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D. G. McCAA.

METHOD OF AND APPARATUS FOR ELECTRICAL COMMUNICATION.

APPLICATION FILED DEC. 19, 1918.

1,344,275.

Patented June 22, 1920.

3 SHEETS—SHEET 1.

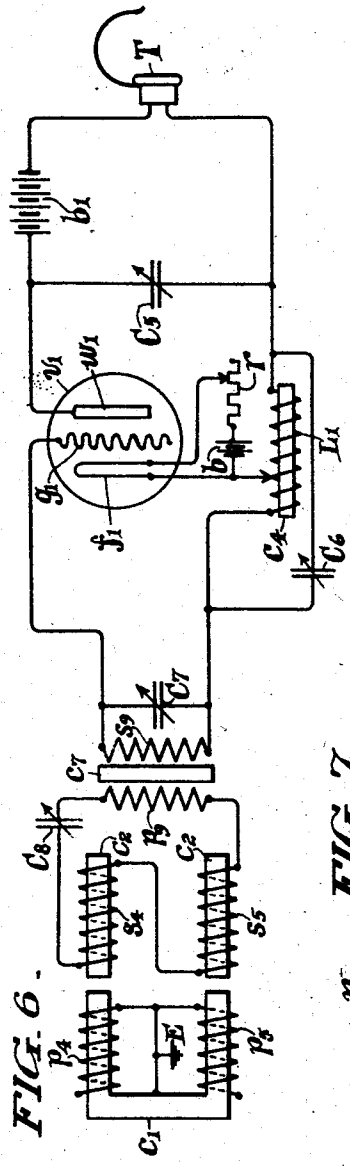


FIG. 6.

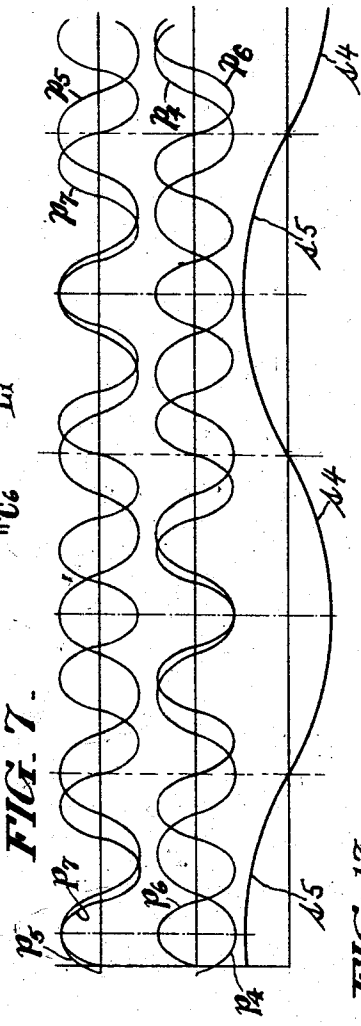


FIG. 7.

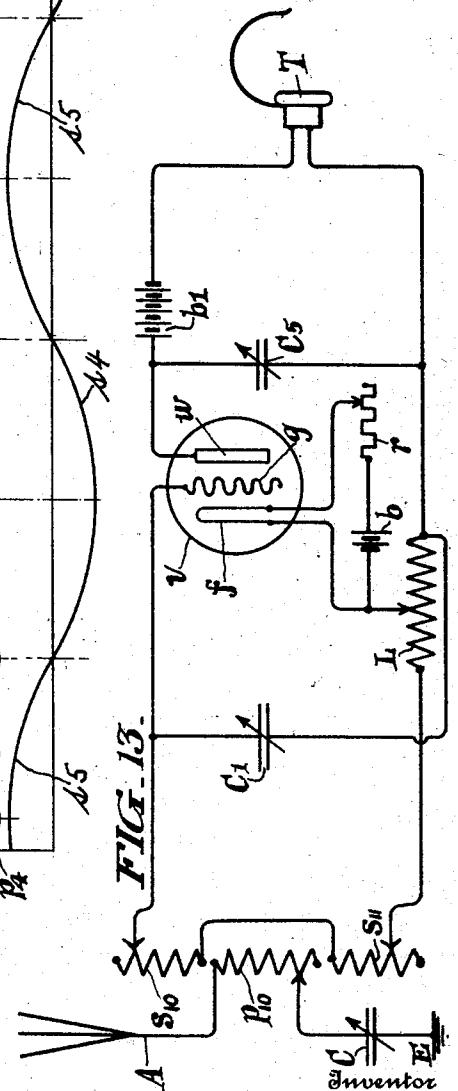


FIG. 13.

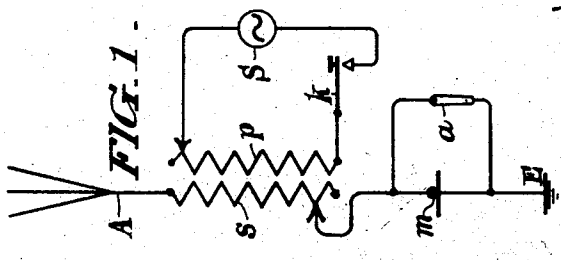


FIG. 1.

Inventor

David G. McCaa

by Cornelius D. Ehret

his Attorney

D. G. McCAA.

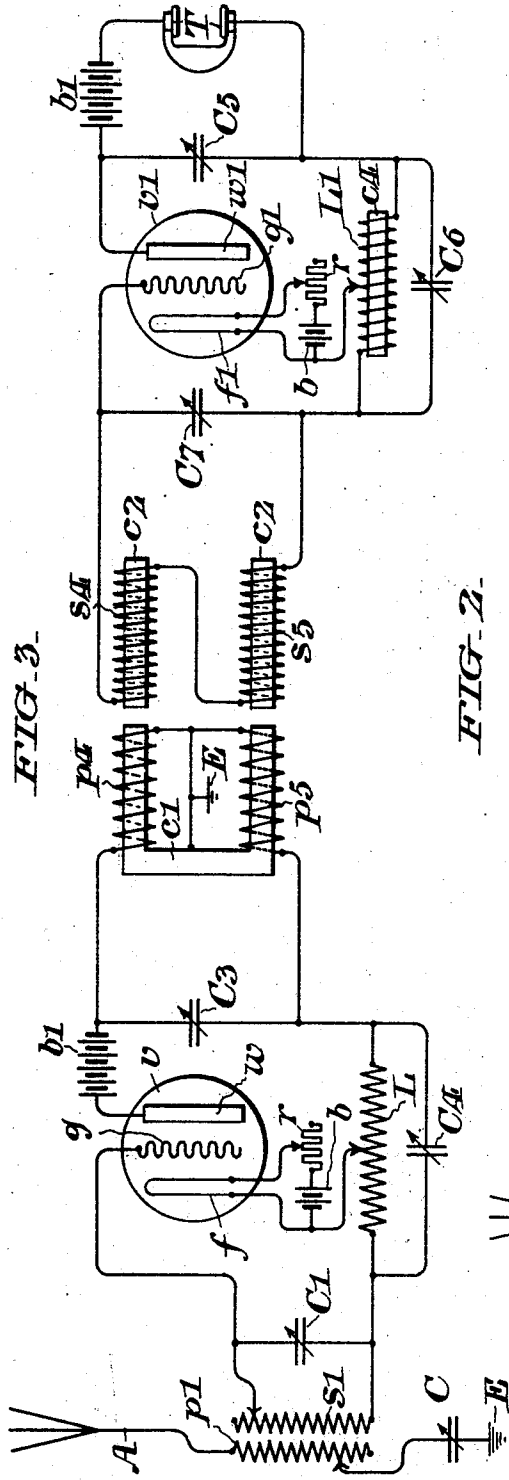
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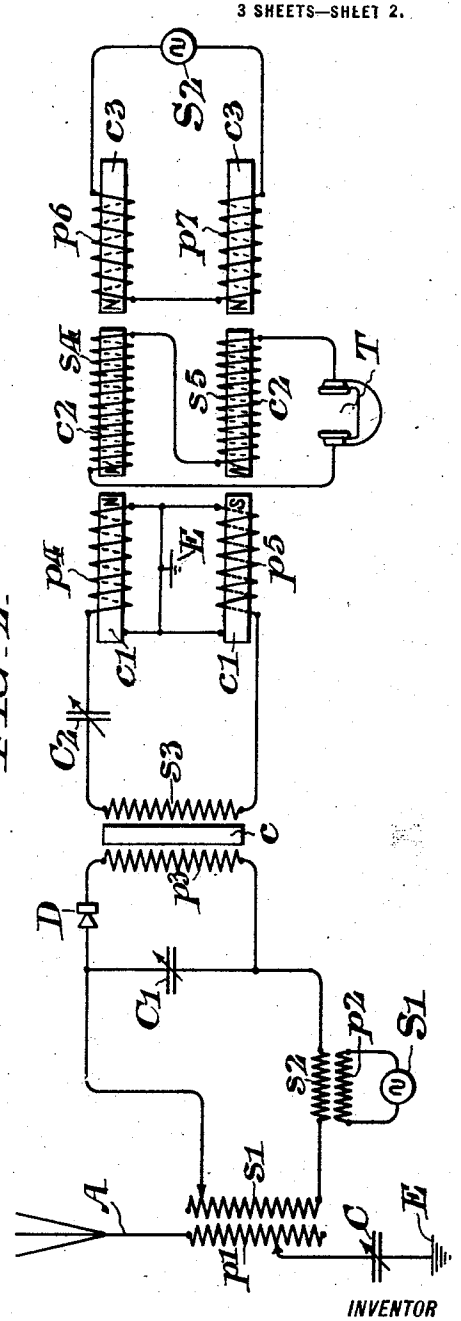
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3 SHEETS—SHEET 2.





INVENTOR

David G. McCaa

by Cornelius D. Ehret

his ATTORNEY

D. G. McCAA.

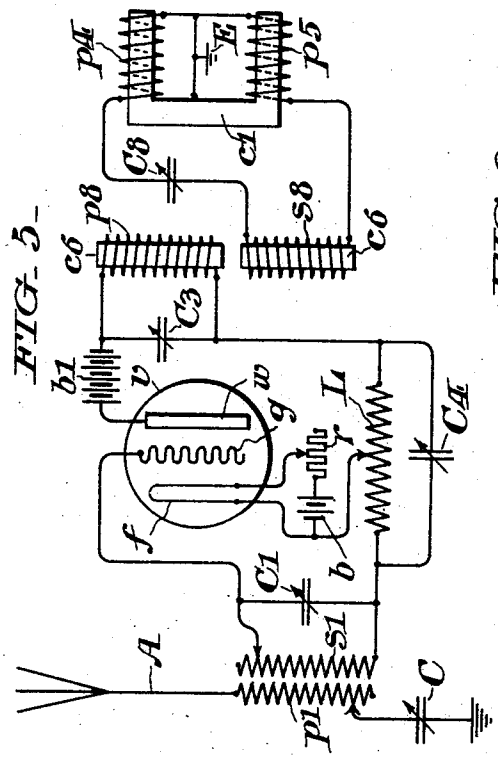
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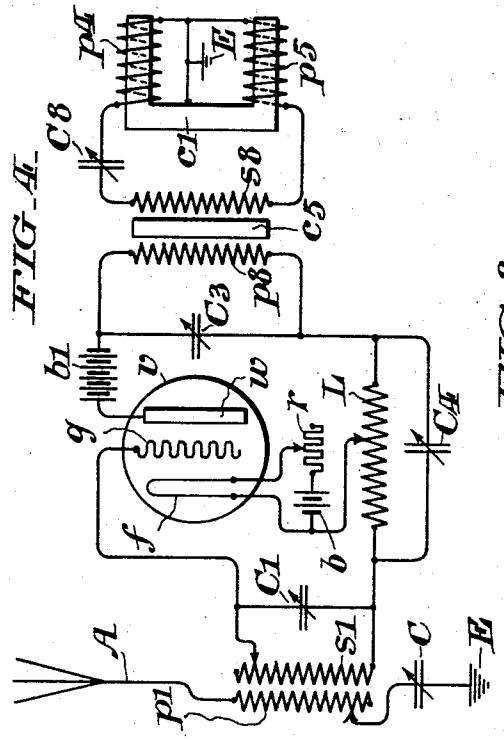
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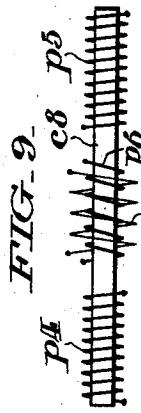
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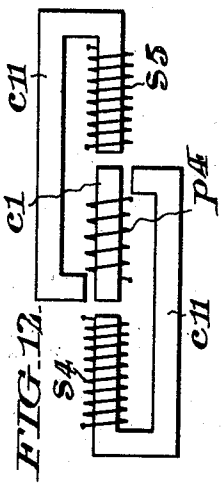
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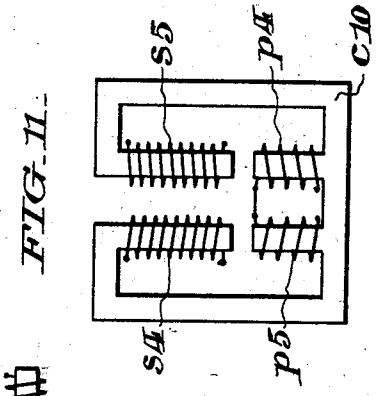
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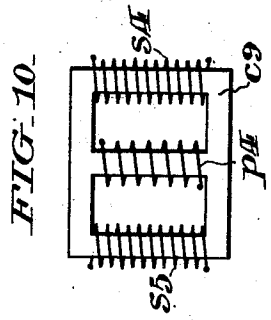












INVENTOR.

David G. McCaa

BY

Cornelius D. Ehret

his ATTORNEY.

UNITED STATES PATENT OFFICE.

DAVID G. McCAA, OF ELIZABETH, NEW JERSEY.

METHOD OF AND APPARATUS FOR ELECTRICAL COMMUNICATION.

1,344,275. Specification of Letters Patent. Patented June 22, 1920.

Application filed December 19, 1918. Serial No. 267,445.

To all whom it may concern:

Be it known that I, DAVID G. McCAA, a citizen of the United States, residing in the city of Elizabeth, county of Union, and State of New Jersey, have invented a new and useful Method of and Apparatus for Electrical Communication, of which the following is a specification.

My invention relates to a method of and apparatus for telegraphy, telephony, or signaling in general, or any analogous purpose, employing high frequency electrical energy used in the so-called radio systems in which the energy is transmitted from station to station in radiant form, as well as in carrier wave systems in which the energy is conducted or guided by wires or conductors extending between stations.

It is the object of my invention to provide a method and apparatus in and by which interference caused by natural electrical effects, as lightning, electrical atmospheric disturbances in general, and particularly the so-called static or stray effects heretofore so troublesome in radio or kindred systems, shall be prevented; and while the foregoing is my principal object, my method and apparatus serve also to prevent interference by other radio systems, particularly when employing damped waves or groups of damped waves, as in so-called spark sets. And my invention is applicable also in case the transmission is by high frequency energy over a wire or wires extending between stations, to prevent interference by other or neighboring high frequency circuits, or by neighboring circuits carrying current of ordinary low or commercial frequency used in lighting or power transmission, or in general inductive effects from neighboring circuits or apparatus, as well as interference caused by any natural disturbances, as earth currents or atmospheric electrical effects.

To these ends I prefer to employ oscillations or current of a frequency well above audibility, for example, a radio frequency, and cause to interact therewith in the receiving apparatus other high frequency oscillations or current of frequency above audibility, for example, a second radio frequency, to produce beats which shall have a frequency above audibility. This primary beat energy is then caused to react, through a magnetic or electromagnetic coupling of suitable character, with high frequency oscillations or current of such high frequency, again above audibility, as to produce secondary beats whose frequency in the case of telegraphy is audible and in the case of telephony is inaudible.

My invention resides also in a method of and apparatus for producing a beat current, comprising alternate uni-directional current waves of opposite signs, similar to a true alternating current, by interaction between currents of different frequencies in a novel arrangement of coupled circuits, as hereinafter described.

It is further characteristic of my method and apparatus that when the frequency of the initial oscillations is changed for any reason, or when it is desired at a receiving station to receive only from a predetermined sending station, only the few and ordinary tuning adjustments now common in radio systems need be effected.

My invention resides in further features of method and apparatus hereinafter described.

For an illustration of several of the many forms my apparatus may take, and for an understanding of my method in some of its various aspects, reference is to be had to the accompanying drawings, in which:

Figure 1 is a diagrammatic view of simple transmitting apparatus for impressing upon the natural media or upon a line conductor sustained or undamped high frequency oscillations controllable either by a telegraph key or a telephone transmitter, as a microphone.

Fig. 2 is a diagrammatic view of receiving apparatus embodying my invention.

Figs. 3, 4, 5 and 6 are diagrammatic views of modified forms of receiving apparatus embodying my invention.

Fig. 7 is a graphic illustration of a principle involved in my invention.

Figs. 8, 9, 10, 11 and 12 are diagrammatic illustrations of modified forms of magnetic circuit arrangements which may be employed in my coupling structure.

Fig. 13 is a diagram of modified circuit arrangements embodying my invention and for practising my method in the case where the received energy, without production of primary beats, co-acts with locally produced oscillations.

Referring to Fig. 1, S is any suitable source of high frequency oscillations or

high frequency alternating current, the frequency being commonly known as a radio frequency, above audibility. In circuit with the source S is the transformer primary p and any suitable signaling instrument, as a telegraph key k. The transformer secondary s is connected in well known manner to the antenna, radiating conductor or structure of any suitable character A and to earth as at E. Or the secondary s may deliver its energy to any single wire or metallic circuit extending between transmitting and receiving stations, as in the carrier wave systems of wire telegraphy or telephony. As well understood, by manipulating the key k, undamped or sustained oscillations will be transmitted in long and short groups. In radio systems the energy radiates from the antenna A to the distant receiving systems, or in wire carrier systems traverses a conductor to the receiving station.

By closing the key k and opening the switch a, the telephone transmitter, as microphone m, is brought into circuit into the antenna, and speech uttered against the microphone will control the amplitude of the transmitted oscillations in accordance with speech.

The apparatus thus far described is of well known character and *per se* is no part of my invention, which, however, resides in a system involving both transmitting and receiving apparatus of suitable character cooperating in novel manner, and in novel method of and apparatus for receiving high frequency energy.

In Fig. 2 A is the receiving antenna or radio energy absorbing structure, or it may be a conductor extending from the transmitting station to the receiving station. The conductor A is connected to earth E through the adjustable transformer primary p^1 and the adjustable tuning condenser C. The adjustable transformer secondary s^1 is connected in series with the tuning condenser C^1 and the transformer secondary s^2, whose primary p^2 is connected in circuit with the source S^1, of any suitable type, delivering preferably undamped or sustained high frequency oscillations, their frequency being a so-called radio frequency above audibility. In shunt to the tuning condenser C^1 is connected a circuit including the detector D, of any suitable type, preferably an integrating detector, as a well known crystal detector or a thermionic or vacuum tube detector, and the primary p^3 of a transformer which may have a core c of laminated iron or other suitable magnetizable material. In circuit with the secondary s^3 is the tuning condenser C^2 and the primary coils p^4, p^5 of apparatus operating, under certain conditions later to be described, as a magnetic coupling. The coils p^4, p^5 are preferably disposed upon cores c^1, c^1, of laminated iron or other magnetizable material. The coils p^4, p^5 are so wound or so connected that there are produced at their right ends magnetic poles of opposite polarities. Disposed in front of the poles of the cores c^1, c^1 are the coils s^4, s^5, so wound or connected that if a current were passed through them their left ends would produce magnetic poles of like polarity. In circuit with the coils s^4, s^5, is connected the receiving telephone structure T, of any suitable type, as for example, the well known magnetic type commonly used in radio apparatus at the present time. The coils s^4, s^5 may be disposed upon laminated cores c^2, c^2 of any suitable magnetizable material. S^2 is a source, of any suitable character or type, of preferably sustained or undamped oscillations or alternating current of a frequency above audibility. In circuit with this source are connected the coils p^6, p^7 so wound or so connected that their left ends produce magnetic poles of like polarity. While the coils p^6, p^7 are shown connected in series with each other, they obviously may be connected in parallel. These coils preferably have laminated cores c^3, c^3 of any suitable magnetizable material.

The mode of operation is as follows:

With the operator at the transmitting station, Fig. 1, manipulating the key k, there are transmitted long and short groups of undamped waves of substantially constant amplitude. These produce their well known effect in the conductor A, Fig. 2, the circuit of the conductor A, particularly when an aerial or absorbing structure in a radio system, being attuned to the frequency of the oscillations transmitted from the apparatus of Fig. 1 by adjusting the primary p^1 and the condenser C. In the circuit of the secondary s^1 oscillations of this same frequency appear, adjustment of the secondary s^1 and condenser C^1 serving to attune the secondary circuit to the frequency of these received oscillations. There are superimposed upon or caused to react or interact with these received oscillations oscillations of frequency above audibility from the source S^1 through the inductive coupling p^2, s^2. The result is in effect beats, herein referred to as the primary beats of the system, which affect the detector or other responsive device D, causing passage through the primary p^3 of a beat current whose beat frequency is above audibility. There is accordingly produced in the circuit of the secondary s^3 a current varying in amplitude at a frequency above audibility and dependent upon the frequency of the primary beats. The current of frequency above audibility in the circuit of the secondary s^3 is passed through the coils p^4 and p^5, causing magneto-motive-forces alternating in intensity at like inaudible fre-

quency and which coöperate, respectively, with the magneto-motive-forces simultaneously produced by the coils p^6, p^7 in influencing the cores c^2, c^2 and their associated coils s^4, s^5, so that in their circuit there results a current whose frequency is the difference between the frequencies of variation of the magneto-motive-forces produced by coils p^4, p^5 and the frequency of the magneto-motive-forces produced by the coils p^6, p^7, whereby the windings of the telephone T are traversed by currents constituting secondary beats of audible frequency.

Accordingly both primary and secondary beats are produced, and the secondary beats are of audible frequency and manifest themselves by notes in the telephone T.

For example, the frequency of the oscillations transmitted from the apparatus in Fig. 1 may be 300,000 per second; the source S^1 may produce current of a frequency of, say, 270,000 or 330,000 per second, whereby the primary beats will have an inaudible frequency of 30,000 per second, this being the frequency also of the magneto-motive-forces produced by coils p^4, p^5. The source S^2 may produce current of frequency of 29,000 or 31,000 per second, with the result that in the circuit of the telephone T there would be produced a current of frequency of 1,000 per second, producing the clear high pitched note commonly used in radio telegraphy.

The cores c^2, c^2 may, respectively, be at any suitable distance from the opposing cores c^1, c^1. That is, the length of the gap between the upper cores c^1 and c^2 may be different from the length of the gap between the lower cores c^1 and c^2. And it is a matter of indifference whether the gap length between the upper cores c^2 and c^3 is the same or different from the length of gap between the lower cores c^2 and c^3. With such inequality of gaps between upper cores c^1 and c^2 and the lower cores c^1 and c^2, signals of greater strength will be produced in the telephone T than in the case when the gaps between the upper cores c^1, c^2 and the lower cores c^1, c^2 are adjusted with great nicety to equality, that is to say, when the cores c^2, c^2 are adjusted with nicety to any such position with respect to the cores c^1, c^1 that with the circuit of the source S^2 open the electro-motive-forces induced by coils p^4 and p^5 in the coils s^4 and s^5 are equal and opposite, with resultant silence in the telephone T. That is, when the cores c^1, c^2 are so adjusted with respect to each other the electro-motive-forces induced in the coils s^4 and s^5 are not only equal to each other, but are opposite in phase, no current will flow in the circuit of the telephone T, and there will be silence; and this is the case whatever the form, character or nature of the current in coils p^4 and p^5. Neither the desired signal nor any undesired or interfering energy will produce any effect in telephone T so long as source S^2 is not operative.

The adjustment of the coils s^4, s^5 with respect to coils p^4, p^5 to position in which, with the circuit of the source S^2 open, there is no signal produced in the telephone T, is the optimum adjustment, and atmospheric disturbances of any character, as lightning, so-called atmospherics, static and strays, in general any disturbance of low or audible frequency, produce no effect in the telephone T, and so their effects are completely eliminated or prevented.

The aforementioned natural electrical disturbances commonly known as lightning, strays, static, atmospherics, etc., produce effects manifesting themselves as electrical charges, aperiodic impulses or damped waves on or in the receiving conductor A. And these undesired effects are to greater or less extent transferred by the transformer p^1, s^1 to the secondary circuit tuned by the condenser C^1, and may even set up in such tuned circuit oscillations of the same frequency to which that secondary circuit is attuned. But these undesirable oscillations in the secondary circuit are in effect trains of damped waves, and generally highly damped; and the wave trains occur at irregular intervals, and generally at decidedly irregular intervals. Such a train of damped waves produces in the primary p^3 in effect a single uni-directional impulse and by inductive action there will be produced in the coils p^4, p^5 a single cycle of current superimposed upon the signaling current hereinbefore referred to. And this result of static or other atmospheric disturbances in the coils p^4, p^5 will occur whether or not the source S^1 is delivering oscillations into the circuit of the secondary s^1. The current from the source S^1 does not react with the train of damped waves caused by the static, stray or other atmospheric effect to produce a series of impulses, as beats, but will cause only a single impulse which will reach, as above described, the coils p^4, p^5. But such a single cycle in the coils p^4, p^5 and due to the natural atmospheric electricity will produce no effect in the coils s^4, s^5 and telephone T when the circuit of the source S^2 is open, owing to the fact that the adjustment is such, as above described, that the effects, if any, in the coils s^4, s^5 are equal and opposite for all forms or kinds of current in coils p^4, p^5. With the circuit of the source S^2 closed through coils p^6, p^7, however, the effect is no different so far as regards production of sound in the telephone T. In such case not only is the effect of the single cycle of current, of audible frequency, without direct effect upon the telephone T, but, being of low or audible frequency, cannot indirectly

produce by reaction with the frequency of the current delivered by source S^2 an audible effect or beat, because the difference between the frequency of this single cycle and the frequency of the source S^2 is still so high as to be above audibility.

And in the case where the stray or atmospheric effect produces not only a train of damped waves as above described, but produces a series of such wave trains, they occur, as above stated, at ununiform or irregular intervals, and whether these intervals be long or short, they occur at a frequency, though not uniform, which is within the range of audibility. And being within the range of audibility, they will not, when the source S^2 is active, produce by reaction audible beats or effects in the telephone T, because the difference between their frequency of recurrence and the frequency of the source S^2 is still above audibility.

When these natural electrical effects occur at their strongest, it is desirable to procure the above-mentioned optimum adjustment as between the coils s^4, s^5 and the coils p^4, p^5. But when these natural effects are weaker, an adjustment other than the optimum may be employed; and when there are no such natural disturbances the adjustment may be that hereinbefore described with the coils s^4, s^5 at such different distances from their coöperating coils p^4, p^5 that a louder beat note will be produced in the telephone T.

When the aforementioned optimum adjustment obtains, there is in effect no coupling between the coils p^4, p^5 and coils s^4, s^5, at least in the sense that coils p^4, p^5 produce no effect in the circuit of coils s^4, s^5. And when the adjustment is varied from the aforementioned optimum there is what may be called in effect a loose coupling between these two sets of coils. When the adjustment is varied but slightly from the aforesaid optimum, notwithstanding the closeness of the two sets of coils to each other, the extent or degree of coupling obtainable is very small, and is as small, notwithstanding the close approach of the two sets of coils to each other, as may be obtained with windings of an ordinary inductive coupling only when they are far apart.

The mode of production of the secondary beats hereinbefore described may be understood by an inspection of Fig. 7 in which abscissae represent time and ordinates represent amplitudes or magnitudes of currents or magneto-motive-forces. In the upper of the three graphs there are plotted the simultaneous currents or magneto-motive-forces in or due to the coils p^5 and p^7. The frequency of change in or due to the coil p^5 is the primary beat frequency and is represented by the curve marked "p^5"; and the simultaneous frequency of change in or due to the coil p^7 is represented by the curve marked "p^7." In the middle graph "p^4" represents the simultaneous primary beat current in or effect due to coil p^4, while the curve marked "p^6" represents the simultaneous effect of current from source S^2 in the coil p^6. It will be noted that the first half wave of the curve marked "p^4" is in exactly opposite phase from the first half wave of the curve marked "p^5," because the coils p^4 and p^5 are so wound or connected that at the right ends of the cores c^1, c^1 there occur at a given instant opposite polarities; for example, the right end of the upper core c^1 may at a given instant be north, as indicated by N on the drawing. Simultaneously the right end of the lower core c^1 will be a south pole indicated by S on the drawing. It will be noted that the first half waves of the curves p^6 and p^7 are in phase with each other, indicating that the left ends of the cores c^3, c^3 are at the same instants both north poles, indicated by N on the drawing. The lowermost curve of Fig. 7 is the resultant in the circuit of the telephone T of the four curves p^4, p^6, p^5 and p^7 of the two graphs above. The first quarter wave s^5 of this lowermost curve represents electro-motive-force or current due to the coil s^5 as the resultant of the effects thereon of coils p^5 and p^7; the next half wave s^4, below the line, is the current or electro-motive-force due to the coil s^4 as the resultant of the later effects thereon of coils p^4 and p^6; and the next part of the wave above the line is again the effect due to the coil s^5 coöperating with coils p^5 and p^7. The lowermost graph indicates a fluctuation of electro-motive-force or current in the circuit of the telephone T of a frequency which is the difference between the beat frequency in coils p^4, p^5 and the frequency of the current from the source S^2. In effect, therefore, the coils s^4 and s^5 alternately deliver to the telephone T uni-directional impulses, alternate impulses, however, being of opposite signs, so that we have in effect in the telephone T a true alternating current of frequency which is the difference between the primary beat frequency and the frequency delivered by source S^2. This method of and apparatus for producing by interaction of currents of different frequencies a beat current which in effect is a true alternating current is, I believe, broadly novel.

While in the foregoing example certain polarities have been assumed at the right and left ends of the cores c^1, c^1 and c^3, c^3, respectively, it will be understood that any other suitable instantaneous polarities may be assumed or provided so long as the principle of action remains the same. For example, with the right end of the upper core c^1 a north pole at a given instant, the right end of the lower core c^1 may be at the same

instant a north pole. The left end of one of the cores c^3, c^3 must, however, in such case be a south pole; and simultaneously the current or direction of winding of one of the coils, either s^4 or s^5, should be reversed. This change of polarity for the core of the lower coil p^5 may be obtained simply by interchanging its terminals; and similarly the terminals of either coil p^6 or p^7 may be interchanged to reverse the current therethrough.

While in the foregoing description it has been assumed that the coupling is entirely magnetic as between the cores p^4, p^5 on the one hand, and coils s^4, s^5 on the other, there may be, and often is, due to their close approach to each other, an electrostatic coupling between the two systems. And such a coupling effect is undesirable as preventing as completely as may be desirable the effects of atmospheric or other disturbances. To minimize this electrostatic coupling between the two systems, the cores c^1, c^1, if employed, may be connected to earth E, as indicated in Fig. 2. And the circuit of the secondary s^3 or coils p^4, p^5 may also be connected to earth E as indicated.

Preferably each of the coils s^4, s^5 is so wound, in any mode now known to the art, to reduce its distributed capacity. Each coil may consist of a plurality of sectional coils serially connected and disposed at different positions longitudinally of the core c^2.

In the foregoing description it has been explained how the effects of natural electrical disturbances may be eliminated and prevented from reaching the telephone T or producing undesirable effects therein. It will be understood, however, that this same method and apparatus may be employed to prevent interference by or from any transmitter station or circuit producing or carrying damped wave trains, even when recurring with fair uniformity, as in the case of the so-called spark transmitters employed in radio telegraphy.

As regards both natural atmospheric disturbances and artificially produced trains of damped waves, as from spark transmitters, it may be stated that by connecting a telephone directly to the terminals of the secondary s^3, such natural disturbances as well as the artificial disturbances will produce an effect or parasitic noise in the telephone receiver when the source S^1 is not in operation. And with the source S^1 in operation, the effect in the telephone so connected may be a hiss in case the interference is caused by a spark transmitter, and in the case of natural electrical effects will be the same sound as heard when the source S^1 is not in operation. Yet under the same circumstances neither the natural nor the artificial disturbances, since they are of audible frequency, will produce any effect in the telephone T connected to coils s^4 and s^5 when source S^1 is in operation, and the optimum or nearly optimum adjustment is made.

When the adjustment of the apparatus in Fig. 2 is varied from the aforementioned optimum at which the effect of coils p^4 and p^5 upon coils s^4, s^5 is zero, the effect is that of a loose coupling, as above stated; therefore for such an adjustment, one coil of each of the three sets may be omitted, as by omitting coils p^5, s^5 and p^7, and in such case the coupling between p^4 and s^4 is made extremely loose. Such loose or extremely loose coupling will then aid largely in preventing static effects from affecting the telephone receiver T, due to the wide difference in the inductive effects produced on the one hand by the natural or artificial disturbances of low or audible frequency, and on the other hand by the undamped high frequency waves representing the signal or message it is desired to receive.

In Fig. 3, which discloses my preferred arrangement, an amplifying oscillating detector of the thermionic type is employed. As well known, it comprises the vessel v, either evacuated to the degree allowing only pure electron discharge or containing ionizable gas, containing a plate or wing electrode w and a cathode f in the form of a filament heated by current from the battery b passing through the adjustable resistance r. In the plate or wing circuit is the source of current or battery b^1, the coils p^4 and p^5, shunted by the condenser C^3, together with a part of the inductance L from a variable point on which a connection is made to the filament f. The other terminal of the inductance L is connected through the variable condenser C^1 and secondary s^1 to the grid g. In shunt to the inductance L is the adjustable condenser C^4. In effect the grid and plate circuits are coupled by the inductance L so that oscillations are set up whose frequency is chiefly determined by inductance L and condenser C^4. The condenser C^3 may be a large condenser of fixed capacity serving as to high frequency oscillations to by-pass the coils p^4, p^5. However, this condenser may be variable if desired, and when variable may to some extent affect the frequency of the oscillations. The frequency of the oscillations so locally produced by the vacuum tube is different from the frequency of the sustained or undamped waves received on the conductor A, so that there is produced a beat current, the frequency of the beats being the difference between the frequency of the incoming or undamped waves and the frequency of the oscillations produced by the vacuum tube, the circuit s^1, C^1 being attuned, as in the case of Fig. 2, to the undamped waves received upon the conductor A. As in the case of Fig. 2, therefore,

there is produced in the coils p^4, p^5 a primary beat current whose frequency is above audibility. In this case the core structure c^1 for the coils p^4, p^5 is in effect a horse shoe, and it, as well as the circuit of the coils p^4, p^5 may be connected to earth E, as indicated. A second vacuum tube v^1 having the plate or wing w^1, the grid g^1 and the filament f^1 is connected in a circuit comprising the source of current or battery b^1, telephone or other translating device T, and part of inductance L^1 to a variable point on which there is a connection to the filament f^1. The signal translating instrument or telephone T is bridged by the condenser C^5 to form a bypass for the high frequency oscillations. Shunted to the inductance L^1 is the variable condenser C^6. The grid g^1 is connected to the inductance L^1 and its condenser C^6 through the coils s^4 and s^5, which may be provided with laminated magnetizable cores c^2, c^2. In shunt to the coils s^4, s^5 is connected the variable condenser C^7. The coils s^4, s^5 are so wound or connected that the left ends of their cores c^2, c^2 are at a given instant of like magnetic polarities.

The inductance L^1 and condenser C^6 are the chief frequency determining elements of the oscillating circuit including the vacuum tube v^1, the frequency of the oscillations being above audibility, and such that its difference from the primary beat frequency in coils p^4, p^5 is an audible frequency which will be heard in the telephone T. In such case the vacuum tube v^1 serves not only as an oscillator, but it has the potential of its grid affected by the resultant produced by the coils s^4 and s^5, which resultant or secondary beat effect is amplified and made manifest in the telephone T.

The condenser C^5 may be a large condenser of fixed capacity for allowing a free path around the telephone T and battery b^1 for the high frequency oscillations. The condenser C^7 is adjustable and may tune the circuit comprising the coils s^4, s^5 and condenser C^7 to the secondary or resultant beat frequency; and this condenser C^7 is preferably adjusted to small capacity value, for in such case the intensity of the signals in telephone T is greater. This is due, I believe, to the fact that the current flowing through the coils s^4, s^5 is larger when the capacity of condenser C^7 is small. By connecting the coils s^4, s^5 in a circuit with the grid g^1, that is, in a grid circuit, the effect as to loudness of signals in the telephone T is greater than were the coils s^4, s^5 connected in the plate circuit.

Inasmuch as the frequency of the oscillations locally produced by the vacuum tube v^1 is or may be relatively low, though above audibility, the inductance L^1 may have a laminated core c^4 of magnetizable material.

It will be noted that the coils s^4, s^5, together with the vacuum tube v^1 and its associated circuits, make possible the omission of the coils p^6, p^7 of Fig. 2. Nevertheless, the principle and mode of operation are the same in that there is set up through the coils s^4 and s^5 a current of the frequency produced by the oscillating circuit of the vacuum tube v^1, with the result that only sustained or undamped waves producing beats in the coils p^4, p^5 will cause such an interaction with the coils s^4, s^5 and the currents carried thereby as to produce a secondary beat note in the telephone T. Here again the optimum adjustment to prevent effects of natural electrical disturbances or disturbances from artificial sources such as spark transmitting sets, is that for which the resultant of the effect of coils p^4, p^5 upon coils s^4, s^5 is zero. Briefly, the difference between Figs. 2 and 3 is that in Fig. 2 there is no source of current directly in the circuit of the coils s^4 and s^5; while in Fig. 3 the coils s^4 and s^5, besides bearing the relation to the coils p^4, p^5 borne by the same coils in Fig. 2, carry locally produced high frequency current.

In Fig. 4 the arrangement is similar to that of Fig. 3 except that the coils p^4, p^5 are in a circuit inductively coupled to the plate circuit of tube v through the transformer whose primary is p^8 and whose secondary is s^8, a laminated core of magnetizable material c^5 being employed if desired. In the circuit of the secondary circuit s^8 is an adjustable condenser C^8 for tuning the circuit to the primary beat frequency, which frequency nevertheless is above audibility. With the coils p^4, p^5 may be associated the apparatus including coils s^4, s^5 to the right of the coils p^4, p^5 in either Figs. 2 or 3.

In Fig. 5 there is again an inductive coupling between the plate circuit of the vacuum tube v and the coils p^4, p^5. In this case, however, the primary coil p^8 and secondary coil s^8 are movable to and away from each other to procure loose coupling. Either or both of these transformer coils may have a laminated core c^6 of magnetizable material. The loose coupling between the coils p^8 and s^8 serves to differentiate in magnitude of energy transfer between the high frequency beat energy and the energy of low or audible frequency due to the artificial or naturally produced interfering effects. With the coils p^4, p^5 may be associated the apparatus including coils s^4, s^5 to the right of coils p^4, p^5 of either of Figs. 2 or 3.

In Fig. 6 the coils p^4, p^5 are assumed to be connected in any of the circuit arrangements of Figs. 2, 3, 4 or 5. In this case, however, the coils s^4, s^5 are in a circuit inductively coupled to the grid circuit of the second oscillating vacuum tube v^1 through

the transformer comprising the coils p^9 and s^9, with which may be employed a laminated magnetizable core c^7. In this case the variable condenser C^7 attunes the circuit of the grid g^1 to the secondary beat frequency; and the adjustable condenser C^8 similarly attunes the circuit of the coils s^4, s^5 to the secondary beat frequency. The transformer p^9, s^9 therefore transfers to the circuit of the grid g^1 the secondary beat effect, and simultaneously transfers from the circuit of the grid g^1 an energizing high frequency current to the coils s^4, s^5; so that as to one aspect the coil s^9 is truly a secondary coil, while in the other aspect it is a primary coil.

The description hereinbefore given has assumed that the intelligence is communicated by telegraphy. However, the system is also utilizable for telephony, in which case the key k of Fig. 1 may remain closed and the switch a opened, whereupon the microphone m is brought into circuit and modifies the amplitude of the sustained or undamped waves in accordance with speech. The receiving apparatus of Figs. 2, 3, 4, 5 and 6 may be the same as previously described, except that the frequency of the secondary beats, caused by the source S^2, Fig. 2, or vacuum tubes v^1 and their oscillating circuits, shall be above audibility, the amplitude of the beat impulses, however, varying in accordance with speech, whereby the envelop of the secondary inaudible beats is reproduced as speech in the telephone T.

In Figs. 8 to 12 inclusive, modified arrangements of the coupling structure are shown.

In Fig. 8 the coil p^4 is a primary coil connected in any of the circuits in which the coil p^4 of the preceding figures is connected; and similarly, the coils s^4 and s^5 are both associated with the primary p^4 and may be the coils s^4, s^5 of any of the preceding figures.

In Fig. 9 a core structure c^8 is common to the primary coils p^4, p^5, connected as in any of the preceding figures, and to the coils s^4 and p^6 connected and operating as in Fig. 2.

In Fig. 10 a primary coil p^4 is on the middle limb of a closed magnetic circuit or core structure c^9, on whose outer limbs are disposed the coils s^4, s^5, connected as in Fig. 8 or in any analogous arrangement hereinbefore described.

In Fig. 11 the primary coils p^4 and p^5 are on inner limbs on a core structure c^{10}, and opposed to these limbs and separated therefrom by gaps are limbs carrying the coils c^4, c^5, all these coils being connected in any arrangement analogous or similar to those hereinbefore described, particularly in connection with Figs. 3 and 6.

In Fig. 12 the primary p^4 is on a core structure c^1 associated with the separate core structures c^{11} carrying the coils s^4 and s^5, these coils being connected in any suitable arrangement to carry out the effect hereinbefore described. In all of these modifications, Figs. 8 to 12 inclusive, as well as those in the preceding figures, one of the objects is to make possible an adjustment whereby zero effect of the character hereinbefore described is procurable.

In all of the figures, including Figs. 8 to 12 inclusive, the coils s^4 and s^5, or either of them if used alone, preferably have or has a great number of turns and high resistance as compared with the primary coils p^4, p^5, or either of them, or as compared, in Fig. 2, with the coils p^6 and p^7.

In all of the arrangements hereinbefore described the coils s^4 and s^5, or either of them, or their cores, are so mounted as to be movable toward and from the coils p^4, p^5, or either of them, by nice adjustment, such, for example, as used for adjusting an armature or poles of a polarized relay.

While in the foregoing description reference has been made to grounding of the core or cores with which are associated a winding or windings traversed by the effects of the received energy, and to grounding of those coils or their circuit, it will be understood that my invention does not exclude grounding under suitable circumstances of any or all of the coöperating cores or the circuits of the coils associated therewith. In this connection, however, it is pointed out that grounding of the cores c^2, c^2, or either of them, Fig. 3, or grounding the circuit of the coils s^4, s^5, with which is associated an oscillating vacuum tube v^1, may often be undesirable in that such grounding stops or tends to stop oscillation of the tube or widely change the conditions for producing oscillations.

In case the energy representing the signal or message is transmitted over a line wire extending between transmitting and receiving stations, the effects of artificial or natural disturbances of the character hereinbefore referred to will not, for the reasons hereinbefore given, be made manifest in the receiving telephone T or other signal translating instrument. And in such case any effect of low or audible frequency, for example, the inductive effect of neighboring low frequency alternating current lines, will not reach or become manifest in the receiving telephone T or other signal translating instrument.

It will further be understood that the energy delivered to telephone T by the coils s^4, s^5 or the plate circuit of the vacuum tube v^1 may be amplified by any suitable means, as one or more thermionic amplifiers.

While in and with the method and appa-

ratus hereinbefore described both primary and secondary beats were produced, my invention, in one of its broader aspects, is also available in a method of and with apparatus for producing only one set of beats. This will be understood by reference to Fig. 13, wherein the sustained or undamped signal waves are received upon the conductor A between which and the earth connection E are connected the adjustable primary p^{10} of an oscillation transformer and the adjustable tuning condenser C. Associated with the primary p^{10} are the adjustable secondaries s^{10} and s^{11}, connected in series with each other and inductance L in the circuit of the grid g of the vacuum tube v, the circuit of whose plate w is in an oscillating circuit comprising the inductance L, the adjustable condenser C^1 being connected across the serially connected inductance L and secondaries s^{10} and s^{11} and being therewith the chief frequency determining elements of the oscillating circuit. The oscillations so locally produced are of a different frequency from the frequency of the undamped waves received upon the conductor A and produce, in the case of telegraphy, an audible beat note in the telephone T, and in the case of telephony inaudible beats whose envelop is reproduced, however, in the telephone T as speech. In this case the windings s^{10}, s^{11}, or either of them, are adjusted with respect to the winding p^{10} to such position that current of whatever type, form or character in the winding p^{10} produces no net effect in the circuit of the windings s^{10}, s^{11}, which are so wound or connected that the effect produced by winding p^{10} in one of them is equal and opposite to the effect simutaneously produced in the other. Accordingly, when no local oscillations are being produced by the tube v, any effect of whatever character in the winding p^{10} will produce no effect upon the telephone T, though the tube v is in such case nevertheless able to act as an amplifier. However, when local oscillations are produced by the tube v and undamped waves of different frequency are received upon the conductor A the magneto-motive-force or other effect produced by the winding p^{10} first co-acts cumulatively with the magneto-motive-force or other effect produced by the locally generated oscillations in the winding s^{10} to produce a uni-directional beat impulse, which is immediately followed by a uni-directional beat impulse of opposite sign, due to the later cumulative coaction between the winding p^{10} and the winding s^{10}, as explained in connection with Fig. 7. When damped waves occur in the winding p^{10}, due either to artificial or natural causes, and particularly when the transient effects in the coil p^{10} are of low or audible frequency, they affect the windings s^{10} and s^{11} equally but oppositely, and no beats are produced by reaction with the locally produced oscillations.

From the foregoing description it will be apparent that it is made possible to prevent interference by natural as well as artificial electrical disturbances in a system in which the signal or message is represented by sustained or undamped waves, by taking advantage of the fact that disturbances or their effects are of low or audible frequency, are in the form of or cause damped waves, and in most cases their recurrence is not at uniform period. By my method and apparatus the ultimate signal or message is made audible by the use of both primary and secondary beats, or by one set of beats only, produced by interaction of locally generated oscillations of such high frequency that even if reaction occurred with the low or audible frequency effects, the beat frequency would still be above audibility, advantage being taken of a coupling, between a circuit traversed by the locally produced high frequency oscillations and a circuit affected by the received energy, of such nature that zero or substantially zero effect is produced by the received energy as well as any disturbing or interference producing effects unless the high frequency oscillations are locally produced, in which case the disturbing or interference producing effects produce no reaction therewith which is audible, while the received signal energy does produce audible reaction therewith.

What I claim is:

1. The method of operating with electrical energy, which consists in producing currents of different frequencies, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when current of either frequency is absent to produce an undulatory magnetic flux of frequency dependent upon the difference between the frequencies of said currents.

2. The method of operating with electrical energy, which consists in producing sustained current waves, producing sustained current waves of different frequency, producing by said current waves magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when the current waves of either frequency are absent to produce an undulatory magnetic flux of frequency dependent upon the difference between the frequencies of said current waves, and effecting a fluctuation of current by said undulatory magnetic flux.

3. The method of operating with electrical energy, which consists in producing sustained current waves, producing sustained current waves of different frequency, pro-

ducing by said current waves magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when the current waves of either frequency are absent to produce an undulatory magnetic flux of frequency dependent upon the difference between the frequencies of said current waves, and producing a beat current by said undulatory magnetic flux.

4. The method of communicating signals electrically, which consists in producing a signal current of sustained or undamped waves, producing a second current of sustained or undamped waves of different frequency, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said second named current is absent to produce a fluctuating magnetic flux of a frequency dependent upon the difference between the frequencies of said currents, effecting a fluctuation of electro-motive-force by said fluctuating magnetic flux, and translating said electro-motive-force into a signal.

5. The method of communicating signals electrically, which consists in producing a signal current of sustained or undamped waves of frequency above audibility, producing a second current of sustained or undamped waves of different inaudible frequency, producing by said currents of different frequencies magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said second current is absent to produce a fluctuating magnetic flux of frequency dependent upon the difference between the frequencies of said currents, producing by said fluctuating magnetic flux a current of audible frequency, and translating said current into an audible signal.

6. The method of communicating signals electrically without interference by disturbances caused by aperiodic impulses, damped waves or the like, which consists in producing a signal current of sustained or undamped waves, producing a second current of sustained or undamped waves of different frequency, producing by said currents and the effects of the interfering disturbances magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said signaling current and disturbances only are present to produce a fluctuating magnetic flux, said fluctuating magnetic flux having no effective component due to said disturbing effects, effecting a fluctuation of electro-motive-force by said fluctuating magnetic flux, and translating said electro-motive-force into a signal.

7. The method of communicating signals electrically without interference by disturbances caused by aperiodic impulses, damped waves or the like, which consists in producing a signal current of sustained or undamped waves of inaudible frequency, producing a second current of sustained or undamped waves of different frequency, producing by said currents and the effects of the interfering disturbances magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said signaling current and disturbances only are present to produce a fluctuating magnetic flux, said fluctuating magnetic flux having no effective component of audible frequency due to said disturbances, producing an electrical effect of audible frequency by said fluctuating magnetic flux, and translating said effect into an audible signal.

8. The method of operating with electrical energy, which consists in producing a fluctuating or alternating current, producing a second fluctuating or alternating current interacting with said first named current to produce beats, producing a third fluctuating or alternating current having a frequency different from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce a fluctuating magnetic flux of a frequency depending upon the difference between the frequencies of said beats and said third current.

9. The method of operating with electrical energy, which consists in producing a fluctuating or alternating current, producing a second fluctuating or alternating current interacting with said first named current to produce beats, producing a third fluctuating or alternating current having a frequency different from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantialy *nil* when said third current is absent to produce a fluctuating magnetic flux of a frequency depending upon the difference between the frequencies of said beats and said third current, and effecting fluctuating of current by said fluctuating magnetic flux.

10. The method of communicating signals electrically, which consists in producing a fluctuating or alternating signal current, producing a second fluctuating or alternating current reacting therewith to produce beats, producing a third fluctuating or alternating current having a frequency different from the frequency of said beats, producing by said beats and said third current mag-

neto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce a fluctuating magnetic flux of frequency dependent upon the difference between the frequencies of said beats and said third current, producing a fluctuating electrical effect by said fluctuating magnetic flux, and translating said effect into a signal.

11. The method of communicating signals electrically, which consists in producing a fluctuating or alternating signal current, producing a second fluctuating or alternating current reacting therewith to produce beats having a frequency above audibility, producing a third fluctuating or alternating current having a frequency above audibility and differing from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce a fluctuating magnetic flux of frequency dependent upon the difference between the frequencies of said beats and said third current, producing a fluctuating electrical effect of audible frequency by said fluctuating magnetic flux, and translating said effect into a signal.

12. The method of communicating signals electrically, which consists in producing electro-radiant energy consisting of sustained or undamped waves, controlling the same in accordance with a signal, and at a receiving station converting the received signal energy into a current of sustained or undamped oscillations, producing at said receiving station a second current of sustained or undamped oscillations of inaudible frequency differing from the frequency of said current, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said second current is absent to produce a fluctuating magnetic flux whose frequency is dependent upon the difference between the frequencies of said currents, producing by said fluctuating magnetic flux a fluctuating electrical effect of audible frequency, and translating said effect into an audible signal.

13. The method of communicating signals electrically, which consists in producing electro-radiant energy consisting of sustained or undamped waves, controlling the same in accordance with a signal, and at a receiving station converting the received signal energy into a current of sustained or undamped oscillations, producing at said receiving station a second current of sustained or undamped oscillations of inaudible frequency interacting with said current to produce beats of inaudible frequency, producing a third current of frequency differing from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce a fluctuating magnetic flux whose frequency depends upon the difference between the frequencies of said beats and said third current, producing by said fluctuating magnetic flux a fluctuating electrical effect of audible frequency, and translating said effect into an audible signal.

14. The method of receiving and translating high frequency sustained or undamped waves without interference by disturbances causing aperiodic impulses, damped waves or the like, which consists in producing by the received energy a current of sustained or undamped oscillations, producing a second current of inaudible frequency differing from the frequency of said current, producing by said currents magneto-motive-forces of different frequencies interacting to produce a coupling whose magnetic resultant due to said disturbances and the received energy is small or substantially *nil* when said second current is absent to produce a fluctuating magnetic flux whose frequency is dependent upon the difference between the frequencies of said currents and having no component due to said disturbances capable of producing audible effects, producing a fluctuating electrical effect of audible frequency by said fluctuating magnetic flux, and translating said effect into an audible signal.

15. The method of receiving and translating high frequency sustained or undamped waves without interference by disturbances causing aperiodic impulses, damped waves or the like, which consists in producing by the received energy a current of sustained or undamped oscillations, producing a second current of different frequency reacting with said current to produce beats of inaudible frequency, producing a third current of inaudible frequency different from the frequency of said beats, producing by said third current and said beats magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant due to the received energy and said disturbances in the absence of said third current is small or substantially *nil* to produce a fluctuating magnetic flux whose frequency depends upon the difference between the frequencies of said beats and said third current, said fluctuating magnetic flux having no component due to said disturbances capable of producing audible

effects, producing a fluctuating electrical effect of audible frequency by said fluctuating magnetic flux, and translating said effect into an audible signal.

16. The method of producing a fluctuating current of waves of opposite signs alternating with each other, which consists in producing alternating or fluctuating currents of different frequencies, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when one of said currents is absent to produce a fluctuating magnetic flux, and producing by said fluctuating magnetic flux a current comprising waves alternating in sign.

17. The method of producing a fluctuating current of waves of opposite sign alternating with each other, which consists in producing alternating or fluctuating currents of different frequencies interacting to produce beats, producing a third current having a frequency differing from the frequency of said beats, producing by said third current and said beats magneto-motive forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce a fluctuating magnetic flux whose frequency is dependent upon the difference between the frequency of said beats and said third current, and producing by said fluctuating magnetic flux a current comprising waves alternating in sign.

18. The method of transmitting sound waves electrically, which consists in producing a current of sustained or undamped waves of frequency above audibility, controlling said current in accordance with the sound waves to be transmitted, producing a second current of sustained or undamped waves of inaudible frequency different from the frequency of said first named waves, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when one of said currents is absent to produce magnetic flux fluctuating at a frequency above audibility and varying in amplitude in accordance with sound waves, and translating said magnetic flux into audible sound waves.

19. The method of transmitting sound waves electrically, which consists in producing a current of sustained or undamped waves of frequency above audibility, controlling said current in accordance with the sound waves to be transmitted, producing a second current of sustained or undamped waves of inaudible frequency different from the frequency of said first named waves and interacting therewith to produce beats of inaudible frequency, producing a third current of sustained or undamped waves of frequency different from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce magnetic flux fluctuating at a frequency above audibility and varying in amplitude in accordance with sound waves, and translating said fluctuating magnetic flux into audible sound waves.

20. The method of transmitting sound waves electrically, which consists in producing electro-radiant energy consisting of sustained or undamped waves, controlling the same in accordance with the sound waves to be transmitted, and at a receiving station converting the received energy into a current of sustained or undamped oscillations, producing a second current of sustained or undamped oscillations of inaudible frequency differing from the frequency of said current, producing by said currents magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said second current is absent to produce magnetic flux fluctuating at a frequency above audibility and dependent upon the difference between the frequencies of said currents, said magnetic flux varying in amplitude in accordance with sound waves, and translating said fluctuating magnetic flux into audible sound waves.

21. The method of transmitting sound waves electrically, which consists in producing electro-radiant energy consisting of sustained or undamped waves, controlling the same in accordance with the sound waves to be transmitted, and at a receiving station converting the received energy into a current of sustained or undamped oscillations, producing a second current of sustained or undamped oscillations of inaudible frequency differing from the frequency of said current and interacting therewith to produce beats of inaudible frequency, producing a third current of sustained or undamped oscillations of frequency different from the frequency of said beats, producing by said beats and said third current magneto-motive-forces of different frequencies interacting through a coupling whose magnetic resultant is small or substantially *nil* when said third current is absent to produce magnetic flux fluctuating at inaudible frequency dependent upon the difference between the frequencies of said third current and said beats, said magnetic flux varying in amplitude in accordance with said sound waves, and translating said magnetic flux into audible sound waves.

22. The combination with circuits trav-

ersed by currents of different frequencies, of windings associated with said circuits and so disposed with respect to each other that one of said circuits produces no inductive influence upon another of said circuits when the current in said other circuit is absent and when present causes interaction between said windings to produce a resultant magnetic flux fluctuating at a frequency depending upon the difference between the frequencies of said currents.

23. The combination with circuits traversed by currents of different inaudible frequencies, of windings associated with said circuits and so disposed with respect to each other that one of said circuits produces no inductive influence upon another of said circuits when the current in said other circuit is absent and when present causes interaction between said windings to produce a resultant magnetic flux fluctuating at a frequency dependent upon the difference between the frequencies of said currents, and effecting by said magnetic flux a fluctuation of current at an audible frequency.

24. The combination with a circuit traversed by fluctuating or alternating current, of means associated therewith for producing fluctuating or alternating current of different frequency adapted to react therewith to produce beats, another circuit traversed by a third alternating or fluctuating current of frequency different from the frequency of said beats, windings associated with said circuits and so disposed with respect to each other that one of said circuits produces no inductive influence upon another of said circuits when said third current is absent and when present there is produced a resultant magnetic flux fluctuating at a frequency dependent upon the difference between the frequencies of said third current and said beats.

25. The combination with a circuit traversed by fluctuating or alternating current, of means associated therewith for producing fluctuating or alternating current of different frequency adapted to react therewith to produce beats of inaudible frequency, another circuit traversed by a third alternating or fluctuating current of inaudible frequency differing from the frequency of said beats, windings associated with said circuits and so disposed with respect to each other that one of said circuits produces no inductive influence upon another of said circuits when said third current is absent and when present there is produced a resultant magnetic flux fluctuating at a frequency dependent upon the difference between the frequencies of said third current and said beats, and producing by said flux a current fluctuating at an audible frequency.

26. The combination with circuits traversed by fluctuating or alternating currents of different frequencies, of means for selectively coupling said circuits whereby a beat effect is produced only when both currents are present and no effect is produced by one of said circuits upon the other when the current in said other circuit is absent, said means comprising at least three windings at least one of which is associated with said one of said circuits and the remainder associated with the other of said circuits, said windings so disposed with respect to each other that the magneto-motive-forces of different frequencies produced thereby interact to produce a coupling whose magnetic resultant is small or substantially *nil* when the current of one frequency is absent and when said currents are present is an undulatory magnetic flux of frequency dependent upon the difference between the frequencies of said currents.

27. The combination with circuits traversed by fluctuating or alternating currents of different frequencies, one at least of said currents having a frequency above audibility, of means for selectively coupling said circuits whereby a beat effect of audible frequency is produced only when both currents are present and no effect is produced by one of said circuits upon the other when the current in said other circuit is absent, said means comprising at least three windings at least one of which is associated with said one of said circuits and the remainder associated with the other of said circuits, said windings so disposed with respect to each other that the magneto-motive-forces of different frequencies produced thereby interact through a coupling whose magnetic resultant is small or substantially *nil* when the current of one frequency is absent and when said currents are present is an undulatory magnetic flux of frequency dependent upon the difference between the frequencies of said currents.

28. The combination with circuits, of a selectively operating coupling between them minimizing inductive effect between said circuits unless said circuits are simultaneously affected respectively by sustained or undamped current waves of different frequencies, said coupling comprising at least one winding in one of said circuits and at least two windings in another of said circuits, said two windings producing equal and opposite effects when a current affects only said one winding, the magnetic circuits of said windings being so disposed that there is a resultant magnetic flux of beat frequency caused by said currents of different frequencies.

29. Receiving apparatus comprising in combination with a circuit or path traversed by received sustained or undamped waves, of a second circuit or path, means for producing therein sustained or undamped waves of fre-

quency different from the received waves, a coupling between said circuits or paths preventing inductive effect by said first circuit or path upon said second circuit or path unless said second named waves affect said second circuit or path, and a signal translating instrument associated with said second circuit or path.

30. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit associated therewith attuned to said waves, a second circuit, means associated therewith producing sustained or undamped waves of different frequency, a coupling intervening between said circuits and preventing inductive effect by said first named circuit upon said second named circuit unless said second named waves are present, and a signal translating instrument associated with said second circuit.

31. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit associated therewith attuned to said waves, a second circuit, means associated therewith producing sustained or undamped waves of different frequency, a coupling intervening between said circuits and preventing inductive effect by said first named circuit upon said second named circuit unless said second named waves are present, and a signal translating instrument subjected to the beat effects permitted by said coupling.

32. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, means for amplifying said waves, a circuit, means associated therewith for producing sustained or undamped waves of different frequency, a coupling between said amplifying means and said circuit preventing inductive effect by said amplifying means upon said circuit unless said second named waves are present, and a signal translating instrument associated with said circuit.

33. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, means for amplifying said waves, a circuit, means associated therewith for producing sustained or undamped waves of different frequency, a coupling between said amplifying means and said circuit preventing inductive effect by said amplifying means upon said circuit unless said second named waves are present, means for amplifying the resultant beat effects in said circuit, and an instrument for translating into signals said amplified beat effects.

34. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit associated therewith, means associated with said circuit for producing sustained or undamped waves of different frequency for producing beats by interaction with the received waves, a second circuit, means associated therewith for producing sustained or undamped waves of frequency differing from the frequency of said beats, a coupling between said circuits preventing inductive effect by said first named circuit upon said second named circuit unless said last named waves are present, and a signaling instrument associated with said second circuit.

35. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit associated therewith, means associated with said circuit for producing sustained or undamped waves of different frequency for producing beats by interaction with the received waves, means for amplifying said beats, a second circuit, means associated therewith for producing sustained or undamped waves of frequency differing from the frequency of said beats, a coupling between said circuits preventing inductive effect by said first named circuit upon said second named circuit unless said last named waves are present, and a signaling instrument associated with said second circuit.

36. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit associated therewith, means associated with said circuit for producing sustained or undamped waves of different frequency for producing beats by interaction with the received waves, means for amplifying said beats, a second circuit, means associated therewith for producing sustained or undamped waves of frequency differing from the frequency of said beats, a coupling between said circuits preventing inductive effect by said first named circuit upon said second named circuit unless said last named waves are present, means for amplifying the beats in said second circuit, and a signaling instrument associated with said second circuit.

37. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, an amplifier-oscillator associated therewith for producing beats, a circuit, means associated therewith for producing sustained or undamped waves of frequency different from said beats, a coupling preventing inductive influence upon said circuit unless said last named waves are present, and a signal translating instrument associated with said circuit.

38. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, an amplifier-oscillator associated therewith for producing beats, a circuit, means associated therewith for producing sustained or undamped waves of frequency different from said beats, a coupling preventing inductive influence upon said circuit unless said last named waves are pres-

ent, means for amplifying the beat effects in said circuit, and an instrument translating said beat effects into signals.

39. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, an amplifier-oscillator associated therewith for producing beats, a circuit, an amplifier-oscillator associated therewith producing sustained or undamped waves of frequency different from said beats, a coupling preventing inductive effect upon said circuit unless said last named waves are present, and a signal translating instrument associated with said circuit.

40. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit, a thermionic oscillator associated therewith producing waves of different frequency, a coupling preventing inductive effect upon said circuit by the received waves unless said second named waves are present, a winding of said coupling affected by waves produced by said oscillator in a grid circuit thereof, and a signal translating instrument associated with said circuit.

41. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit, a thermionic oscillator associated therewith producing waves of different frequency, a coupling preventing inductive effect upon said circuit by the received waves unless said second named waves are present, a winding of said coupling affected by said waves produced by said oscillator in a grid circuit thereof, a coupling between said winding and said grid circuit, and a signal translating instrument associated with said circuit.

42. Receiving apparatus comprising a conductor for receiving sustained or undamped waves, a circuit, a coupling between said conductor and said circuit comprising at least three windings at least one of which is in circuit with said conductor, means associated with said circuit for producing sustained or undamped waves of frequency different from those received upon said conductor, said coupling preventing inductive effect upon said circuit unless said last named waves are present, and a signal translating instrument associated with said circuit.

43. A telephone system comprising means for producing sustained or undamped waves of frequency above audibility controlled in accordance with sound waves, a circuit, means for producing sustained or undamped waves of frequency different from said first named waves, a coupling preventing inductive effect upon said circuit unless said last named waves are present, said waves of different frequency producing beats above audibility, and an instrument for translating into sound waves the varying amplitude of said beats.

44. A telephone system comprising means for producing sustained or undamped waves varying in amplitude in accordance with sound waves, means producing sustained or undamped waves of different frequency reacting with said first named waves to produce beats whose frequency is above audibility, means for producing sustained or undamped waves of frequency different from the frequency of said beats, a coupling between said means preventing inductive effect upon said last named means unless said last named waves are present, said last named waves and said beats producing beat effects above audibility, and an instrument for translating the varying amplitude of said secondary beats into sound waves.

In testimony whereof I have hereunto affixed my signature this 12th day of December, 1918.

DAVID G. McCAA.