No. 884,109.

PATENTED APR. 7, 1908.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED AUG. 3, 1906.

5 SHEETS—SHEET 1.

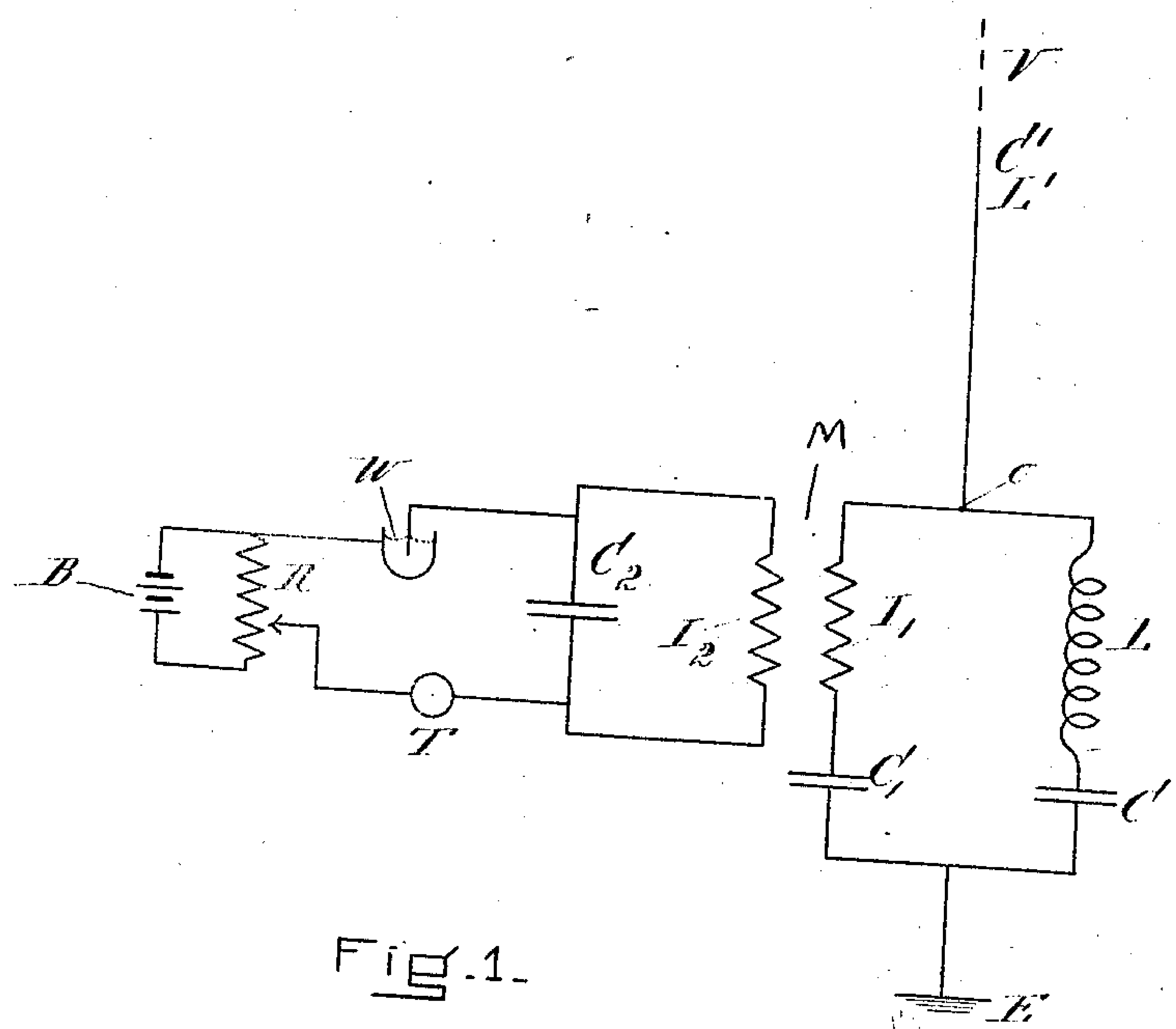

Fig. 1.

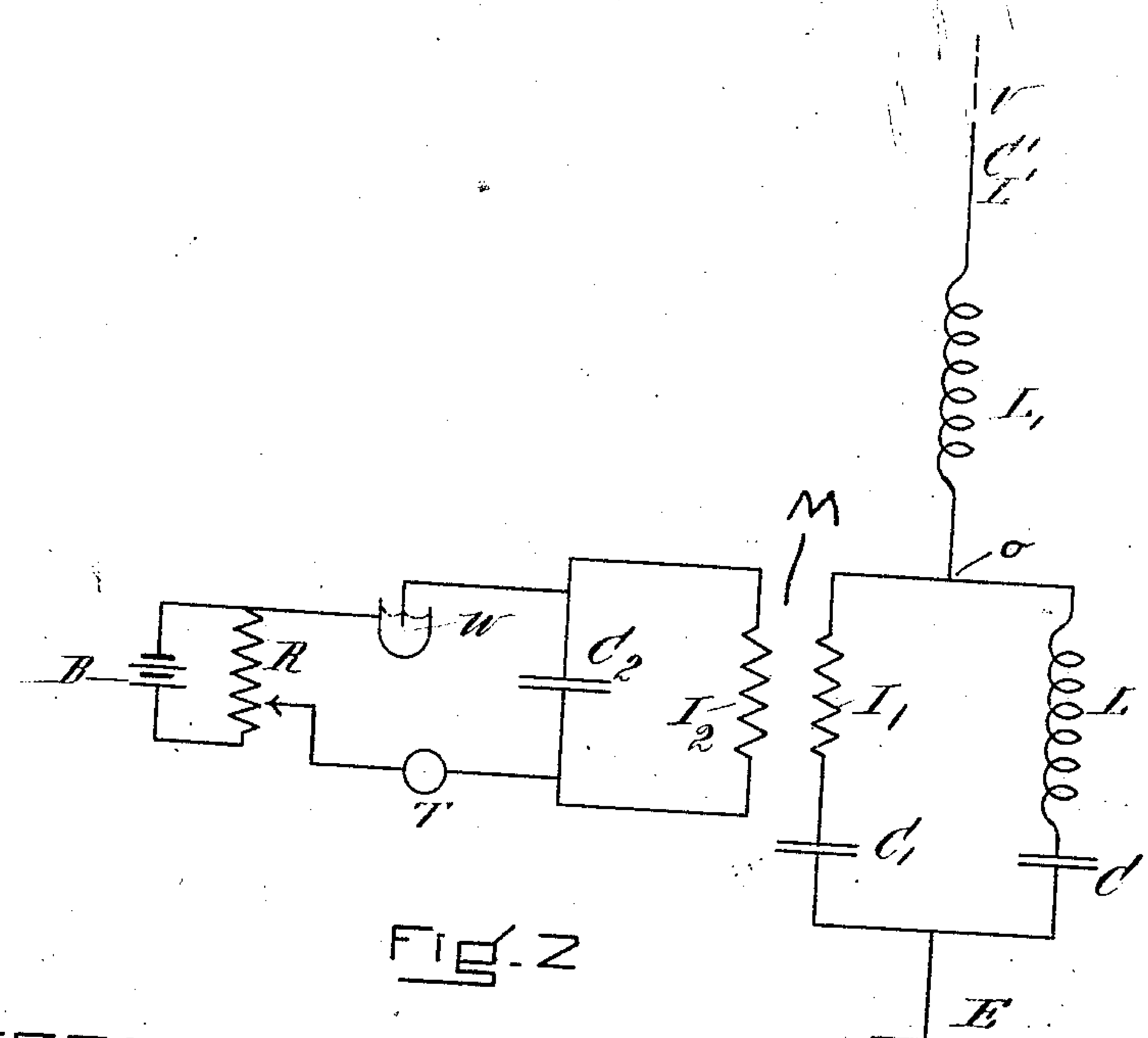

Fig. 2

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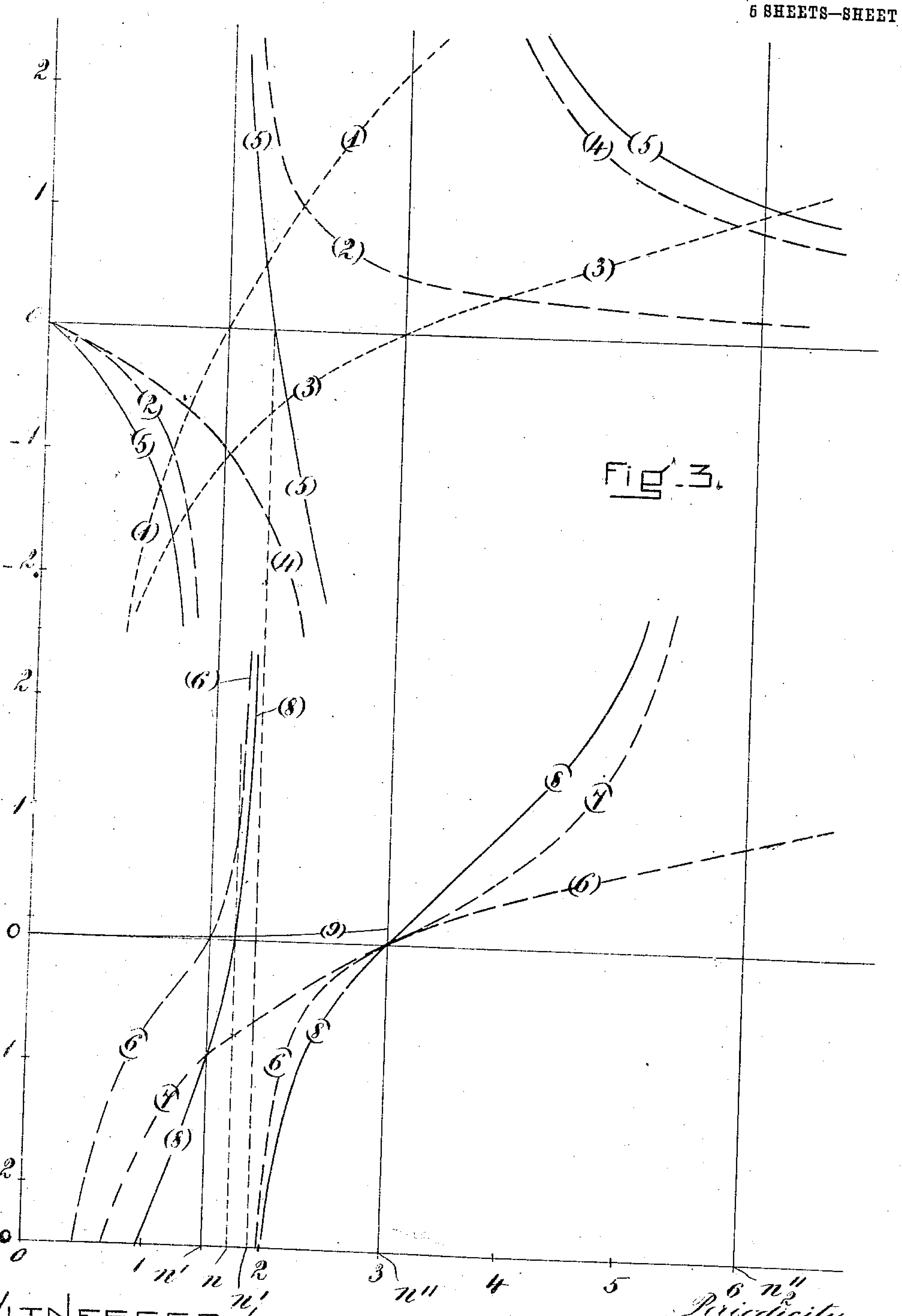

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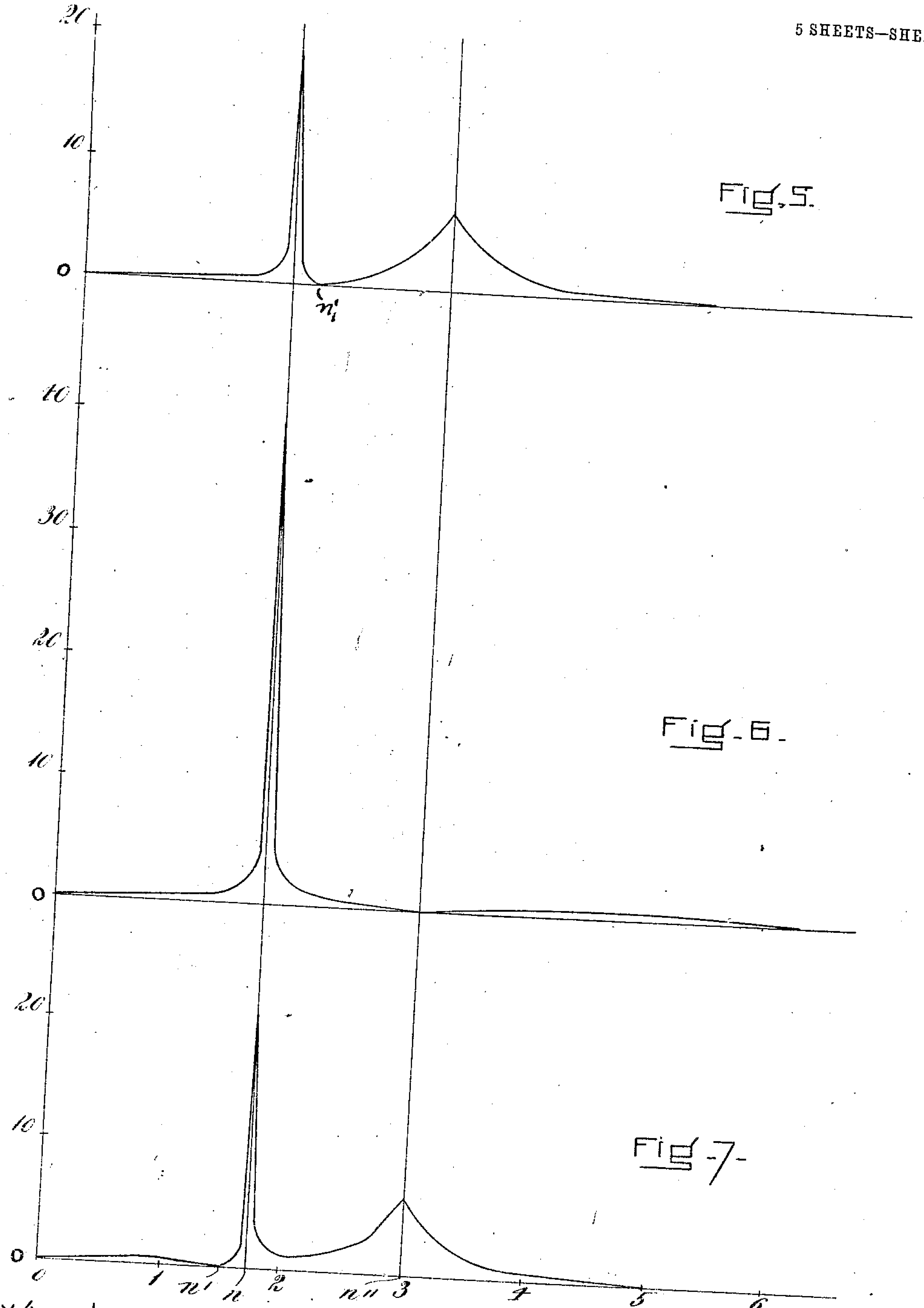

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5 SHEETS—SHEET 4.

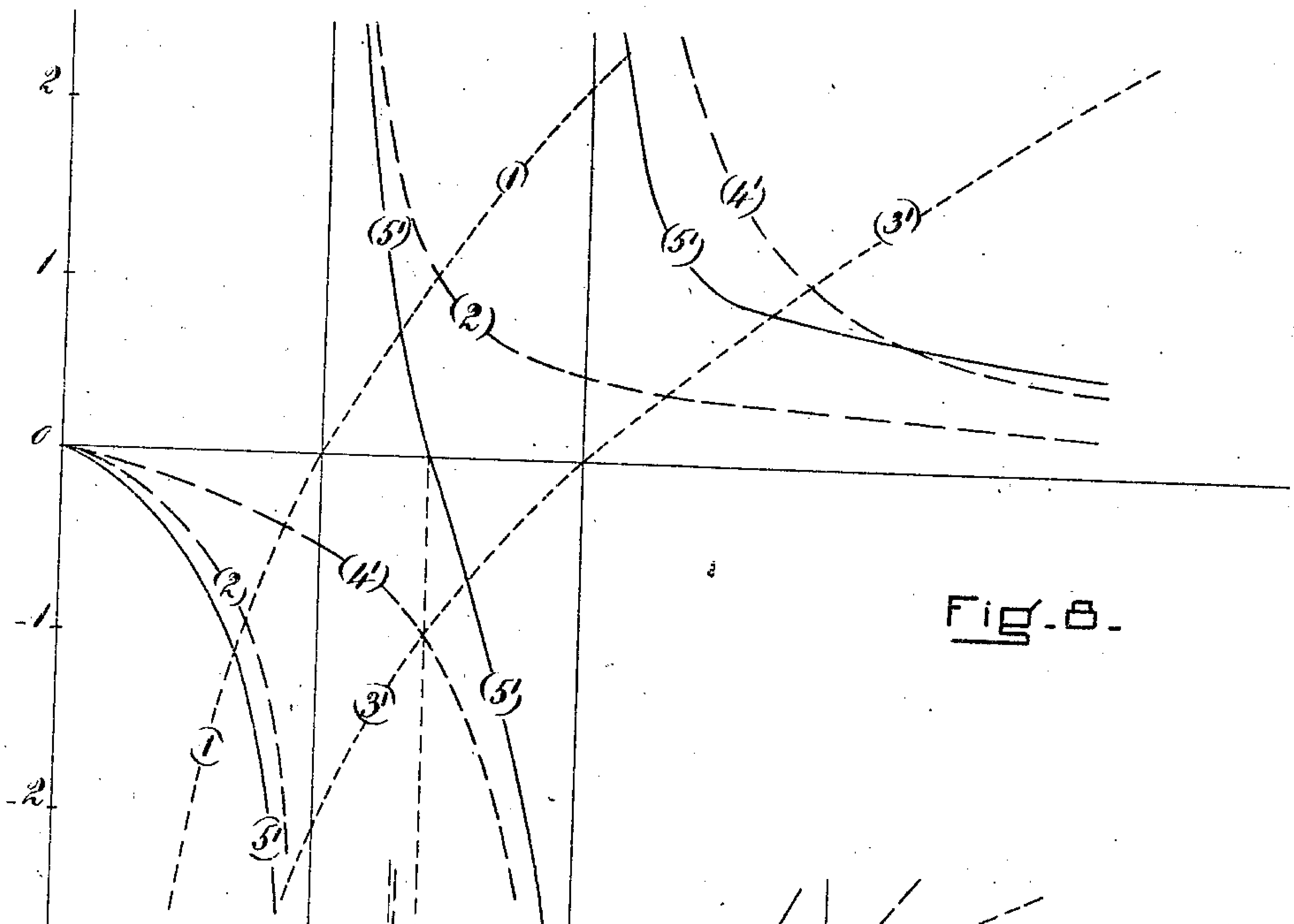

Fig. 8.

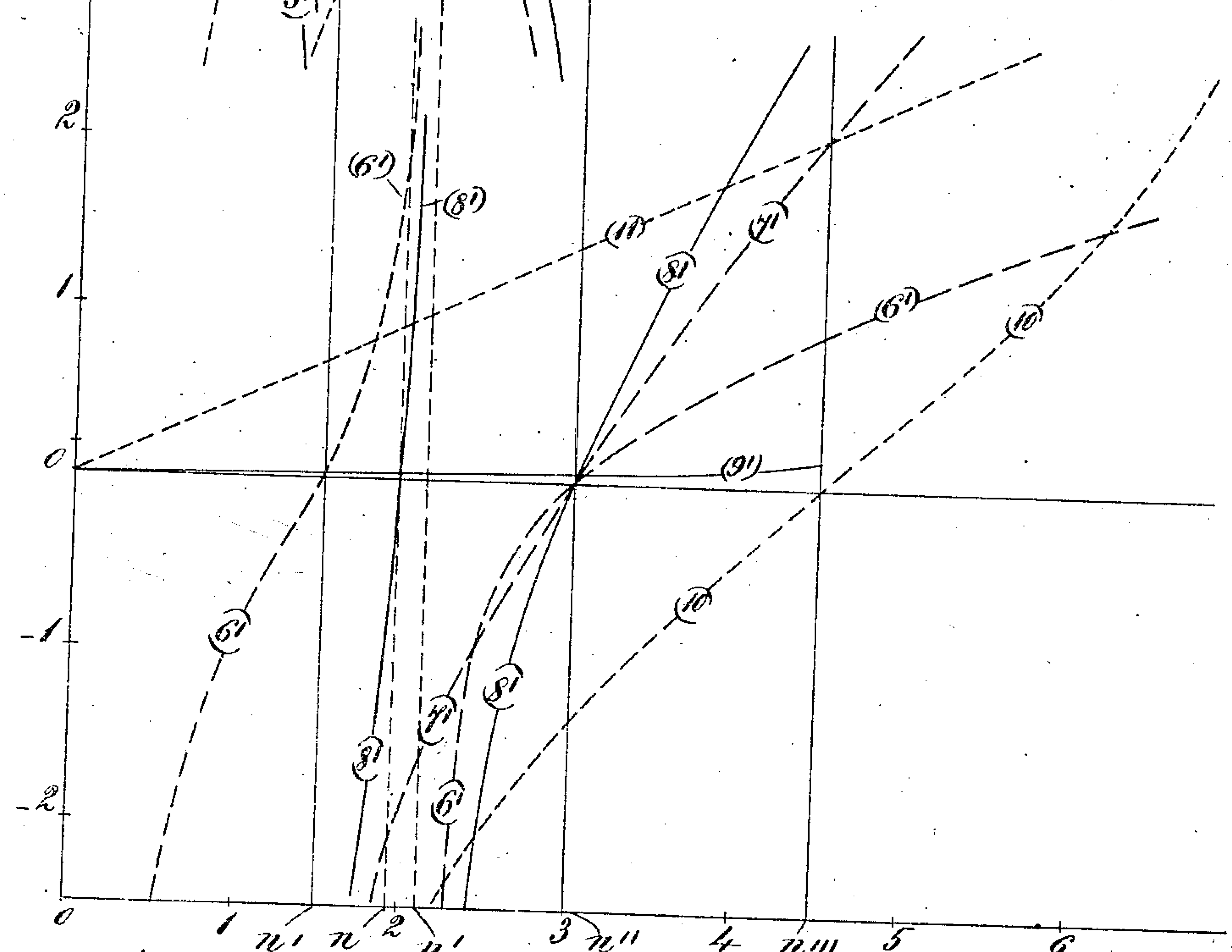

Fig. 9.

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5 SHEETS—SHEET 5.

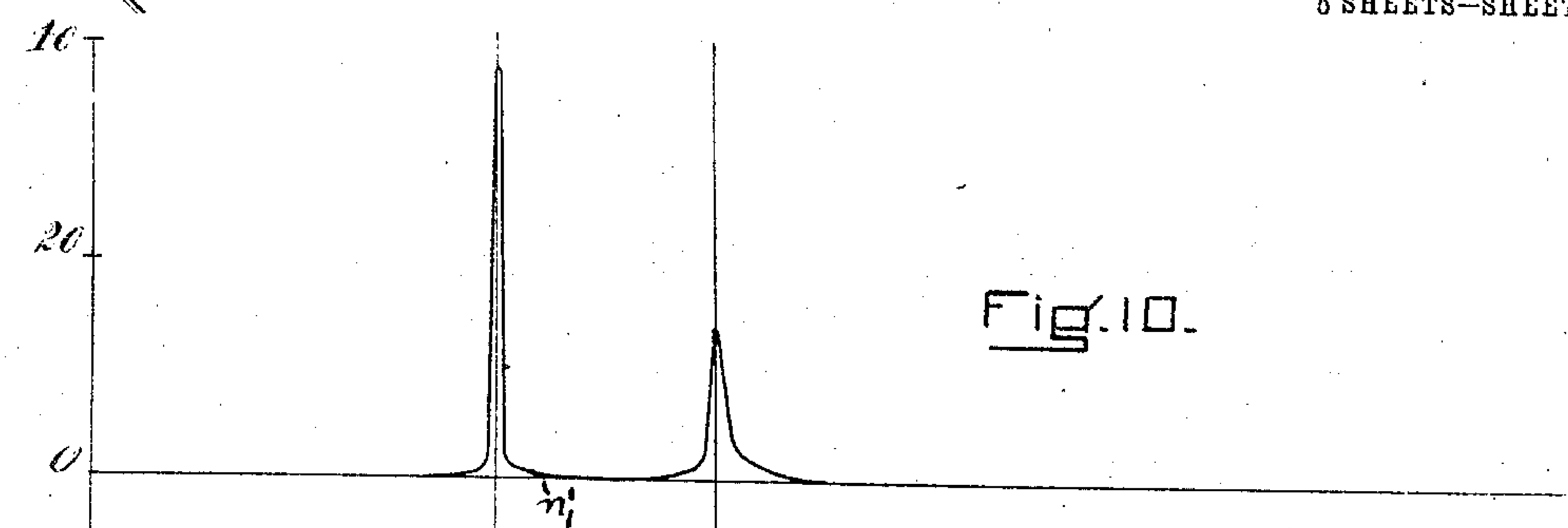

Fig. 10.

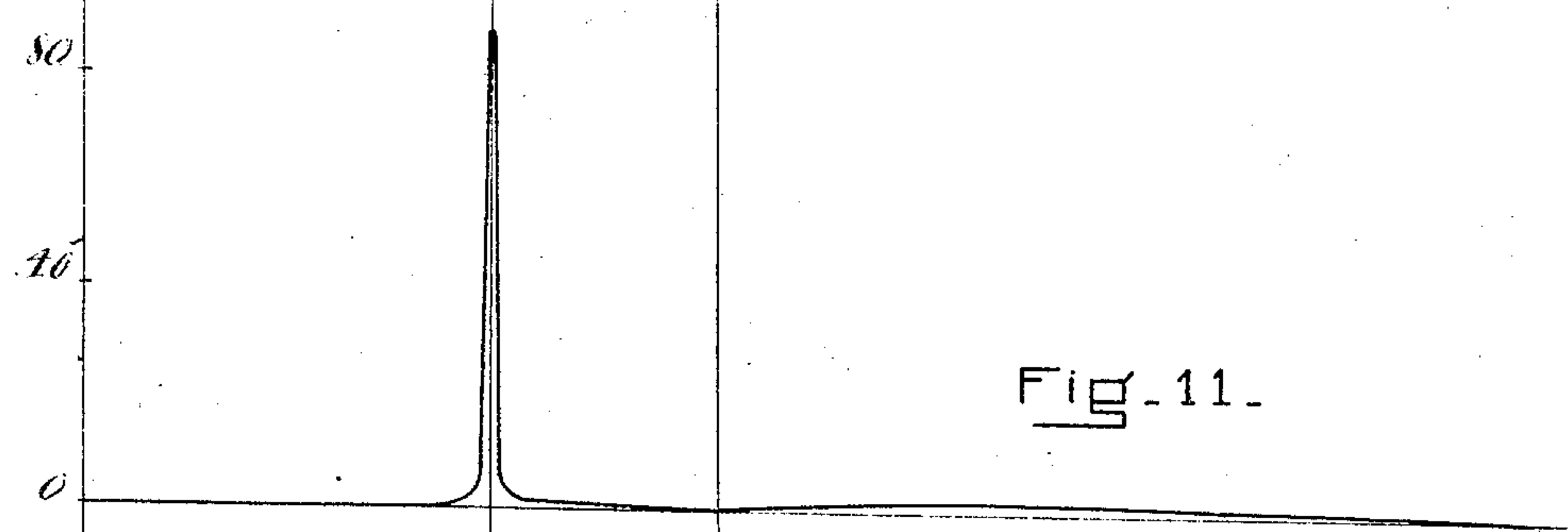

Fig. 11.

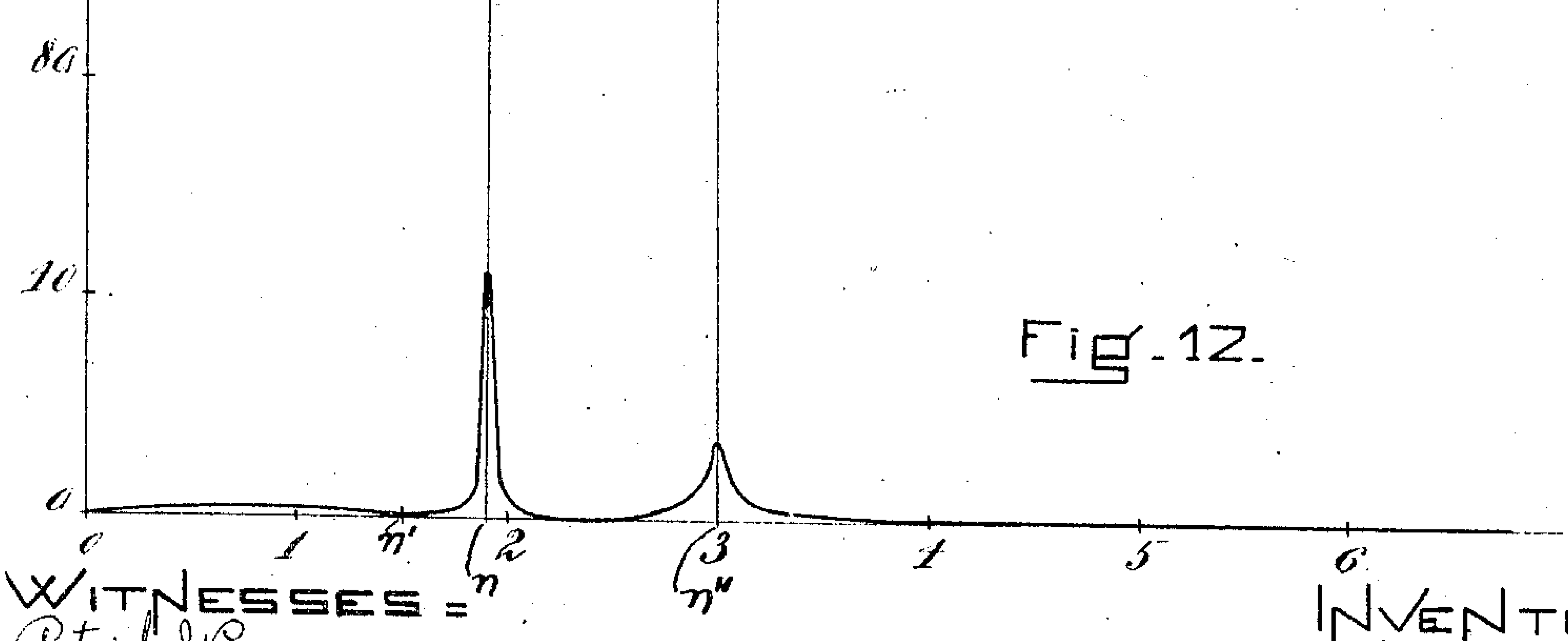

Fig. 12.

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UNITED STATES PATENT OFFICE.

JOHN STONE STONE, OF CAMBRIDGE, MASSACHUSETTS, ASSIGNOR TO WILLIAM W. SWAN, TRUSTEE, OF BROOKLINE, MASSACHUSETTS.

SPACE TELEGRAPHY.

No. 884,109. Specification of Letters Patent. Patented April 7, 1908.

Application filed August 3, 1906. Serial No. 329,096.

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 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 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 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 elevated conductor, or at the center of the receiving conductor, if it be an unearthed conductor, as thereby the receiving conductor 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 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 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.

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 resonant 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; and finally by conveying such natural oscillations 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.

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 including a serially connected coil and condenser, 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. The results are, that the earth connector determines the most pronounced natural rate of vibration of the elevated conductor system because, for either natural or forced electrical oscillations having such rate of vibration, the reaction of the aforesaid circuit which includes the serially connected coil and condenser upon the rest of the elevated conductor system is zero, said circuit being shunted by the earth connector which for such oscillations has zero reactance and practically zero impedance; that the aforesaid circuit which includes the serially connected coil and condenser, 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; and, that 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.

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 modification of the invention described in my application Serial No. 329,094, filed simultaneously herewith, in which I have fully explained certain of the particular principles involved in the present application.

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 organizations of circuits and apparatus whereby the hereinbefore stated objects may conveniently be realized in practice.

In the drawings, Figure 1 is a diagram representing a space telegraph receiving system which embodies my invention in its simplest form. Fig. 2 is a diagram representing another and preferred form of my invention. Figs. 3 to 12 inclusive show a set of curves drawn to rectangular coördinates in which the ordinates represent reactances or current amplitudes and the abscissæ represent frequency, which illustrate the proportionment of the various electro-magnetic constants of the several elements of the systems shown in Figs. 1 and 2, and which graphically set forth the mode of operation of the invention.

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

E is an earth connection.

C C_1 C_2 are condensers.

L L_1 are inductance coils.

I_1 and I_2 are the primary and secondary coils of the transformer M, said coils being preferably so spatially related that the mutual energy between the primary and secondary circuits is small as compared with the product of the self energies of said circuits.

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 three essential elements of my invention are the elevated conductor V*o*, the earth connector *o* L C, shown herein as earthed at E, which is the same point at which the circuit *o* I_1 C_1 is earthed, although it will be understood that the circuits *o* L C and *o* I_1 C_1 may have separate earth connections, and the circuit which includes the serially connected coil and condenser I_1 and C_1.

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 consisting in Fig. 1 of the elevated conductor *per se*, and in Fig. 2 of the elevated conductor *per se* and the serially connected inductance coil L_1.

o L C E is an earth connector having in both cases 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.

I_1 C_1 is a circuit including a serially co - nected coil and condenser and having for persistent electrical oscillations of the frequency to which the resonant receiving circuit C_2 I_2 is attuned, a reactance equal and opposite to the resultant reactance of the elevated conductor Vo and earth connector o L C E, which are connected in parallel with respect to the system o I_1 C_1 E.

The system, o I_1 C_1 E together with the elevated conductor Vo and earth connector o L C E, which are connected in parallel with respect to the system o I_1 C_1 E, constitutes the elevated conductor system. For persistent electrical oscillations of the frequency to which the resonant receiving circuit C_2 I_2 is attuned said elevated conductor system has zero reactance, the resultant reactance of the two components Vo and o L C E of said elevated conductor system being balanced by the reactance of the circuit which includes the inductance I_1 and the capacity C_1. Under these circumstances it will be seen, especially by reference to the curves shown in Figs. 4 and 9, that the earth connector o L C E and the circuit which includes the coil I_1 and condenser C_1 constitute a 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 reactance of the rest of the elevated conductor system, so that said system is highly responsive to electrical oscillations of said frequency; and that one branch of said parallel branch circuit, namely, the branch o L C E, E in this case being common to both branches, has such capacity and inductance that the reactance of said branch is zero for the frequency for which the reactance of the elevated conductor is zero, so that the elevated conductor system thereby is given a pronounced natural rate of vibration different from that of the waves the energy of which is to be received.

C′ represents the apparent capacity of the vertical and L′ represents its apparent inductance. In the earth connector, 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 Vo, the reactance of said earth connector is the same in sign and is approximately the same in value as the reactance of said elevated conductor; and the elevated conductor and earth connector, when isolated, each has zero reactance for oscillations of the lowest frequency natural to the elevated conductor. However the selectance function of the earth connector for a given frequency may be made equal to that of the elevated conductor for such frequency by any suitable means.

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 I_1 which is included in the circuit o I_1 C_1 E. The oscillation detector W and the local circuit including the same may be associated with said resonant receiving circuit in any suitable manner, and in the present instance are shown as connected across the terminals of the condenser C_2.

In the manner more fully set forth by me in my Letters Patent No. 767,994 hereinbefore referred to, the parallel branch circuit I_1 C_1' gives the entire elevated conductor system shown in said Letters Patent natural rates of vibration different from that of the waves the energy of which is to be received while for a persistent simple harmonic forces having the frequency of said waves, the reactance of the parallel branch circuit balance the reaction of the rest of the elevated conductor system and thereby makes said system highly responsive to persistent forces of said frequency. In the systems described in said Letters Patent, the natural oscillations developed in the elevated conductor system are of frequencies ill adapted to cause a response of the associated resonant receiving circuit by passing to earth through the parallel branch circuit with which said resonant circuit is associated, on account of the high impedance offered by said resonant circuit to natural oscillations of said frequencies. Such natural oscillations, however, pass to earth through the parallel branch circuit and if they are of sufficiently high intensity they may produce a noticeable response of the associated resonant receiving circuit unless the mutual inductance between said parallel branch circuit and said associated resonant circuit be made excessively small.

The particular improvement effected by the present invention over the state of the art as shown by my hereinbefore mentioned Letters Patent consists in obviating even a tendency for said natural oscillations to pass through the circuit with which the resonant receiving circuit is associated. To this end I may employ means whereby the elevated conductor system is given natural rates of vibration different from that of the associated resonant receiving circuit and whereby said system is made highly responsive to persistent trains of waves of the frequency to which the resonant receiving circuit is attuned, said means comprising preferably the circuits which include the serially connected coil and condenser I_1 and C_1 and the serially connected coil and condenser L and C; and I may also employ means for preventing such natural oscillations as may by extraneous forces be created in the elevated conductor from passing through the circuit which includes the serially connected coil and condenser I_1 and C_1, said latter means comprising preferably the earth connector o L C E, which, for natural oscillations having a frequency equal to the most pronounced natural rate of vibration of the elevated conductor system, has zero reactance and practically zero impedance or, at least, an impedance low as compared to the impedance offered by the circuit o I^1 C^1 E to such natural oscillations. It will be seen therefore that the elevated conductor system is so designed that the frequencies of the natural oscillations which are created in said system by abrupt or impulsive electrical forces may be made different from the frequency to which the resonant receiving circuit is attuned, that said system may be made highly responsive to persistent electrical forces of the frequency to which said resonant receiving circuit is attuned and that for oscillations having a frequency which is equal to the most pronounced natural rate of vibration of said system, the reactance of the elevated conductor Vo and the earth connector o L C E, as well as the reactance of the system v o L C E, is zero.

Having set forth in general the fundamental principles of my invention I shall now describe specifically those embodiments thereof which are illustrated in the drawings accompanying this application, although it will be understood that I do not limit myself to such particular embodiments of the present invention, inasmuch as many modifications may be made therein by those skilled in the art without departing from the principle or spirit of my invention.

In order that the particular embodiments of my invention which I have selected for diagrammatic illustration for the purpose of more fully disclosing the same may be described with sufficient particularity to enable those skilled in the art to make and use the same, it will be necessary to refer to the curves shown in Figs. 3 to 12 inclusive.

Figs. 3 and 4 show the variation with frequency for persistent electrical forces of the reactance of the several components of the system illustrated in Fig. 1; Figs. 8 and 9 show the variation with frequency for persistent electrical forces of the reactance of the several components of the system illustrated in Fig. 2; Figs. 5, 6 and 7 show the variation with frequency for persistent electrical forces of the current amplitudes of the several parts of the system illustrated in Fig. 1; and Figs. 10, 11 and 12 show the variation with freq ncy for persistent electrical forces of the current amplitudes in the several parts of the system illustrated in Fig. 2.

A practically infinite number of relations may exist between the frequencies natural to the circuits o I_1 C_1 and o L C, although for the purpose of conveniently representing in Figs. 3, 4, 5 and 9 the various relations shown therein, I have chosen the frequency natural to the circuit I_1 C_1 as equal to one-half of the frequency natural to the circuit L C. In all cases the frequency natural to the earth connector L C is equal to the fundamental frequency of the elevated conductor Vo, whether or not the coil L_1 be employed.

In the following discussion of the curves shown in Figs. 3, 4, 8 and 9 it is to be understood that while said curves give the values of reactances whereby the several component parts of the system may be designed, I do not limit myself to systems, the component parts of which necessarily have the reactances shown in said curves inasmuch as an infinite number of systems may be designed in accordance with the principle of the present invention, the reactances of whose component parts would be vastly different from those shown in said curves. So far from limiting myself to systems designed according to the aforesaid curves, I consider said curves merely as illustrative of two special cases of the present generic invention, that is to say, Figs. 3 and 4 are illustrative of one specific case shown in diagram in Fig. 1, in which an unloaded vertical is employed and Figs. 8 and 9 are illustrative of one specific case shown in diagram in Fig. 2 in which the loading inductance L_1 is serially connected with the elevated conductor Vo.

The reactance of the elevated conductor system at the point o may most conveniently be found by adding the conductances of the circuit I_1 C_1 and the earth connector, and then adding the reactance of the elevated conductor at the point o to the reciprocal of such joint conductance—*i. e.*, the joint reactance. For convenience, the term "conductance" is used herein as meaning the reciprocal of reactance.

Curve (1) in Fig. 3 shows the reactance-frequency variation of the circuit I_1 C_1 and curve (2) shows the conductance-frequency variation thereof.

Curve (3) shows the reactance-frequency variation of the earth connector and curve (4) shows the conductance-frequency variation thereof.

Curve (5), being the algebraic sum of curves (2) and (4), represents the variation with frequency of the joint conductance of the two circuits I_1 C_1 and L C, or the total conductance of the parallel branch circuit o I_1 C_1 L C. n_1' at which curve (5) crosses the axis of abscissæ therefore represents the frequency natural to said parallel branch circuit, when isolated, and for persistent electrical forces of said frequency the reactance of said parallel branch circuit as measured between its points of connection with the circuit upon which such forces are impressed is practically infinite.

Curve (6), being the reciprocal of curve (5), represents the joint reactance of the circuits I_1 C_1 and L C or the total reactance of the parallel branch circuit *o* I_1 C_1 L C, and for persistent electrical forces of frequency n_1' the ordinates of said curve are infinite as shown in Fig. 4 in which curve (6) is asymptotic to the ordinate drawn from the point n_1' on the axis of abscissæ. Thus it will be seen that the parallel branch circuit *o* I_1 C_1 L C presents these characteristics, that for persistent electrical oscillations of frequency n_1' its reactance on the driving point is practically infinite, while for natural oscillations of frequencies n' and n'', being those natural to its branches I_1 C_1 and L C respectively, its reactance is zero, as hereinafter more fully explained in connection with Figs. 5, 6 and 7.

Curve (7) represents the variation with frequency of the reactance of the elevated conductor V*o*, in Fig. 1, as measured at its electrical center *o*.

Curve (8), which is the algebraic sum of curves (6) and (7), represents the variation with frequency of the total reactance of the elevated conductor system as measured at the point *o*. Curve (8) crosses the axis of abscissæ at two points, namely, n and n''. For electrical oscillations of frequencies n and n'' therefore the reactance of the elevated conductor system is zero.

n represents the frequency of the waves the energy of which is to be received and to which the resonant receiving circuit is attuned, and for persistent electrical forces of this frequency the reactance of the circuit including the serially connected coil and condenser I_1 and C_1 is equal in value and opposite in sign to the resultant reactance of the elevated conductor V*o* and its earth connector *o* L C E which are connected in parallel with respect to said circuit. Stated in another way, for persistent electrical forces of frequency n, the reactance of the parallel branch circuit *o* I_1 C_1 L C is equal and opposite to the reactance of the rest of the elevated conductor system, as clearly shown in Figs. 4 and 9, in which the ordinates of curves (6) and (7), or (6′) and (7′), at abscissæ n are, pair by pair, equal in value and opposite in sign.

n'' represents the fundamental frequency natural to the elevated conductor V*o*, when isolated, and n_2'' is the first even harmonic thereof. n'' represents also the frequency natural to the earth connector when isolated. Furthermore n'' represents the most pronounced and gravest natural rate of vibration of the elevated conductor V*o* and earth connector *o* L C E connected in series and isolated; and finally n'' represents the most pronounced natural rate of vibration of the elevated conductor system considered as a whole—*i. e.*, V*o* and *o* L C E connected in series with each other and in parallel with respect to I_1 C_1,—because for oscillations, either natural or forced, of frequency n'' the circuit I_1 C_1 does not react upon the system V *o* L C E inasmuch as said circuit I_1 C_1 is shunted by the earth connector *o* L C E which for oscillations of said frequency has zero reactance and practically zero impedance. Accordingly electrical oscillations of frequency n'' which are developed in the elevated conductor pass to earth by way of the earth connector and have no tendency to pass to earth through the means whereby the resonant receiving circuit is associated with the elevated conductor system, said means being the circuit I_1 C_1. The natural oscillations which are developed in the elevated conductor by abrupt or impulsive electrical forces are chiefly of frequency n'', that is to say, the most pronounced natural rate of vibration of the elevated conductor system is determined by the earth connector and is not affected by the circuit I_1 C_1.

Curve (9) shows the variations with frequency of the resistance equivalent of radiation of the elevated conductor V*o* in Fig. 1, and the ordinate of curve (9) for frequency n'' is 40, irrespective of its geometric or electromagnetic constants. This value accordingly fixes the scale of ordinates for the other curves shown in Figs. 3 and 4. The abscissæ of said curve are expressed as arbitrary numbers 1, 2, 3 etc., and these numbers may be multiplied by the proper constants such as 7.10^5, 10^6, 2.10^6 etc., to suit the ordinary working conditions of wireless telegraph practice.

The curve in Fig. 5 shows the variation with frequency for persistent electrical forces of the amplitude of the current developed in the elevated conductor V*o* of Fig. 1 at a point slightly above the point *o* therein.

The curve in Fig. 6 shows the variation with frequency for persistent electrical forces of the amplitude of the current developed in the circuit I_1 C_1. For frequency n, which is that of the waves the energy of which is to be received, there is a sharply defined current maximum in said circuit, while for frequency n'' the current in said circuit is zero because, as above pointed out, the earth connector which is connected in shunt to said circuit has zero reactance for oscillations of frequency n''.

The curve in Fig. 7 shows the variation with frequency for persistent electrical forces of the amplitude of the current developed in the earth connector. While a well defined and in fact relatively large current maximum occurs at frequency n, nevertheless said amplitude in the present instance will be seen to be about one-half of that for which said frequency is developed in the circuit I_1 C_1, owing to the fact that the reactance of the earth connector, in this particular instance, is about twice as large as that of the circuit I_1 C_1, as may be seen by comparing the ordinate of curve (3) for frequency n with the ordinate of curve (1) for said frequency. It will be noted that the ordinate of the curve shown in Fig. 7 is zero for frequency n' because as above pointed out the circuit I_1 C_1 which is connected in shunt to the earth connector has zero reactance for frequency n'. It will further be noted that the ordinate of the curve shown in Fig. 5 is zero for frequency n_1' because, as above noted in connection with Figs. 3 and 4, the reactance of the parallel branch circuit o I_1 C_1 L C is practically infinite for persistent electrical forces of frequency n_1',—see curve (6).

The elevated conductor Vo and earth connector o L C E being connected in parallel with respect to the circuit o I_1 C_1, it will be seen that the sum of the currents in said elevated conductor and earth connector is equal to the current in the circuit o I_1 C_1.

In Figs. 26[a] and 28 of my Letters Patent No. 767,994 above referred to, are shown curves somewhat similar in shape to the curve shown in Fig. 5 of the present case and representing the variation with frequency for persistent electrical forces of the current amplitudes in the elevated conductor. In the system disclosed in said Letters-Patent natural oscillations created in the elevated conductor system by extraneous electrical forces pass to earth through the parallel branch circuit I_1 C_1', as indicated at n' in Fig. 24[a] of said patent. In the present invention, however, the circuit o L C E connected between the earth and the point of association of the circuit I_1 C_1 with the elevated conductor constitutes a path of practically zero reactance for any natural oscillations of frequency n'' that may be created in the elevated conductor by such extraneous forces, because, for such natural oscillations so created, the reaction of the circuit I_1 C_1 upon the system V o L C E is zero, so that said oscillations have no tendency to pass to earth by way of the circuit I_1 C_1 and therefore have no tendency to cause a response of the resonant receiving circuit which may be associated therewith. For such natural oscillations of said frequency so created in the elevated conductor by extraneous electrical forces the circuit I_1 C_1 has a reactance which in the present instance is very high as compared to that of the circuit o L C E, as shown in Fig. 3 or, in other words, said circuit o L C E affords a path to earth around said circuit I_1 C_1 of practically zero impedance for such natural oscillations of said frequency, so that said natural oscillations have practically no tendency to pass to earth by way of said circuit I_1 C_1. For persistent electrical forces of frequency n the circuit o L C E has a reactance which is very high as compared with that of the circuit I_1 C_1 as shown in Fig. 3, so that there is but little tendency for persistent oscillations of frequency n—*i. e.*, the frequency of the waves the energy of which is to be received, to pass to earth by way of said circuit o L C E.

As shown in Figs. 1 and 2 the oscillation detector W is associated with the elevated conductor by means of the circuit which includes the serially connected coil I_1 and condenser C_1 through the intermediary of the resonant receiving circuit C_2 I_2; but 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 this art. It will be seen therefore that my invention comprises an elevated receiving conductor Vo, an oscillation detector W, means associating said oscillation detector with said elevated conductor, said means being shown in the present instance as the circuit I_1 C_1, and a circuit connected around the latter and being shown in the present instance as the earth connector o L C E. It will be seen also that said circuit I_1 C_1 has, for persistent electrical oscillations of frequency n, a reactance smaller than that of said earth connector while for such natural oscillations as may be created in the elevated conductor said earth connector has a reactance smaller than that of the circuit I_1 C_1. Furthermore it will be seen that my invention comprises a circuit, herein shown as the circuit I_1 C_1, an elevated conductor Vo and an earth connector o L C E, said elevated conductor and earth connector being connected in parallel with respect to said circuit and that, by virtue of the proportionment of the reactances of the various components of the system as hereinbefore set forth, the system as a whole has zero reactance for oscillations of a frequency equal to the fundamental frequency of the elevated conductor Vo—viz., the frequency n'', and has zero reactance for one other frequency, namely, that of the waves of the energy of which is to be received; that currents of the frequency of the waves to be received, namely, n, pass chiefly through the circuit I_1 C_1 with which the oscillation detector preferably is associated in any suitable manner; and that currents of frequency n'' pass to earth entirely through the earth connector and therefore do not affect said oscillation detector however the latter may be associated with the circuit I_1 C_1.

The elevated conductor system shown in Fig. 2 is the same in all respects as that shown in Fig. 1 except that in Fig. 2 the loading coil L_1 is employed for stiffening the elevated conductor—*i. e.*, for elevating its selectance function.

For the purpose of more readily comparing the reactance-frequency curves shown in Figs. 8 and 9 for the system illustrated in

Fig. 2, with those shown in Figs. 3 and 4 for the system illustrated in Fig. 1, as well as for comparing the current-frequency curves of Figs. 10, 11 and 12 with those of Figs. 5, 6 and 7, the fundamental n'' of the loaded vertical of Fig. 2 is made equal to the fundamental of the unloaded vertical of Fig. 1. In other words, the fundamental of the elevated conductor *per se* of Fig. 2 is taken as higher than that of the elevated conductor *per se* of Fig. 1. It will be understood of course that I am not limited to any particular relation between the fundamentals of the elevated conductors *per se* of the two cases, and that the foregoing proportionment has been made merely for the purpose of conveniently representing and comparing the two cases.

In Fig. 9 the fundamental of the elevated conductor *per se* is designated as n'''.

Curve (10) represents the variation with frequency of the reactance of the elevated conductor *per se* of Fig. 2.

Curve (11) shows the reactance-frequency variation of the inductance L_1 of Fig. 2.

Curve (7'), being the resultant of curves (10) and (11), represents the reactance-frequency variation of the elevated conductor V*o* of Fig. 2.

Curve (6') shows the variation with frequency of the joint reactance of the two circuits which constitute the parallel branch circuit *o* I_1 C_1 L C.

Curve (6') is the reciprocal of curve (5'), the latter representing the joint conductance of the aforesaid parallel branch circuit and being the algebraic sum of curves (2) and (4'). Curves (2) and (4') represent the conductances of the circuits *o* I_1 C_1 and *o* L C respectively, the reactances of which circuits are shown by the curves (1) and (3'). In the present instance the circuit I_1 C_1 of Fig. 2 is identical with the correspondingly lettered circuit of Fig. 1 as shown by the identity of curves (1) and (2) in Figs. 3 and 8. The employment of the loading coil L_1 in the elevated conductor of Fig. 2 requires, other things being equal, that the earth connector of said figure be stiffer than that of Fig. 1, and this is shown by the fact that curve (3') is a steeper curve than curve (3).

Curve (8'), being the algebraic sum of curves (6') and (7'), represents the variation with frequency of the total reactance of the elevated conductor system of Fig. 2 as measured at the point *o*. Curve (8') crosses the axis of abscissæ at two points, namely, n and n'', in a manner similar to the corresponding curve shown as (8) in Fig. 4, with this difference, however, that in Fig. 9 the point n is higher than in Fig. 4. The significance of the frequencies represented by n and n'' in Fig. 9, as well as those represented by n' and n_1' in Fig. 9 is the same as that of the frequencies represented by the same reference characters, respectively, upon the axis of abscissæ in Fig. 4 and discussed above in connection with said figure.

Curve (9') in Fig. 9 represents the variation with frequency of the resistance equivalent of radiation of the elevated conductor *per se* in Fig. 2, and the ordinate of said curve (9') is 40 for frequency n''', which as above stated, represents the fundamental of the unloaded vertical V.

The current-frequency variation curves shown in Figs. 10, 11 and 12 for the system illustrated in Fig. 2 present in general the same characteristics as those shown in Figs. 5, 6 and 7 for the system illustrated in Fig. 1. The most marked difference between the two sets of current-frequency variation curves is, that those shown in Figs. 10, 11 and 12 are in general steeper than those shown in Figs. 5, 6 and 7, the reasons being that for frequencies n and n'' the resistance equivalent of radiation for the system of Fig. 2 is less than that for the system of Fig. 1 at the same frequencies respectively, and because the component parts of the system are electrically stiffer than those of Fig. 1. The effect of employing the loading inductance L_1 will be clear from an inspection of curve (8') which will be seen to be much steeper throughout its entire extent than the corresponding curve represented as (8) in Fig. 4, thereby showing that the selectance function of the elevated conductor system has been increased.

Although as above stated the frequency natural to the circuit I_1 C_1 is herein shown as less than the frequency n'' which is that natural to the elevated conductor V*o* and its earth connector *o* L C E, said frequency which is represented by n' may have any value except the value n''. It will readily be apparent that as the frequency n' is elevated, the frequency n is increased, and that frequency n' may be chosen as greater than the frequency n'', in which case the characteristic maxima for frequency n'' which are shown in Figs. 5, 7, 10 and 12 will occur for frequencies lower than the frequency n, or in other words, the frequency of the waves to be received in such case will be greater than that of the elevated conductor V*o* and for said frequency, in such cases, the reactance of the elevated conductor will be an inductance reactance. In the particular examples herein given in curves (3), (4), (8) and (9), the reactance of the elevated conductor V*o* for frequency n is a capacity reactance and is balanced by the joint reactance of the two circuits which together form the parallel branch circuit *o* I_1 C_1 L C, said joint reactance being an inductance reactance. This particular proportionment, however, is not intended as a limitation, but is merely incidental to the particular example chosen for completely disclosing the present invention.

I claim,—

1. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor and a 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 reactance of the rest of the elevated conductor system, and one branch of said parallel branch circuit having such capacity and inductance that said branch has zero reactance for the same frequency for which the reactance of the elevated conductor is zero.

2. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor and a 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 reactance of the rest of the elevated conductor system, and each branch of said parallel branch circuit including a serially connected coil and condenser.

3. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor and a 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 reactance of the rest of the elevated conductor system, and a resonant circuit associated with one branch of said parallel branch circuit, the other branch of said parallel branch circuit having such capacity and inductance as to form a path to earth having practically zero impedance for natural electrical oscillations created in the elevated conductor.

4. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor and including a serially connected inductance, and a 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 reactance of the rest of the elevated conductor system, one branch of said parallel branch circuit having such capacity and inductance that said branch has zero reactance for the same frequency for which the reactance of the elevated conductor is zero.

5. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor including a serially connected inductance, and a 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 reactance of the rest of the elevated conductor system, and each branch of said parallel branch circuit including a serially connected coil and condenser.

6. In a space telegraph receiving system, an elevated conductor system comprising an elevated conductor and including a serially connected inductance, and a 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 reactance of the rest of the elevated conductor system, and a resonant circuit associated with one branch of said parallel branch ciruict, the other branch of said parallel branch circuit having such capacity and inductance as to form a path to earth having practically zero impedance for natural electrical oscillations created in the elevated conductor.

7. In a space telegraph receiving system, an elevated conductor system comprising a circuit including a serially connected coil and condenser, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said circuit and each, when isolated, having zero reactance for the same definite frequency.

8. In a space telegraph receiving system, an elevated conductor system comprising a circuit including a serially connected coil and condenser, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said circuit, and said circuit having, for persistent electrical oscillations of the frequency of the waves the energy of which to be received, a reactance equal and opposite to the resultant reactance of said elevated conductor and its earth connector.

9. In a space telegraph receiving system, an elevated conductor system comprising a circuit including a serially connected coil and condenser, an elevated conductor and an earth connector; said elevated conductor and earth connector being connected in parallel with respect to said circuit and each, when isolated, having zero reactance for the same definite frequency; 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 and opposite to the resultant reactance of said elevated conductor and its earth connector.

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.