No. 884,108.

PATENTED APR. 7, 1908.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED AUG. 3, 1906.

2 SHEETS—SHEET 1.

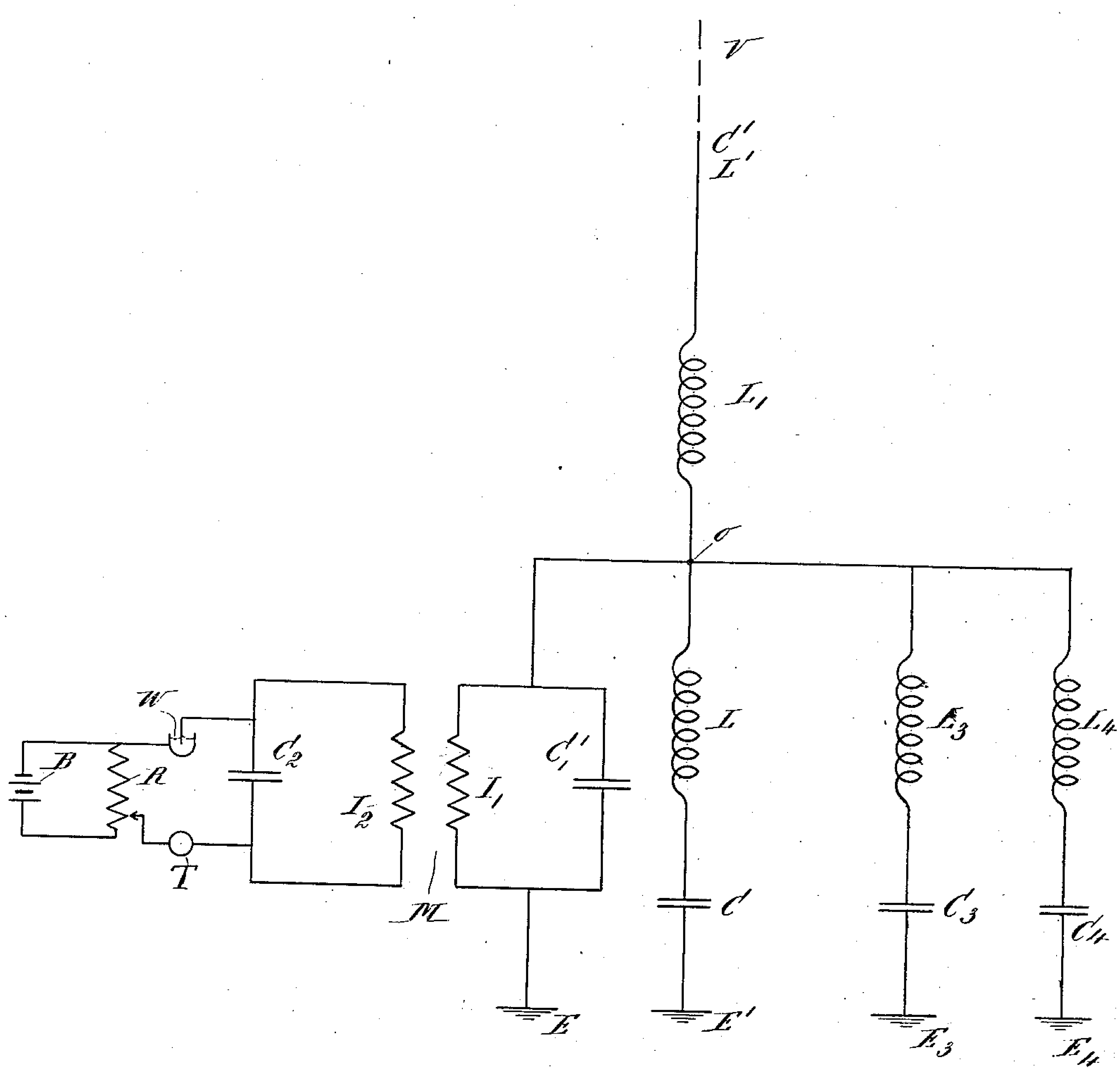

Fig. 1.

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2 SHEETS—SHEET 2.

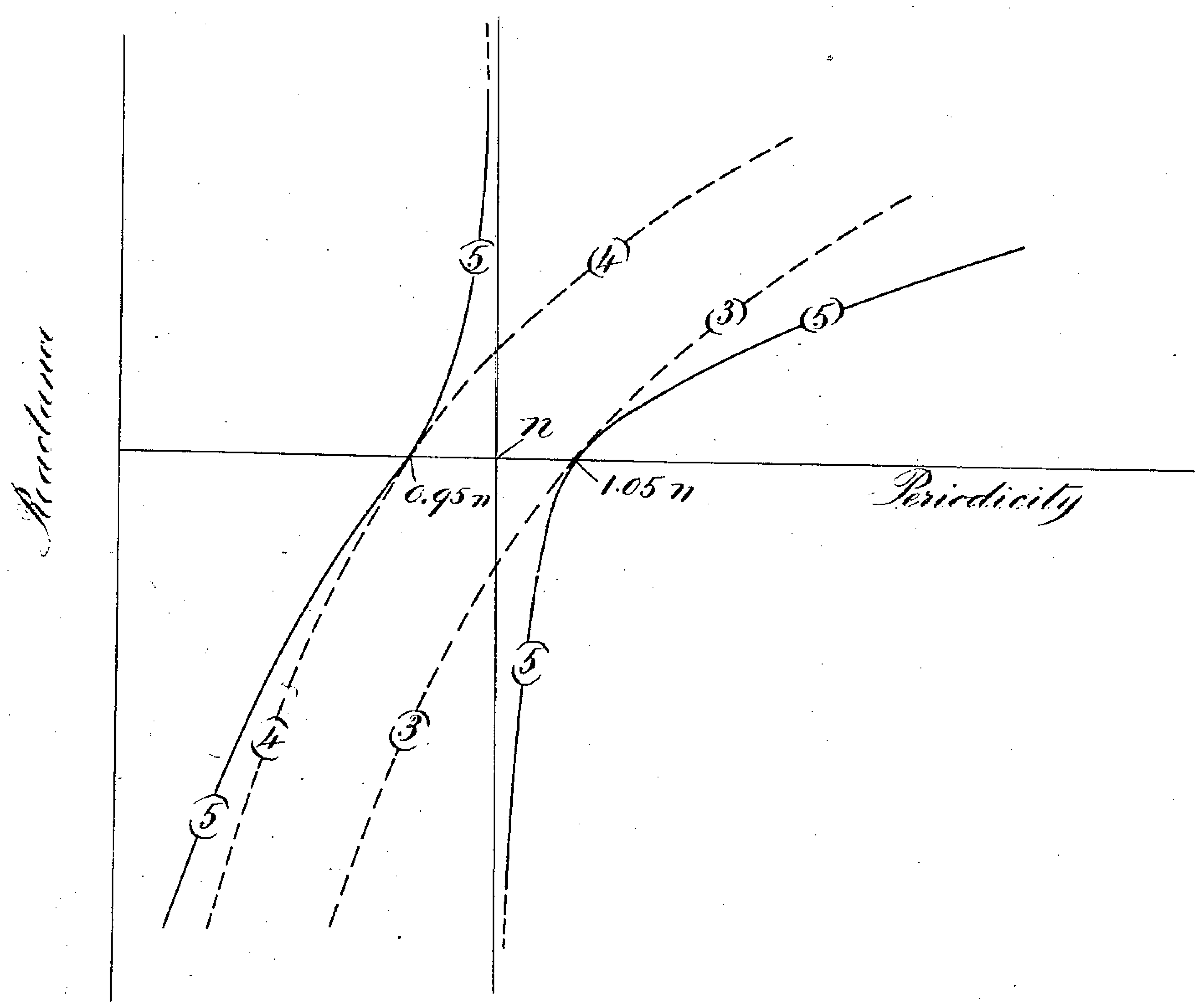

Fig. 2.

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UNITED STATES PATENT OFFICE.

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SPACE TELEGRAPHY.

No. 884,108. Specification of Letters Patent. Patented April 7, 1908.

Application filed August 3, 1906. Serial No. 329,095.

To all whom it may concern:

Be it known that I, JOHN STONE STONE, a citizen of the United States, and a resident of Cambridge, in the county of Middlesex and State of Massachusetts, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

This invention relates to the art of transmitting intelligence from one station to another by means of electromagnetic waves without the use of wires to guide the waves to their destination; and it relates more particularly to systems for receiving signals transmitted by such waves.

The object of the present invention is to so adjust the elevated conductor system of a wireless or space telegraph receiving system relative to an associated tuned or resonant receiving circuit or circuits that, first, a persistent train of electromagnetic waves of a predetermined frequency impinging upon the elevated conductor shall cause the associated circuit or circuits to respond energetically; that, second, a persistent train of electromagnetic waves of frequency other than said predetermined frequency impinging upon the elevated conductor shall cause the associated tuned or resonant circuit or circuits to respond but feebly or not at all; and that, third, abrupt or impulsive electric forces acting upon the elevated conductor shall likewise produce but feeble response or no response at all in the associated tuned or resonant circuit or circuits.

The first and second objects of this invention may be attained by giving the elevated receiving conductor system a pronounced fundamental rate of vibration equal in frequency to that to which the tuned or resonant receiving circuit or circuits is attuned. The first and second objects of this invention may therefore be attained by placing a suitable inductance or capacity in the elevated conductor near its connection to earth, if it be an earthed conductor, or at the center of the receiving conductor, if it be an unearthed conductor, as thereby the receiving system will be given a pronounced and predetermined rate of vibration, much as a stretched string may be given a predetermined and more pronounced rate of vibration by the addition of a suitable load at its center. If, therefore, the loading inductance or capacity added be made such as to give the elevated conductor system a pronounced natural rate of vibration equal to the frequency to which the associated tuned or resonant receiving circuit or circuits is attuned, the first and second objects of the invention will be realized. This simple expedient, however, is not sufficient to accomplish the third object of the present invention, and for this purpose I may give the elevated conductor system a pronounced natural rate of vibration different from that to which the associated tuned or resonant receiving circuit or circuits is attuned while making the elevated conductor system highly responsive to persistent trains of waves of the frequency to which the associated tuned or resonant receiving circuit or circuits is attuned. For the purpose of accomplishing the third object of the present invention I may also provide means having for such natural vibrations as may by abrupt or impulsive electrical forces be created in the elevated conductor, practically zero reactance or, at least, an impedance low as compared to the impedance of the means by which the tuned or resonant receiving circuit or circuits is associated with the elevated conductor system, whereby such natural vibrations may be conducted to earth around such associating means and hence prevented from passing through said means and thereby producing even a feeble response in the aforesaid tuned or resonant receiving circuit or circuits; and I may further provide means having zero reactance for persistent trains of oscillations slightly higher in frequency and slightly lower in frequency than that of the waves the energy of which is to be received for conducting persistent oscillations of said frequencies to earth and thereby preventing them from passing through the aforesaid means by which the receiving circuit is associated with the elevated conductor system.

In other words, I accomplish the objects of the present invention by giving the elevated conductor system a pronounced natural rate of vibration different from that of the waves the energy of which is to be received and, consequently, different from that to which the associated tuned or receiving circuit or circuits is attuned; by making the elevated conductor system highly responsive to persistent trains of waves having the frequency of those the energy of which is to be received and, consequently, the frequency to which the associated tuned or resonant receiving circuit or circuits is attuned; by conveying such natural vibrations as may be developed in the elevated conductor by extraneous electrical impulses of frequency different from that to which the tuned or resonant receiving circuit or circuits is attuned or such as may be developed therein by abrupt or impulsive electrical forces, to earth around the means whereby said tuned or resonant receiving circuit or circuits is associated with the elevated conductor system; and finally by conveying persistent oscillations developed in the elevated conductor by persistent trains of waves of frequencies higher or lower than that of the waves the energy of which is to be received to earth around the aforesaid associating means.

One of the several embodiments of my invention whereby the above mentioned objects have been realized in practice consists of an elevated conductor system comprising a circuit which may be a parallel branch circuit including capacity in one branch and inductance in the other branch, or which may be a circuit including a serially connected capacity and inductance, an elevated conductor and an earth connector; the elevated conductor and earth connector being connected in parallel with respect to said circuit and each, when isolated, having zero reactance for the same frequency,—that is to say, the fundamental period of the elevated conductor, when isolated, being equal to the period of the earth connector, when isolated; and said circuit having for persistent electrical oscillations of the frequency of the waves the energy of which is to be received, a reactance equal in value and opposite in sign to the resultant reactance of the elevated conductor and its earth connector; and finally two circuits connected to the elevated conductor system in parallel with the aforesaid circuit, one of said two circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received and the other having zero reactance for a frequency lower than that of said waves, and being so constructed and arranged that their reactances for the frequency of said waves are respectively equal in value and opposite in sign, whereby their joint reactance for said frequency is practically infinite. In this way, the earth connector determines the most pronounced natural rate of vibration of the elevated conductor system because, for oscillations having such rate of vibration, the reaction of the circuit which as above stated may be a parallel branch circuit, upon the rest of the elevated conductor system is zero, said circuit being shunted by the earth connector which for said oscillations has zero reactance and practically zero impedance; the aforesaid circuit, by balancing the resultant reactance of the rest of the elevated conductor system for persistent electrical oscillations having the frequency of the waves the energy of which is to be received, renders said system highly responsive to persistent oscillations of such frequency; the earth connector, having zero reactance and practically zero impedance for electrical oscillations having the frequency of the most pronounced natural rate of vibration of the elevated conductor system, conducts such natural oscillations as may be developed in the system to earth around the aforesaid circuit with which the resonant receiving circuit or oscillation detector may be associated; and the aforesaid two circuits which have zero reactance for frequencies respectively higher and lower than that of the waves the energy of which is to be received conduct such persistent oscillations of frequencies in the neighborhood of those to which they are most responsive to earth around the aforesaid circuit with which the resonant receiving or oscillation detector is associated.

The present invention is a development of those described in my U. S. Letters Patent Nos. 767,994, dated Aug. 16, 1904, and 802,417, 802,421, 802,425 and 802,426, dated Oct. 24, 1905, to which reference may be had for a more complete explanation of certain of the general principles involved in the present application than need be set forth herein; and it is especially a development and extension of the inventions described in my applications Serial Nos. 329,094 and 329,096 filed simultaneously herewith, to which reference may be had for an extended explanation of the specific principles involved.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which diagrammatically illustrate one of the several organizations of circuits and apparatus whereby the hereinbefore stated objects may be conveniently realized in practice.

In the drawings Figure 1 is a diagram representing a space telegraph receiving system constructed in accordance with my invention. Fig. 2 shows a set of curves drawn to rectangular coördinates in which the ordinates represent reactances and the abscissæ represent frequency and which is hereinafter referred to in explaining the mode of operation of said invention.

In the figures V is an elevated conductor *per se*.

E E′ E_3 and E_4 are earth connections.

C C_1' C_2 C_3 C_4 are condensers.

L L_1 L_3 L_4 are inductances.

I_1 and I_2 are the primary and secondary coils of the transformer M and they are preferably so spatially related that the mutual energy between them is small as compared with the product of the self energies of the circuits in which they are included.

W is an oscillation detector of any suitable construction and is herein shown as consisting of a Wollaston anode immersed in an electrolyte.

T is a signal indicating device which may be a telephone receiver.

B is a battery and R is an adjustable resistance, said battery and resistance constituting a potentiometer.

The five essential elements of my invention are the elevated conductor V*o*, the earth connector *o*E′ and the circuit *o*E, the latter being shown in the present instance as a parallel branch circuit, and the two circuits L_3 C_3 and L_4 C_4. My invention resides in the arrangement of the aforesaid elements and in the proportionment of their electromagnetic constants whereby the foregoing objects may be realized.

V*o* is an elevated conductor which as shown herein consists of an elevated conductor *per se* and the serially connected coil L_1.

*o*E′ is an earth connector having zero reactance for the same frequency for which the elevated conductor V*o* has zero reactance, so that for natural oscillations of a frequency equal to the most pronounced natural rate of vibration of the elevated conductor system, the point *o* is a point having practically zero potential to earth.

The circuit *o*E, which is shown herein as including the parallel branch circuit I_1 C_1', for persistent electrical oscillations of the frequency to which the resonant receiving circuit C_2 I_2 is attuned, has a reactance equal and opposite to the resultant reactance of the elevated conductor V*o* and earth connector *o*E′ which are connected in parallel with respect to the circuit *o*E.

The elevated conductor system consists of the elevated conductor V*o*, the earth connector *o*E′, the circuit *o*E and the two circuits oE_3 and oE_4; the elevated conductor, the earth connector and the aforesaid two circuits all being connected in parallel with respect to the circuit *o*E.

The circuit oE_3 which includes the serially connected inductance L_3 and condenser C_3 is attuned to a frequency higher than that of the waves the energy of which is to be received, and the circuit oE_4 which includes the serially connected inductance L_4 and condenser C_4 is attuned to a frequency lower than that of said waves. In the present instance the circuit oE_3 has zero reactance for a frequency equal to $1.05n$, and the circuit oE_4 has zero reactance for a frequency equal to $0.95n$, n being the frequency to which the resonant receiving circuit is attuned. Inasmuch as in the present case the frequency of one of the two circuits oE_3 and oE_4 is as much higher than the frequency n as the frequency of the other is lower, it follows that the selectance functions of said circuits must be equal so that the reactances of said circuits for the frequency n may be respectively equal in value and opposite in sign. It will be understood, however, that the foregoing relations between the frequency n and the frequencies to which the circuits oE_3 and oE_4 are most highly responsive are merely given as a concrete example of one manner of proportioning, constructing and arranging the constants of said circuits. It will be seen, of course, that the best results will be obtained when the reactances of said circuits for the frequency n are respectively equal in value and opposite in sign so that for persistent trains of waves of the frequency n the joint reactance of said circuits on the driving point is practically infinite; and accordingly said circuits may be proportioned in any suitable manner for the accomplishment of the foregoing results. It follows therefore that the selectance functions of said circuits need not be equal and that the frequencies for which they have zero reactance need not be symmetrical with the frequency of the waves the energy of which is to be received although this is the preferred arrangement.

For persistent electrical oscillations of the frequency to which the resonant receiving circuit C_2 I_2 is attuned, the aforesaid elevated conductor system has zero reactance, because as more fully explained in my application Serial No. 329,094 the reactance of the circuit *o*E is equal and opposite to the resultant reactance of the elevated conductor and its earth connector, and because as above explained the joint reactance of the circuits oE_3 and oE_4 is infinite for said frequency.

C′ represents the apparent capacity of the vertical or elevated conductor *per se*, and L′ represents the apparent inductance thereof. In the earth connector *o*E′ the coil L and condenser C may be so chosen that for persistent electrical oscillations of frequencies from zero to approximately the fundamental of the elevated conductor V*o*, the reactance of *o*E′ is the same in sign and approximately the same in value as the reactance of the elevated conductor; and V*o* and *o*E′, when isolated, each has zero reactance for oscillations of the lowest frequency natural to the elevated conductor.

The circuit C_2 I_2 is a resonant receiving circuit attuned to the frequency of the waves the energy of which is to be received and associated in the present instance with the inductance branch of the parallel branch circuit. The oscillation detector W and the local circuit including the same may be associated with the resonant receiving circuit in any suitable manner, and in the present instance said circuit is shown as connected across the terminals of the condenser C_2. Although the oscillation detector is shown in the present instance as associated with the elevated conductor by means of the circuit oE through the intermediary of the resonant receiving circuit, I do not limit myself to such means for associating said oscillation detector with said elevated conductor inasmuch as other means will readily suggest themselves to those skilled in the art.

It has before been stated that in lieu of connecting the parallel branch circuit I_1 C_1' between the point o and the earth connection E, as in my application Serial No. 329,094 I may connect a serially connected inductance and capacity between o and E, as in my application Serial No. 329,096. In either event the operation of the system consisting of the elevated conductor Vo and its earth connector which are both connected in parallel with the circuit oE, is the same as described at length in said applications respectively. Accordingly having set forth herein the general principles of my invention so far as the three elements Vo, oE' and oE are concerned, and having described the same at length in the aforesaid applications, I shall now describe specifically the operations effected by the circuits oE_3 and oE_4 wherein the present invention solely differs from those described in the above mentioned applications.

Referring to Fig. 2, the curve (3) shows the variation with frequency for persistent electrical forces of the reactance of the circuit oE_3, and the curve (4) shows the variation with frequency for such forces of the reactance of the circuit oE_4. The curve (5), which is obtained by adding the reciprocals of curves (3) and (4) to obtain the joint conductance of the circuits oE_3 and oE_4, and then finding the reciprocal of such joint conductance, represents the variation with frequency for persistent electrical forces of the parallel branch circuit, the branches of which include the serially connected inductance and capacity L_3 C_3 and the serially connected inductance and capacity L_4 C_4 respectively. The curve (5) crosses the axis of abscissæ at two points herein shown as $0.95n$ and $1.05n$, and accordingly in the present example the aforesaid parallel branch circuit has zero reactance for frequencies 5% (five per cent.) higher and 5% (five per cent.) lower than the frequency for which the elevated conductor system has zero reactance and to which the resonant receiving circuit is attuned. The ordinates of the curve (5) for frequency n are infinite and accordingly for persistent electrical forces of said frequency no current passes to earth by way of the branches oE_3 and oE_4. It follows therefore that the frequency, namely, n, for which the reactance of the circuit oE is equal and opposite to the resultant reactance of the elevated conductor Vo and its earth connector oE', is not altered by connecting the two circuits oE_3 and oE_4 to the point o.

The earth connector oE' having zero reactance for the same frequency as the fundamental of the elevated conductor Vo, namely the frequency n'', it follows that the most pronounced natural rate of vibration of the system VoE' is not altered by connecting the circuit oE to said system at the point o, because for oscillations, either natural or forced of frequency n'', the circuit oE is shunted by the circuit oE' which for said oscillations has zero reactance. In like manner it follows that the most pronounced natural rate of vibration of the system consisting of the elevated conductor Vo and earth connector oE' connected in parallel with the circuit oE is not altered by connecting the circuits oE_3 and oE_4 to said system at the point o, the circuits oE_3 and oE_4 being shunted by the circuits oE' which for oscillations having said rate of vibration has zero reactance. Accordingly it will be seen that the most pronounced rate of vibration of the elevated conductor system considered as a whole is equal to the frequency n'', and that therefore oscillations developed in the elevated conductor by abrupt or impulsive electrical forces will assume said frequency and will pass to earth by way of the path oE' without affecting the resonant receiving circuit; that persistent trains of electrical oscillation of frequency n will not pass to earth by way of the paths oE_3 and oE_4 because the joint reactance of said paths which form a parallel branch circuit is practically infinite for oscillations of said frequency; that persistent trains of oscillations of frequency n will pass to earth chiefly through the circuit oE because for said frequency the reactance of the parallel branch circuit I_1 C'_1 balances the joint reactance of the elevated conductor Vo and earth connector oE', the circuits oE_3 and oE_4 having no effect on such balance owing to the fact that they in parallel present an infinite reactance to persistent oscillations of said frequency n; and finally that persistent trains of oscillations of frequencies respectively higher and lower than that of the waves the energy of which is to be received will pass to earth by way of the paths oE_3 and oE_4 which are made highly responsive to persistent oscillations of frequencies higher and lower, respectively, than that to which the elevated conductor system is made responsive. It will be seen that although in the present instance the circuits oE_3 and oE_4 are so constructed and arranged as to have zero reactance for frequencies five per cent. (5%) higher and five per cent. (5%) lower, respectively, than the frequency n, each will have for a relatively wide range of frequencies on either side of that to which it is attuned, a reactance much lower than that of the circuit oE, and that the circuits oE_3 and oE_4 may be made to provide almost any degree of protection to the circuit oE and the associated oscillation detector by suitably proportioning their selectance functions.

While I have shown herein only one pair of circuits associated with the elevated conductor system, one having zero reactance for a frequency higher than that of the waves the energy of which is to be received and the other having zero reactance for a frequency lower than that of said waves, the said circuits being so constructed and arranged that their reactances for the frequency of said waves are, respectively, equal and opposite in sign, it will be understood that an obvious extension of my invention would consist in employing a plurality of such pairs of circuits so proportioned that, pair by pair, they would exhibit in general the characteristics above described in connection with the pair of circuits oE_3 and oE_4, the two members of each pair of circuits having, respectively, zero reactance for frequencies different from those for which the two members of any other pair have zero reactance and the joint reactance of each pair in parallel, for the frequency of the waves the energy of which is to be received, being practically infinite.

I claim,

1. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said parallel branch circuit; in combination with two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

2. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, an elevated conductor and an earth connector, said elevated conductor and earth connector being connected in parallel with respect to said parallel branch circuit and each, when isolated, having zero reactance for the same definite frequency; in combination with two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

3. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said parallel branch circuit, and said parallel branch circuit having, for persistent electrical oscillations of the frequency of the waves the energy of which is to be received, a reactance equal and opposite to the resultant reactance of said elevated conductor and its earth connector; in combination with two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

4. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said parallel branch circuit and each, when isolated, having zero reactance for the same definite frequency; and said parallel branch circuit having, for persistent electrical oscillations of the frequency of the waves the energy of which is to be received, a reactance equal and opposite to the resultant reactance of said elevated conductor and its earth connector; in combination with two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

5. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, a circuit including inductance and capacity connected across the terminals of said parallel branch circuit, and two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

6. In a space telegraph receiving system, an elevated receiving conductor, an oscillation detector, means associating said oscillation detector with said elevated conductor, a circuit connected around said means and determining the most pronounced natural period of the elevated conductor system, said circuit being so constructed and arranged as to constitute a path of low im-

pedance for natural oscillations of such period, and two circuits connected to the elevated conductor system in parallel with the aforesaid means, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

7. In a space telegraph receiving system, an elevated conductor system comprising a circuit, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said circuit; in combination with two circuits connected to the elevated conductor system in parallel with the first mentioned circuit, one of the last mentioned circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received, and the other having zero reactance for a frequency lower than that of said waves.

8. In a space telegraph receiving system, an elevated conductor system constructed and arranged to be highly responsive to persistent electrical oscillations of a definite frequency, and two circuits each including a serially connected inductance and capacity associated with said elevated conductor system, the inductance and capacity of one of said circuits being so proportioned that said circuit is highly responsive to electrical oscillations of a frequency higher than that to which the elevated conductor system is responsive, and the inductance and capacity of the other circuit being so proportioned that the latter is highly responsive to electrical oscillations of a frequency lower than that to which the elevated conductor system is responsive.

9. In a space telegraph receiving system, an elevated conductor system comprising a parallel branch circuit including capacity in one branch and inductance in the other branch, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said parallel branch circuit and each, when isolated, having zero reactance for the same definite frequency; and said parallel branch circuit having, for persistent electrical oscillations of the frequency of the waves the energy of which is to be received, a reactance equal and opposite to the resultant reactance of the elevated conductor and its earth connector; in combination with two circuits connected to the elevated conductor system in parallel with the aforesaid parallel branch circuit, one of said circuits having zero reactance for a frequency higher than that of the waves the energy of which is to be received and the other having zero reactance for a frequency lower than that of said waves, and being so constructed and arranged that their joint reactance is practically infinite for the frequency of said waves.

10. In a space telegraph receiving system, an elevated conductor system having zero reactance for persistent electrical oscillations of the frequency of the waves the energy of which is to be received, and two circuits associated with said elevated conductor system, one having zero reactance for a frequency higher than that of the waves the energy of which is to be received and the other having zero reactance for a frequency lower than that of said waves, and being so constructed and arranged that their joint reactance is practically infinite for the frequency of said waves.

11. In a space telegraph receiving system, an elevated conductor system constructed and arranged to be highly responsive to persistent electrical oscillations of a definite frequency, and two circuits associated with said elevated conductor system, one having a relatively low reactance for a frequency higher than that of the waves the energy of which is to be received and the other having a relatively low reactance for a frequency lower than that of said waves, the said circuits being so constructed and arranged that their joint reactance is relatively high for the frequency of said waves.

12. In a space telegraph receiving system, an elevated conductor system constructed and arranged to be highly responsive to persistent electrical oscillations of a definite frequency, and two circuits associated with said elevated conductor system, one having zero reactance for a frequency higher than that of the waves the energy of which is to be received and the other having zero reactance for a frequency lower than that of said waves, the said circuits being so constructed and arranged that their reactances for the frequency of said waves are respectively equal in value and opposite in sign.

13. In a space telegraph receiving system, an elevated conductor system constructed and arranged to be highly responsive to persistent electrical oscillations of a definite frequency, and two circuits associated with said elevated conductor system, said circuits being so constructed and arranged that their reactances for the frequency of the waves the energy of which is to be received are respectively equal in value and opposite in sign and their joint reactance for said frequency is practically infinite.

In testimony whereof, I have hereunto subscribed my name this 31st day of July, 1906.

JOHN STONE STONE.

Witnesses:
GEO. K. WOODWORTH,
E. B. TOMLINSON.