J. W. LEE & J. L. HOGAN, JR.

TRANSMITTING INTELLIGENCE BY RADIANT ENERGY.

APPLICATION FILED NOV. 16, 1912.

1,141,717.

Patented June 1, 1915.

2 SHEETS—SHEET 1.

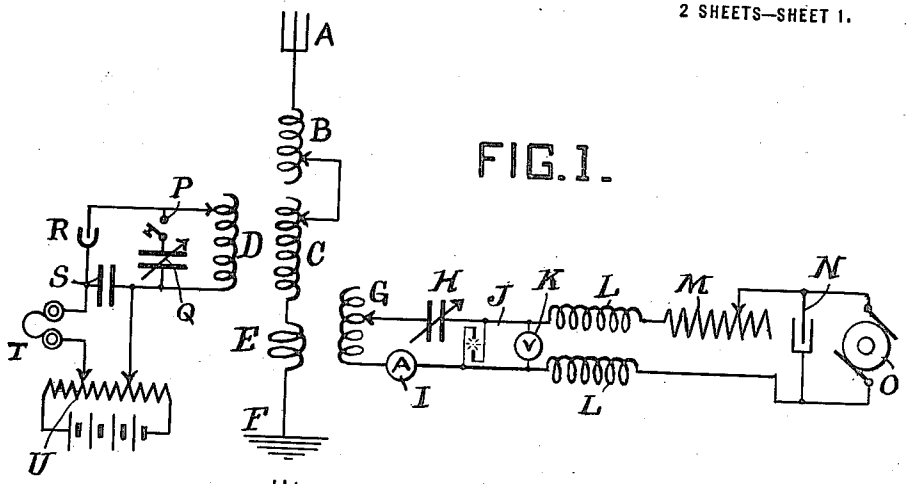

FIG. 1.

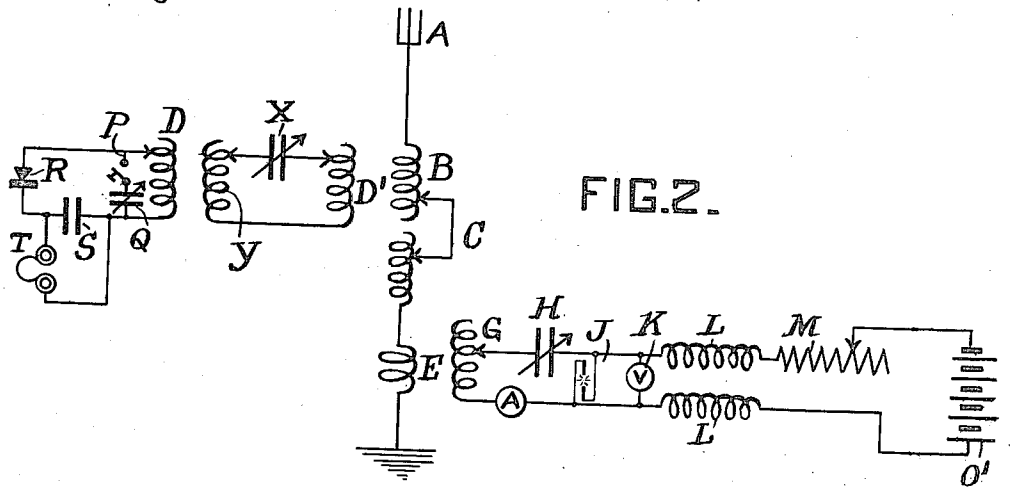

FIG. 2.

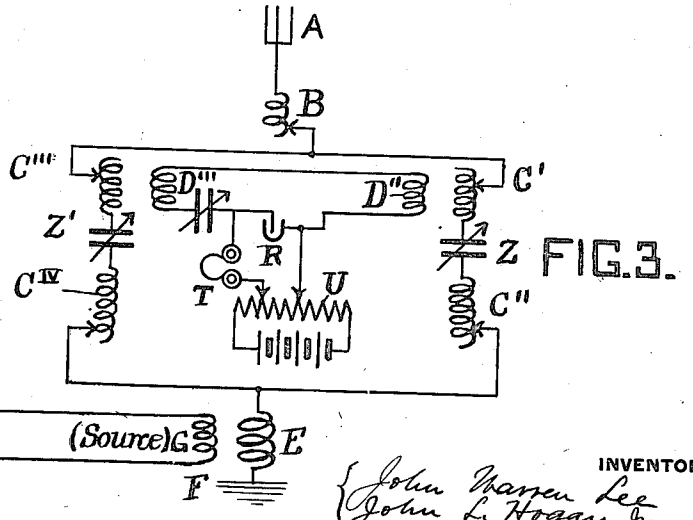

FIG. 3.

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2 SHEETS—SHEET 2.

FIG. 4

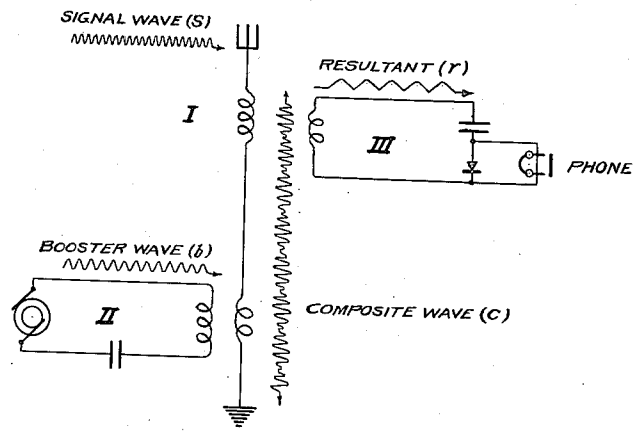
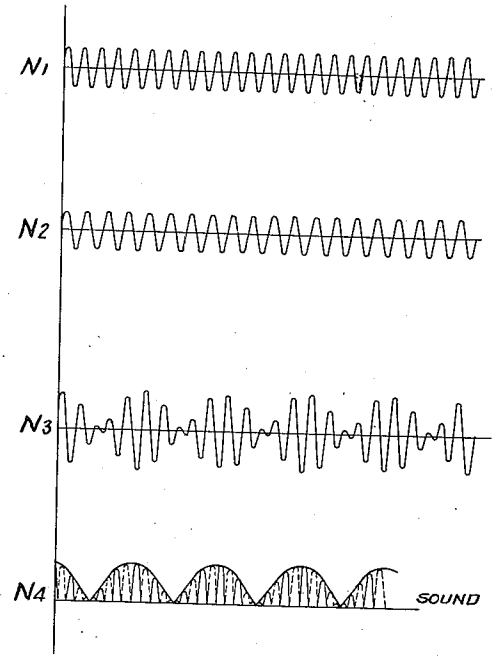


FIG. 5



WITNESSES

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UNITED STATES PATENT OFFICE.

JOHN WARREN LEE, OF BROOKLYN, AND JOHN L. HOGAN, JR., OF WEST ROCKAWAY, NEW YORK, ASSIGNORS, BY MESNE ASSIGNMENTS, TO SAMUEL M. KINTNER, OF PITTSBURGH, PENNSYLVANIA, AND HALSEY M. BARRETT, OF BLOOMFIELD, NEW JERSEY, RECEIVERS.

TRANSMITTING INTELLIGENCE BY RADIANT ENERGY.

1,141,717. Specification of Letters Patent. Patented June 1, 1915.

Application filed November 16, 1912. Serial No. 731,747.

To all whom it may concern:

Be it known that we, JOHN WARREN LEE and JOHN L. HOGAN, Jr., citizens of the United States, residing, respectively, at Brooklyn and at West Rockaway, in the State of New York, have invented certain new and useful Improvements in the Art of Transmitting Intelligence by Radiant Energy, of which the following is a specification.

Our invention relates to electric signaling generally and is herein described as applied to receiving wireless telegraph messages, though it is not confined to that particular art.

Its more particular objects are to avoid the effects of interference and static disturbances, to amplify the final physical effect of the energy of the received messages and subject it to immediate control of the receiving operator. In other words, it is to improve the range, clearness and accuracy of signaling.

We have illustrated the invention in the accompanying drawings, wherein—

Figure 1 is a diagram representing a receiving wireless telegraph station with a standard arrangement of receiver and the necessary auxiliaries for employing our invention. Figs. 2 and 3 show alternative arrangements of receiving circuits to be hereinafter described. Fig. 4 is an explanatory diagram illustrating one possible explanation of the theory of the invention, and Fig. 5 is a set of diagrams illustrating the combination of several oscillating current waves into a component or resultant for use in the receiver.

We understand the essence of the well known Fessenden heterodyne receiver to lie in the production of a signal at the receiving station by combining the effects of the received energy of the message with the effect of other energy emanating from a different source, and usually locally produced at the receiving station. Our invention in a general way embodies the same idea but comprises a method and apparatus for making a receiver more sensitive and controllably selective than those heretofore known. It contemplates, in a broad sense, the creation of a controllable artificial wave form at the receiving station by the combined effects of the received electrical signaling wave and another wave produced from another source, such combination being accomplished before the energy reaches the receiver, and thereupon operating a detector and indicator by this newly created electric wave train.

The matter may be made clearer by first referring to the diagram of Fig. 4, wherein the elements are shown in simplified form as three circuits (I), (II), (III). The signaling wave s is here shown as arriving from a station signaling with a sustained radio frequency alternating current, and it of course sets up in the antenna circuit (I) an oscillating current represented by this wave form. The circuit (II) generates continually an auxiliary or booster wave b which is also impressed upon the antenna circuit or some other circuit anterior to the detector itself.

The result of the two wave forms s and b is to produce in the antenna circuit (I) a composite wave form such as illustrated at c. This composite wave being impressed on the receiver circuit (III), it is rectified by an integrating detector into a resultant such as illustrated at r, which in turn moves the telephone diaphragm. That is to say in some way the combined signal wave and booster wave form beats and these beats operate the telephone after the current has been rectified. The essence of our discovery is that this mode of operation has the effect of greatly amplifying the signal, of giving it a distinctive character peculiar to the adjustment of the receiving station and always under control, and moreover of weakening all interfering signals and largely suppressing the effects of static disturbances. (Of course, it is immaterial whether the character of the detector is such as to actually rectify the current or whether it is to vary a continual current or otherwise act in any way.)

In the simple embodiment of apparatus for practicing our invention as shown in Fig. 1, the antenna A—F contains a tuning inductance B, the primary C of a transformer, adjustable in both its coils and in its coupling, and a secondary E of another transformer likewise adjustable in coils and

coupling. The secondary D is in circuit with a detector or converter R which may be of any modern form which acts cumulatively and is proportionally responsive, and a condenser S and indicator such as telephone T. The circuit also is preferably provided with an adjustable condenser Q controlled by switch F, and a battery and potentiometer U is used to render the detector more sensitive.

The primary coil G of the other transformer, is in circuit with an adjustable condenser H, an arc J, a direct current generator O, and in this case inductances L, L, for steadying the arc and preferably also a volt meter K, an ammeter I, and a small condenser N across the commutator of the dynamo to suppress variation of voltage on the arc. We also use a variable resistance M for adjusting the voltage on the arc.

In operation the generating circuit of the primary G is at first left open, and the antenna circuit A—F and the responsive receiver circuit connected with the secondary D are adjusted to the frequency of the waves of the signal. The generator circuit of the primary G is then closed and adjusted to a frequency preferably slightly above or below that of the received waves. A current from this circuit therefore coöperates with the current produced by the arriving waves and results in an amplified response in the telephone T. In Fig. 2 the antenna circuit is the same, the booster or generator circuit is the same except for use of a storage battery O′ and the omission of the condenser N in Fig. 1, while the receiver circuit D, Q, R, S, T, is the same except for use of an ordinary solid rectifier R in place of the electrolytic cell shown in Fig. 1, and the omission of the local battery U; also excepting that the receiver circuit is coupled to the antenna inductively through an intermediate oscillating circuit D′, X, Y. These arrangements allow of a greater degree of electrical selection between received waves of different frequencies and therefore assist in eliminating interference. In Fig. 3 we show a receiver involving the well known Fessenden interference preventer, the antenna having two branches C′, Z, C″, and C‴, Z′, C^{IV}, which branches are respectively tuned to different frequencies, one of which is the frequency of the received waves, so that undesired waves equally and oppositely affect the secondaries D″, D‴, of the detector circuit, while for the wave to which the branch C′, Z, C″, is tuned for example, the energy is transferred through the secondary D″ freely to the detector R and indicator T.

It is preferred that the responsive receiver circuits should be of the usual low resistance type and the various elements should be assembled and arranged for easy adjustment of resonance period.

The apparatus forming the booster generating circuit should be combined in a unit separate from the usual receiving apparatus and located so as to have no stray inductive action on the receiver. The only connection should be by way of the inductive coupling G, E, which should be easily variable since the value of the current put into the antenna from this booster circuit largely governs the effectiveness of the apparatus. In some practical cases we have found that the induced booster current should be less than 500 microamperes, though it varies widely under differing conditions.

In some cases it is advantageous to introduce the booster current into the intermediate coupling circuit such as D′, X, Y in Fig. 2, rather than directly into the antenna. It will be understood that the generator of the booster current may be of any form, either a radio-frequency alternator or an arc converter or an interrupter circuit or otherwise. Any means of producing feebly damped alternating currents comparable in frequency to those received, may be employed. It is preferable to have the booster current continuous, or when it must be produced in oscillation groups the group frequency should be high. It will also be understood that the booster current need not be generated at the receiving station. Thus it would be a feasible plan to have one station produce a booster current for several others.

With the above described apparatus, and with any standard receiving set having an integrating and cumulatively acting detector or current converter, with the addition of a generator for the booster current, we find that the combination has the peculiar property of amplifying the received signals while it simultaneously suppresses the effect of interfering signals as well as of atmospheric disturbances. Apparently various beats are formed when the oscillations of the booster circuit are of a frequency which is a multiple or sub-multiple of the frequency of the received waves, as well as when the frequency is slightly different.

While we are of course not bound to any theory of operation, the invention may be better explained by considering the diagrams of Fig. 5. Assume that the wave marked N_1 emanates from a sending station signaling with a sustained radio frequency alternating current and that the receiving antenna circuit is nearly or exactly in resonance with this frequency, it will of course be traversed by oscillating current represented by this wave form N_1. Suppose also that from another source, which may be the local booster circuit G, J, O, of Fig. 1, there is impressed upon the antenna an oscillating current such as shown at N_2, be-

ing slightly different in frequency from the wave N_1, the amplitude of the wave N_2 being adjusted by varying the mutual induction between the coils G and E, the result will be that the two oscillating currents of frequencies N_1, N_2, will re-act upon each other to form a resultant current in the antenna of the frequency N_3 which is the arithmetic mean difference between the frequencies N_1 and N_2 and is of variable amplitude. This interference of these two currents produces an alternating reinforcement and annulment of each wave by the other in a manner analogous to the production of beats in acoustics, and the resultant variations of amplitude of course pass through complete cycles at a rate per second which is in general the difference of the frequencies N_1 and N_2: This current in the antenna being induced into the receiver circuit will be converted by the detector R into a series of uni-directional pulses through the telephone coil, these pulses having the same variation in amplitude as the composite alternating current in the antenna. Such pulses may be represented by the heavy line N_4 and it is evident that this line represents also the sound wave formed by the telephone.

It is obvious that whatever frequency we have in the wave N_1, the resultant wave may be made of any value desired by varying the value of the booster current N_2. We thus get an audible signal from continuous radiation from the transmitting station, the audible beats being under entire control of the receiving operator, so that he may easily arrange them to distinguish from any interfering wave. It is well known in acoustics that the amplitude of the beats may be considerably greater than the amplitude of one of the component waves. We have found in practice that the composite wave can be clearly heard when the received signal wave alone can produce no audible effect whatever. We have frequently obtained amplification of as much as ten times in current and correspondingly as much as a hundred times in energy. It will be understood of course that the same phenomena occur when the received signal is composed of groups of waves rather than continuous radiation, though the control of the response tone is not so complete in this case. Some persistence of the received radiation is necessary for the best results.

In addition to the amplification of response, and the control of the character of the response, attained by our invention, we find the application of the local excitation to the antenna or other circuit anterior to the detector causes a reduction of the effect of waves having frequencies outside the range for reacting in audible beats. The static disturbances are in all cases reduced and in some cases entirely eliminated, probably because of the rapid decay in current produced by such shocks. That is, we may increase the sensitiveness and selectivity of the receiver without increasing its sensitiveness to static disturbances.

It is quite probable that many oscillating currents produced by electromagnetic waves or otherwise are waves which are not simple sine waves and the beats of course may be produced with either the fundamental or the subsidiary variations of amplitude.

Our invention does not depend upon any theory or explanation of the phenomena, but upon the discovery of the phenemena and their application to a useful purpose as described. Many advantages of the invention will be readily appreciated by those familiar with the art.

Having thus described our invention and illustrated its use, what we claim is—

1. The method of receiving oscillating current energy by first combining it with the energy of a separately produced auxiliary oscillating current whose frequency is slightly different from the frequency of the received current, and then rectifying and utilizing the combined current to operate an indicator.

2. The method of wireless signaling which comprises exciting a receiving circuit by the received wave energy and also by an auxiliary alternating current of a frequency so related to the frequency of the received energy as to produce beats therewith, and then rectifying and using this composite current to operate a receiving instrument, whereby to amplify the effect of the received signal.

3. The method of wireless signaling which comprises the constant production of an auxiliary oscillating current of frequency similar to that of the received signaling waves, combining such auxiliary current with the received current, electrically rectifying the combined current, and utilizing it to operate an indicator.

4. An amplifier and discriminator for wireless signal receiving apparatus, comprising an auxiliary source of current adapted to excite the receiving circuits with a frequency near to, and different from the frequency of the current of the received waves, means for electrically rectifying the current resulting from the combined effects of said two currents, and an indicator operated by the rectified current.

5. A receiver for wireless signaling, comprising an antenna, a cumulatively and proportionally responsive detector associated therewith, a current operated indicator, and an independent coöperating source of current also associated with the antenna and having a frequency differing slightly from the frequency of the received signaling current, so as to produce beats therewith and thereby

operate the indicator by the combined currents.

6. Wireless signaling apparatus, comprising the combination of an antenna circuit, a resonant receiving circuit containing an integrating rectifying detector and an indicator, a local source of continuous oscillating current at a frequency differing slightly from the frequency of the received oscillations, and means to excite said antenna therewith, whereby to affect the detector and indicator by the combined power of the locally generated current and the received signaling current.

7. In wireless signaling apparatus the combination with the receiving circuits, a detector and a current operated indicator, of a local means to generate a coöperating current and produce beats with the current of the received waves, whereby to control the character of the signal note during the receipt of messages, substantially as described.

In testimony whereof we have hereunto signed our names in the presence of the two subscribing witnesses.

JOHN WARREN LEE.
JOHN L. HOGAN, Jr.

Witnesses:
FLORENCE M. LYN,
F. H. KROGER.