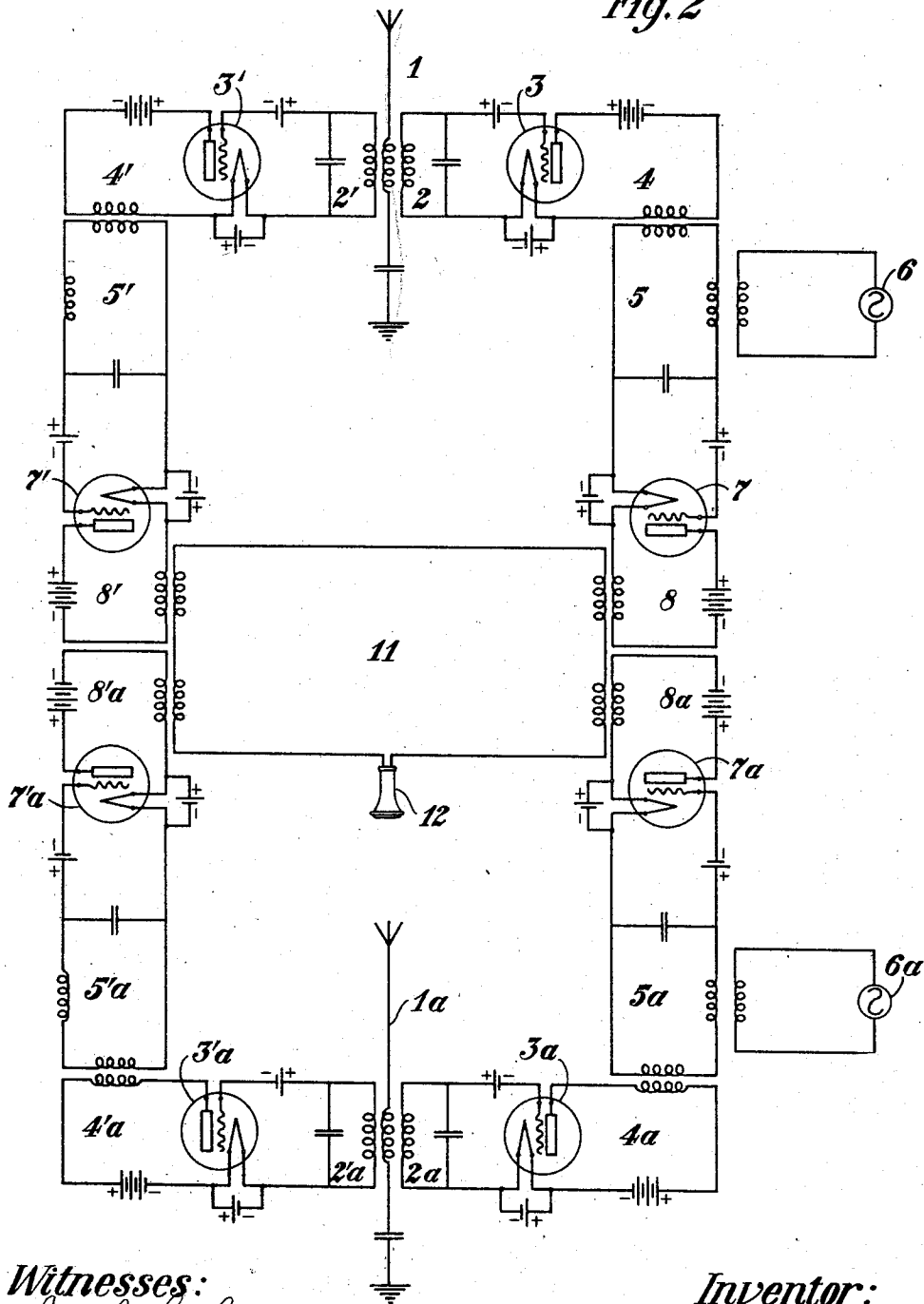
John R. Carson
per Thomas D. Lockwood
Attorney.

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Fig. 2 2 SHEETS—SHEET 2.



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UNITED STATES PATENT OFFICE.

JOHN R. CARSON, OF NEW YORK, N. Y., ASSIGNOR TO AMERICAN TELEPHONE AND TELEGRAPH COMPANY, A CORPORATION OF NEW YORK.

WIRELESS RECEIVING SYSTEM.

1,244,697.

Specification of Letters Patent.

Patented Oct. 30, 1917.

Application filed January 7, 1916. Serial No. 70,778.

To all whom it may concern:

Be it known that I, JOHN R. CARSON, residing at New York, in the county of New York and State of New York, have invented certain Improvements in Wireless Receiving Systems, of which the following is a specification.

This invention relates to a signaling system and more particularly to a signaling system wherein speech signals are transmitted by the agency of a high frequency carrier wave modulated in accordance with said speech signals. It is the object of this invention to provide means in the receiving part of said system whereby the quality of the received speech signals is considerably improved and interference, particularly that known as "static," is reduced or eliminated.

The transmitting part of the signaling system with which the receiving organization of my invention coöperates in the transmission of speech may be of any form in which a high frequency carrier wave is modulated in accordance with the signals to be transmitted, the carrier wave being preferably generated by a source of undamped continuous waves. In transmitting signals, this carrier wave is combined with a low frequency signal wave, so that the transmitted wave is modulated. The modulation of the carrier wave results, in general, as is well known, in the transmission of three waves of frequencies which may be designated as F , $F+f$, and $F-f$ where F is the frequency of the carrier and f the frequency of the signal wave of audio-frequency. (See patent to Leblanc, No. 857,079, January 18, 1907.) When the transmitted wave reaches the receiving system it sets up corresponding oscillations therein which are impressed on the input side of a detector to whose output side is operatively connected a receiving device, preferably a telephone receiver. The object in such a signaling system is to produce in the receiving device oscillations equal in frequency and proportional in magnitude to the oscillations in the transmitting device at the transmitting station. In the ordinary receiving system the oscillations in the receiver are not faithful copies of the original oscillations in the transmitter and as a consequence the signals are distorted. The

present invention provides means whereby this distortion is greatly reduced.

For the sake of clearness, this invention will be described in terms of a wireless telephone system, though it is not so limited in its scope and is applicable to and finds its useful embodiment in any system wherein signals are transmitted by the agency of a modulated high frequency or carrier wave, a further example of such system being the wire system commonly known as the Squier high frequency telephone system.

The arrangements of my invention as embodied in a wireless telephone receiving system may be described broadly as follows: To the receiving antenna is coupled a receiving arrangement comprising tuned oscillation circuits, amplifiers and a detector, to the last of which is connected a receiving device such as a telephone receiver. This arrangement constitutes the receiving system as ordinarily employed. In this invention I couple to the antenna a receiving arrangement substantially identical with the first named receiver system as regards oscillation circuits, amplifiers and detector. The two detectors are differentially connected to the same receiving device. It will be clear that in such case the receiver will not be energized, since the oscillations in the two similar and equal receiving arrangements oppose and substantially neutralize with respect to said receiver. To prevent this complete neutralization and to provide for good quality of received speech, this invention contemplates operatively connecting to one and one only of said receiving arrangements a source of energy generating continuous undamped waves of frequency F , that is the frequency of the carrier wave generated at the transmitting station. This source of energy is loosely coupled to the receiving arrangement between the antenna and detector, preferably to the input side of the detector. As a result of this arrangement the oscillations in the two receiving arrangements do not completely neutralize but the neutralization extends only to oscillations which are conducive to distortion and which, therefore, it is desirable to eliminate.

My invention, as embodied in a wireless telephone system, is best understood by reference to the accompanying drawings in

which Figure 1 is a diagram illustrating a wireless receiving system embodying the arrangements of my invention and Fig. 2 is a diagram of an organization in which the arrangements shown in Fig. 1 are coöperatively combined with an auxiliary system. Referring to Fig. 1, 1 is a receiving antenna, tuned to a frequency differing from that of the carrier wave by approximately 1600 cycles per second, that is by mean speech frequency. Coupled to said antenna are two similar and equal oscillation circuits 2 and 2' tuned to the same frequency as antenna 1. 3 and 3' are amplifiers, preferably of the vacuum tube type and preferably similar and equal. Coupled to the output circuits 4 and 4' of said amplifiers are oscillation circuits 5 and 5', preferably similar and equal and tuned to the same frequency as antenna 1. To oscillation circuit 5 is loosely coupled a source of high frequency energy, conventionally represented by 6, said source generating undamped continuous waves of the carrier wave frequency.

It is desirable that the coupling of generator 6 to circuit 5 should be loose in order that generator 6 shall not affect to any extent the natural oscillations in circuit 5. Connected to oscillation circuits 5 and 5' are detectors 7 and 7' respectively, preferably of the vacuum tube type and preferably similar and equal as regards adjustments and operating characteristics. Differentially coupled to output circuits 8 and 8' of detectors 7 and 7' is coupled a circuit 9 containing a receiving device 10, preferably a telephone receiver. Circuit 9 is coupled to circuits 8 and 8' in such a manner that no sound is heard in the telephone receiver when generator 6 is removed. When this condition obtains the oscillations of audio-frequency in circuits 8 and 8' excited by the waves absorbed by antenna 1, oppose and substantially neutralize with respect to circuit 9 and receiver 10. The operation of the system shown, when generator 6 is generating a wave of carrier frequency, will be readily understood from the explanation now to be given, from which it will be seen that not only is the quality of the received speech signals improved, but also interference is largely reduced.

The transmitted wave which reaches antenna 1 and excites oscillations therein is a wave of carrier frequency F , whose amplitude is modulated in accordance with a signal wave of audio-frequency f . Such a wave may be analyzed into three waves of constant amplitude and frequencies F , $F+f$, and $F-f$, respectively. In consequence currents of said three frequencies are excited in the antenna. As heretofore stated, I contemplate tuning the antenna and the associated oscillation circuits to a frequency differing from F by mean speech frequency;

assume for definiteness that the antenna is tuned to F plus mean speech frequency. As a consequence the current of frequency $F-f$ is reduced in amplitude as compared with the current of frequency $F+f$ and this reduction may be made as great as desired by sharp tuning and by providing a plurality of oscillation circuits between the antenna and the detector. It will therefore be assumed that the currents of frequency $F-f$ reaching detectors 7 and 7' are negligibly small in comparison with the currents of frequencies F and $F+f$.

It will be readily seen that since the two paths whereby the receiving circuit proper 9 is coupled to antenna 1 are similar and equal and similarly related to said antenna, equal currents will be excited in said paths by the oscillations in the antenna. Therefore if generator 6 were removed no current would be induced in circuit 9 since its connections with circuits 8 and 8' are differential. Generator 6, however generates a wave of constant amplitude and of carrier frequency F ; the resultant wave of frequency F is therefore larger in circuit 5 than in circuit 5', while the waves of frequency $F+f$ are equal in said circuits. Now it has been experimentally shown that the action of a detector is such that two waves of frequencies F and $F+f$ presented to the input circuit excite in the output circuit audio-frequency oscillations of frequencies f and $2f$ respectively, the latter wave being independent of the wave of frequency F , while the wave of frequency f is proportional in amplitude to the product of the amplitudes of the input waves of frequencies F and $F+f$. A full theoretical discussion of these phenomena will be found in my copending application Serial Number 64,524, filed December 1, 1915. It is the wave of frequency f alone which reproduces speech signals, the wave of frequency $2f$ representing an interfering or distorting harmonic. Now the waves of frequency $2f$ being independent of frequency F are generated with equal amplitude in circuits 8 and 8' and hence neutralize in the receiving system of my invention, while the desired wave of frequency f , since its amplitude depends upon the amplitude of frequency F , is generated with greater amplitude in circuit 8 because frequency F is reinforced in said circuit by generator 6, and hence frequency f is not neutralized. In other words the receiving system of my invention transmits to the receiver proper the wave necessary to set up sound vibrations therein which are faithful copies of the transmitted signals while suppressing oscillations which serve only to distort the received signals. Further the signals may be amplified by making the wave of generator 6 large compared with the received wave. As regards static interfer-

ence, the amplitude of static is in general much greater than that of the wave it is desired to receive and the interference is represented largely by an audio-wave proportional to the square of the static or interfering wave. This term is completely neutralized by the differential connections of the receiving system of my invention, which, therefore, provides a large measure of protection from static or other foreign interference.

To summarize, the arrangements of my invention as illustrated in Fig. 1, provide for improved quality and increased volume of received speech signal while at the same time providing for a large measure of protection against static and other foreign interference.

As hereinbefore stated the organization illustrated in Fig. 1 does not completely eliminate the effect of interference although it reduces the magnitude of interference in large measure. In Fig. 2 is illustrated a receiving system which provides for practically complete elimination of interference due to natural oscillations such as those excited by static or atmospheric disturbances. Referring to Fig. 2, receiving antenna 1 and its associated circuits and apparatus are identical with the arrangements of Fig. 1 and corresponding component parts are designated by the same numerals. An auxiliary antenna 1_a with corresponding associated circuits and apparatus is shown, component parts of the auxiliary antenna system corresponding to component parts of the receiving antenna system being designated by the same numeral with the subscript "a."

The operation of the receiving antenna system is the same as that described and illustrated in Fig. 1, and the function of the auxiliary antenna system is to eliminate interference. Auxiliary antenna 1_a, and associated circuits 2_a, 2_a', 5_a, 5_a', are tuned to the same frequency, said frequency differing materially from that to which antenna 1 is tuned. As a result the auxiliary system is unresponsive to the signals which antenna 1 is tuned to receive, and antenna 1_a plays no part in the reception of signals, although obviously it is capable of receiving signals transmitted on a wave to which the auxiliary system is tuned.

When a static disturbance sets up oscillations in antenna 1, it simultaneously excites oscillations in antenna 1_a, the periodicity of the natural oscillations in antenna 1 differing by approximately 1000 cycles per second, or mean speech frequency, from that of the wave generated by generator 6, while the periodicity of the natural oscillations of antenna 1_a is that to which said antenna is tuned. Generator 6_a is adjusted to generate a wave whose frequency differs from that of the natural oscillations of antenna 1_a by substantially the same amount as does the wave

generated by generator 6 from the natural frequency of antenna 1. Natural oscillations of the same periodicity and damping are excited in oscillation circuits 5_a and 5_a' by the natural oscillations in antenna 1_a, and said oscillations would produce the same low frequency oscillations in the output circuits 8_a and 8_a' of detectors 7_a and 7_a' if generator 6_a were removed. Owing to the presence of the continuous wave generated by generator 6_a in oscillation circuit 5_a the low frequency oscillations in circuits 8_a and 8_a' differ just as do the low frequency oscillations in circuits 8 and 8'. Circuits 8, 8', 8_a and 8_a' are coupled to circuit 11 including a telephone receiver 12 in such a manner that the low frequency oscillations in circuits 8 and 8' oppose, in circuits 8_a and 8_a' oppose and in circuits 8 and 8_a oppose. As a consequence the effects due to natural oscillations in antennæ 1 and 1_a oppose and tend to neutralize each other with respect to receiver 12. This neutralization may be made complete by adjustment of the relative amplifying powers of amplifiers 3, 3', 3_a, 3_a'. It is desirable for complete neutralization that the damping factor of the natural oscillations in circuits 5_a and 5_a' be substantially the same as the damping factor of the natural oscillations in circuits 5 and 5'. This may be practically attained by adjustment of the inductances in said oscillation circuits.

While two separate antennæ have been shown in Fig. 2 it is evident that an equivalent arrangement may be secured by providing a single antenna, said antenna having two degrees of freedom and being therefore resonantly responsive to currents of two frequencies. Such an equivalent arrangement is disclosed in application of Espenschied, Serial #52,260, filed September 23, 1915.

This invention is not limited to the specific structure shown but is directed to the broad idea of differentially connecting a receiving device to the source of the energy to be received by two similar and equal circuit arrangements in one of which a locally generated high frequency wave is combined with the received wave to the improvement of quality of received signal and also to the reduction of interference.

For the complete elimination of static interference my invention contemplates and includes also the cooperative combination with the receiving system illustrated in Fig. 1 of an auxiliary system structurally similar in its component parts to said receiving system but tuned to a different frequency and having an associated source of continuous high frequency energy which generates a wave of frequency differing slightly from that to which said auxiliary system is resonantly responsive, said auxiliary system be-

ing connected to the same receiving device as said receiving system.

I claim:

1. In a system for receiving electric waves, a receiving device, two similar and equal paths oppositely applying the received waves thereto, and means local to said receiving system for generating additional waves and impressing them on one of said paths only.

2. In a signaling system wherein signals are transmitted by the agency of a modulated high frequency carrier wave, a receiving system comprising two similar and equal circuit arrangements similarly related to the energy to be received, a receiving device differentially related to said receiving circuit arrangements, and means local to the receiving arrangement for impressing a continuous wave on one of said circuit arrangements only.

3. In a signaling system wherein signals are transmitted by the agency of a modulated high frequency carrier wave, a receiving system comprising two similar and equal circuit arrangements similarly related to the energy to be received, a receiving device differentially related to said circuit arrangements, and means local to said receiving arrangement for impressing on one of said circuit arrangements a continuous wave of the frequency of said carrier wave.

4. In a signaling system wherein signals are transmitted by the agency of a high frequency carrier wave, two similar and equal circuit arrangements similarly related to the energy to be received, a translating device in each of said circuit arrangements; a receiving device differentially connected to said circuit arrangements; and a generator of high frequency energy connected to one of said circuit arrangements only.

5. A wireless receiving system comprising an antenna; two similar and equal circuit arrangements similarly related to said antenna; a generator of high frequency energy connected to one of said circuit arrangements; and a receiving device connected differentially to said circuit arrangements only.

6. A wireless receiving system comprising an antenna; two similar and equal circuit arrangements similarly related to said antenna; a generator of high frequency waves connected to one of said circuit arrangements; a receiving device; and two detectors differentially connecting said receiving device to said circuit arrangements only.

7. In a signaling system wherein signals are transmitted by the agency of a modulated high frequency carrier wave, a receiving arrangement comprising two similar circuit arrangements similarly related to the energy to be received, each of said circuit arrangements including a detector; a tele-

phone receiver differentially connected to said two circuit arrangements; and a source of energy generating waves whose frequency is that of said carrier wave, said source of energy being connected with one of said circuit arrangements.

8. In a wireless signaling system wherein signals are transmitted by the modulated high frequency carrier wave the combination of a receiving antenna, a receiving circuit operatively connected to said antenna and including an amplifier and a detector, a second similar and equal receiving circuit related to said antenna in a manner similar and equal to that of said first named circuit, a source of energy generating waves of the frequency of said carrier wave and connected to said first named circuit, and a receiving device differentially connected to said receiving circuits.

9. In a wireless receiving system, a receiving antenna, an oscillation circuit coupled to said antenna, a second similar oscillation circuit similarly coupled to said antenna, an amplifier connected to said first named oscillation circuit, a second similar amplifier connected to said second named oscillation circuit, a detector connected to said first named amplifier, a second similar detector connected to said second named amplifier, a source of high frequency undamped waves connected to said first named detector, and a receiving device differentially connected to both of said detectors.

10. A wireless receiving system comprising a receiving antenna; an auxiliary antenna; a receiving device; two similar and equal circuit arrangements differentially connecting said receiving device to said receiving antenna; two similar and equal auxiliary circuit arrangement differentially connecting said receiving device to said auxiliary antenna; a source of high frequency waves connected to one of said first named circuit arrangements; and a second local source of high frequency waves connected to one of said second named auxiliary circuit arrangements.

11. In a signaling system, wherein signals are transmitted by the agency of a high frequency carrier wave modulated in accordance with said signals, a receiving organization comprising a receiving antenna tuned to a frequency differing from that of said carrier wave by approximately mean speech frequency, an oscillation circuit coupled to said antenna and tuned to the same frequency as said antenna, a second similar and equal oscillation circuit similarly related to said antenna, a vacuum tube amplifier whose input side is connected to said first named oscillation circuit, a second similar and equal vacuum tube amplifier whose input side is connected to said second named oscillation circuit, a third oscillation circuit, tuned

to the same frequency as said antenna, and connected to the output side of said first named amplifier, a fourth oscillation circuit, similar and equal to said third named oscillation circuit and connected to the output circuit of said second named amplifier, a source of high frequency energy, generating undamped waves of the frequency of said carrier wave, and connected to said third named oscillation circuit, a vacuum tube detector whose input side is connected to said third named oscillation circuit, a second similar and equal vacuum tube detector whose input side is connected to said fourth named oscillation circuit, and a telephone receiver differentially connected to the output circuits of said vacuum tube detectors.

12. A wireless receiving system comprising a receiving antenna; two similar and equal circuit arrangements including amplifiers and detectors similarly connected to said antenna; a local source of energy generating a continuous wave of the same frequency as said carrier wave and impressing it on one of said circuit arrangements; an auxiliary antenna tuned to a frequency

differing from that to which said receiving antenna is resonantly responsive; two similar and equal circuit arrangements including amplifiers and detectors similarly coupled to said auxiliary antenna; a local source of energy, generating a continuous wave and impressing said wave on one of said circuit arrangements associated with said auxiliary antenna; and a receiving device coupled to all of said circuit arrangements the coupling being differential as regards the two circuit arrangements having locally generated waves impressed thereon and differential as regards the two circuit arrangements associated with said receiving antenna, and also as regards the two circuit arrangements associated with said auxiliary antenna.

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

JOHN R. CARSON.

Witnesses:

FRED'K S. ROBINSON,
GEORGE E. FOLK.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."