No. 884,106. PATENTED APR. 7, 1908.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED MAY 7, 1906.

6 SHEETS—SHEET 1.

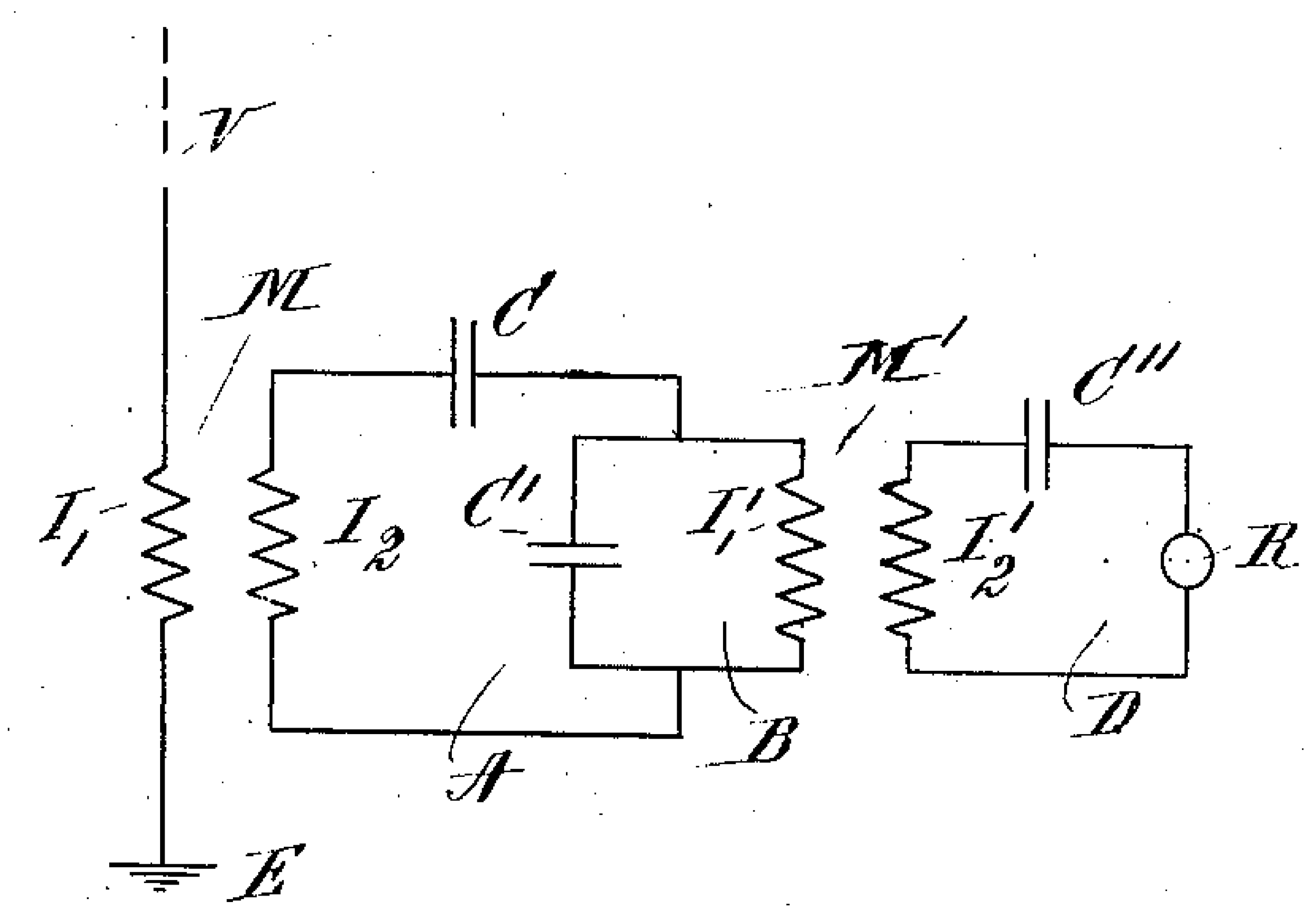

Fig. 1.

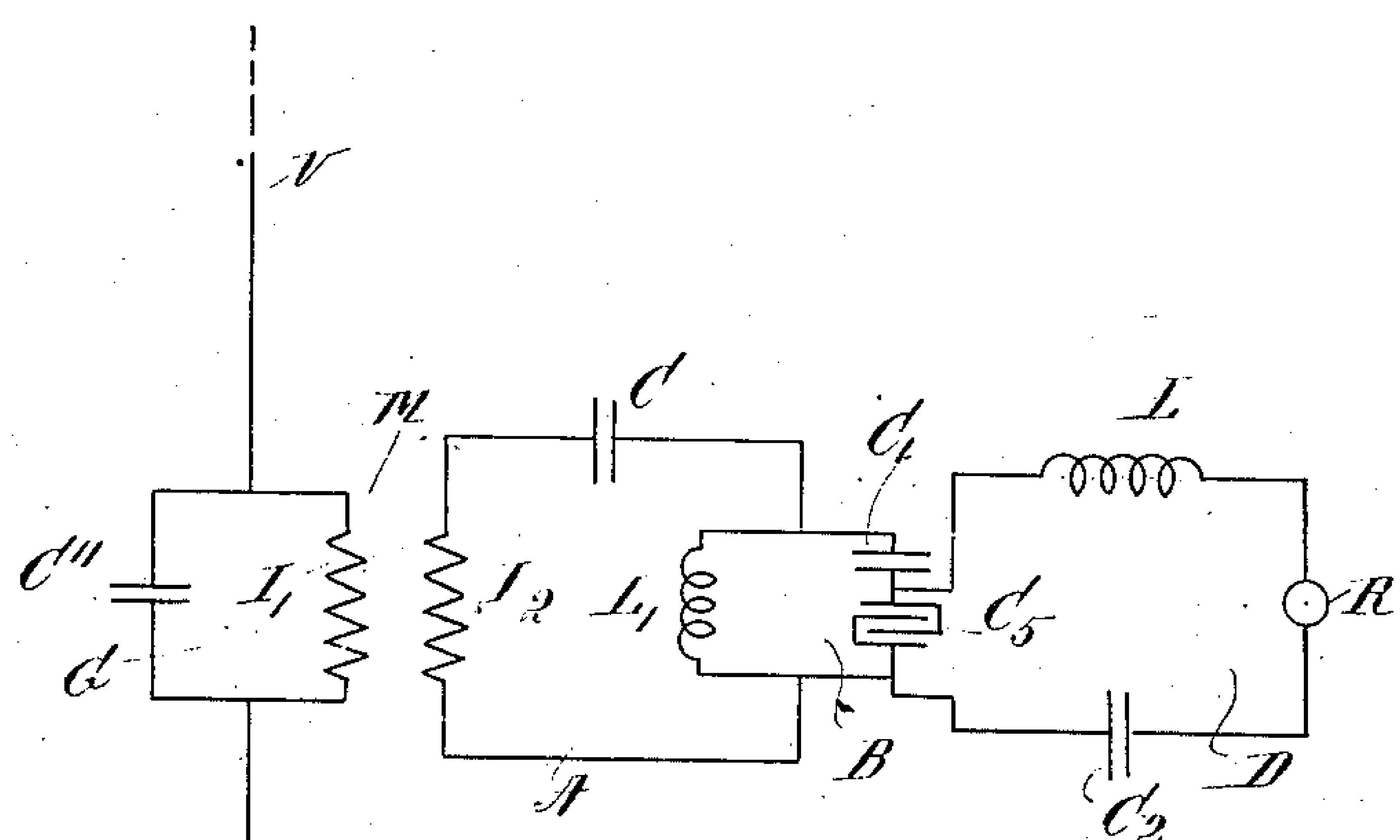

Fig. 2.

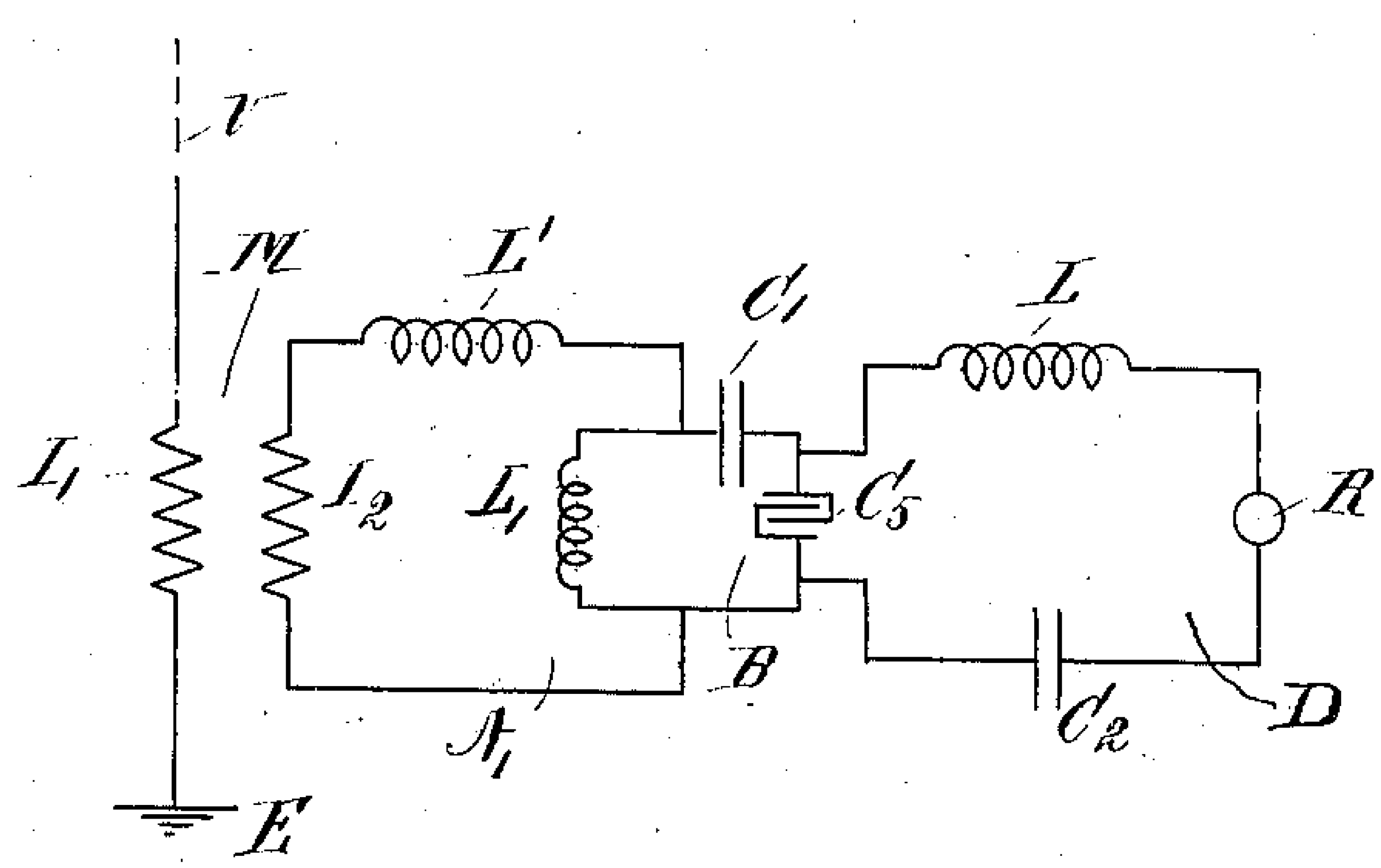

Fig. 3.

WITNESSES:

Geo. W. Woodworth

E. B. Tomlinson.

INVENTOR:

John Stone Stone

by Alex. P. Browne

attorney

No. 884,106.

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6 SHEETS—SHEET 2.

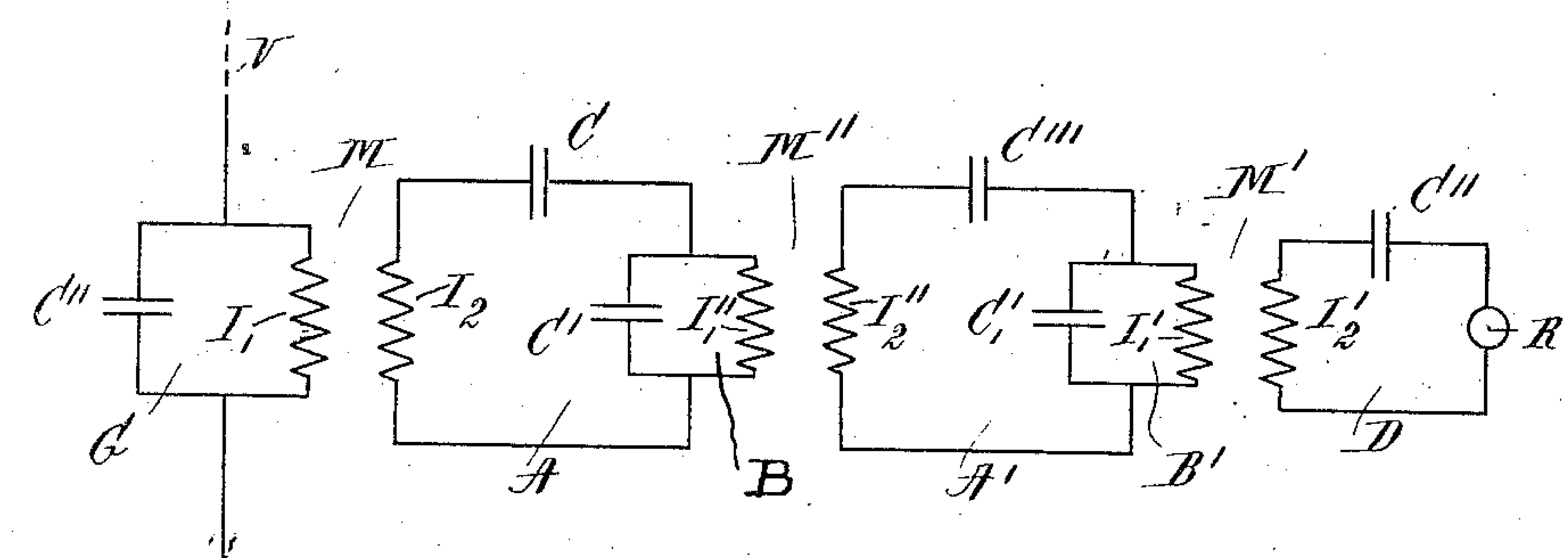

Fig-4-

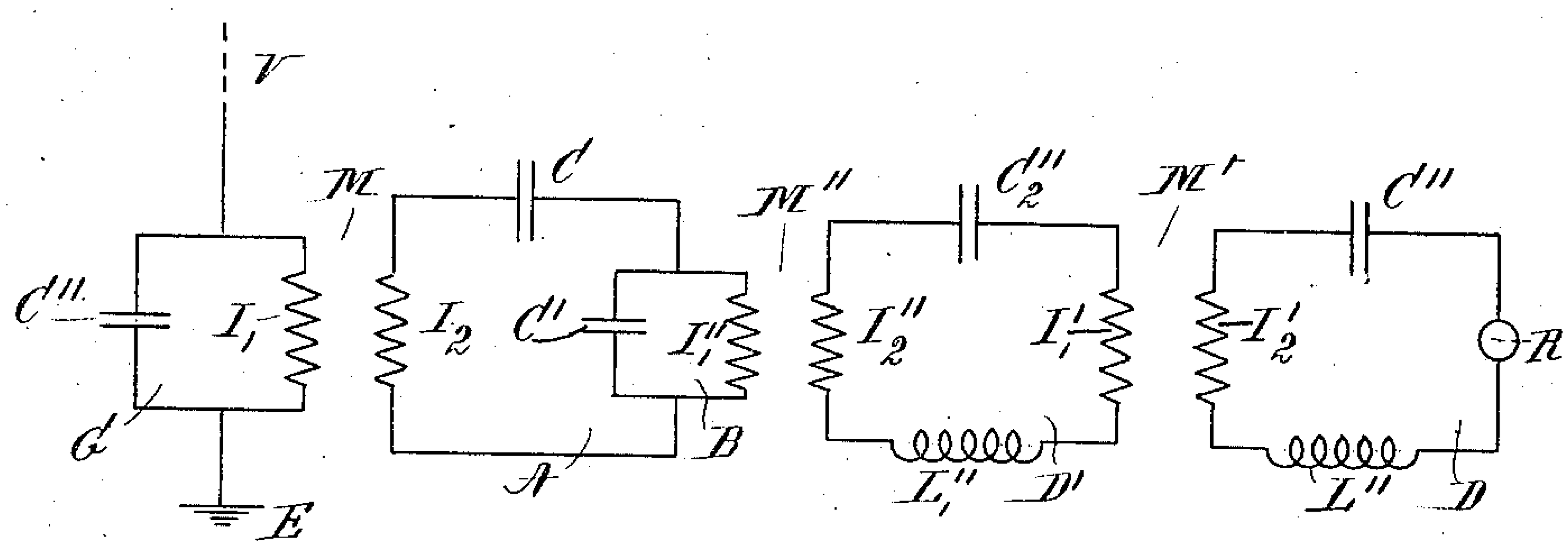

Fig-5-

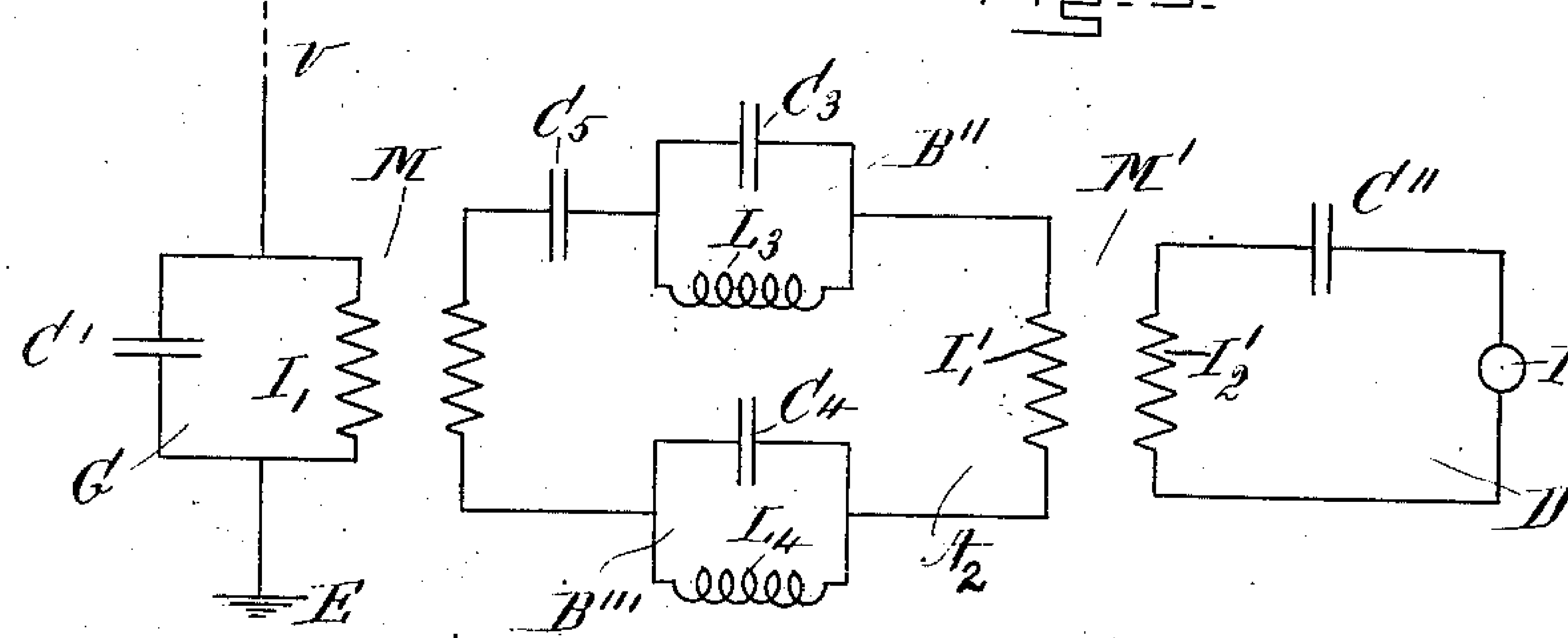

Fig 6

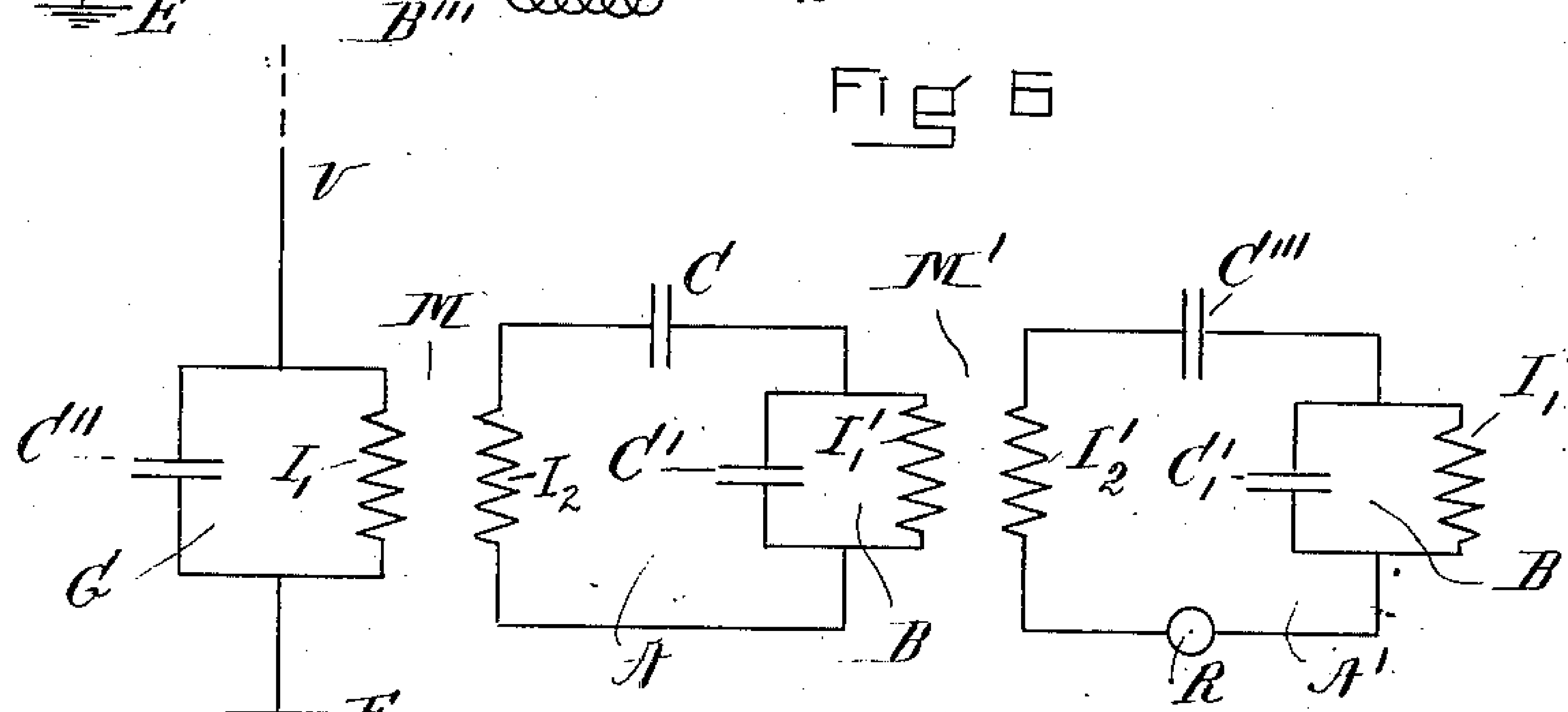

Fig-7-

WITNESSES:

George Woodworth

E. B. Tomlinson

INVENTOR:

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SPACE TELEGRAPHY.

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6 SHEETS—SHEET 3.

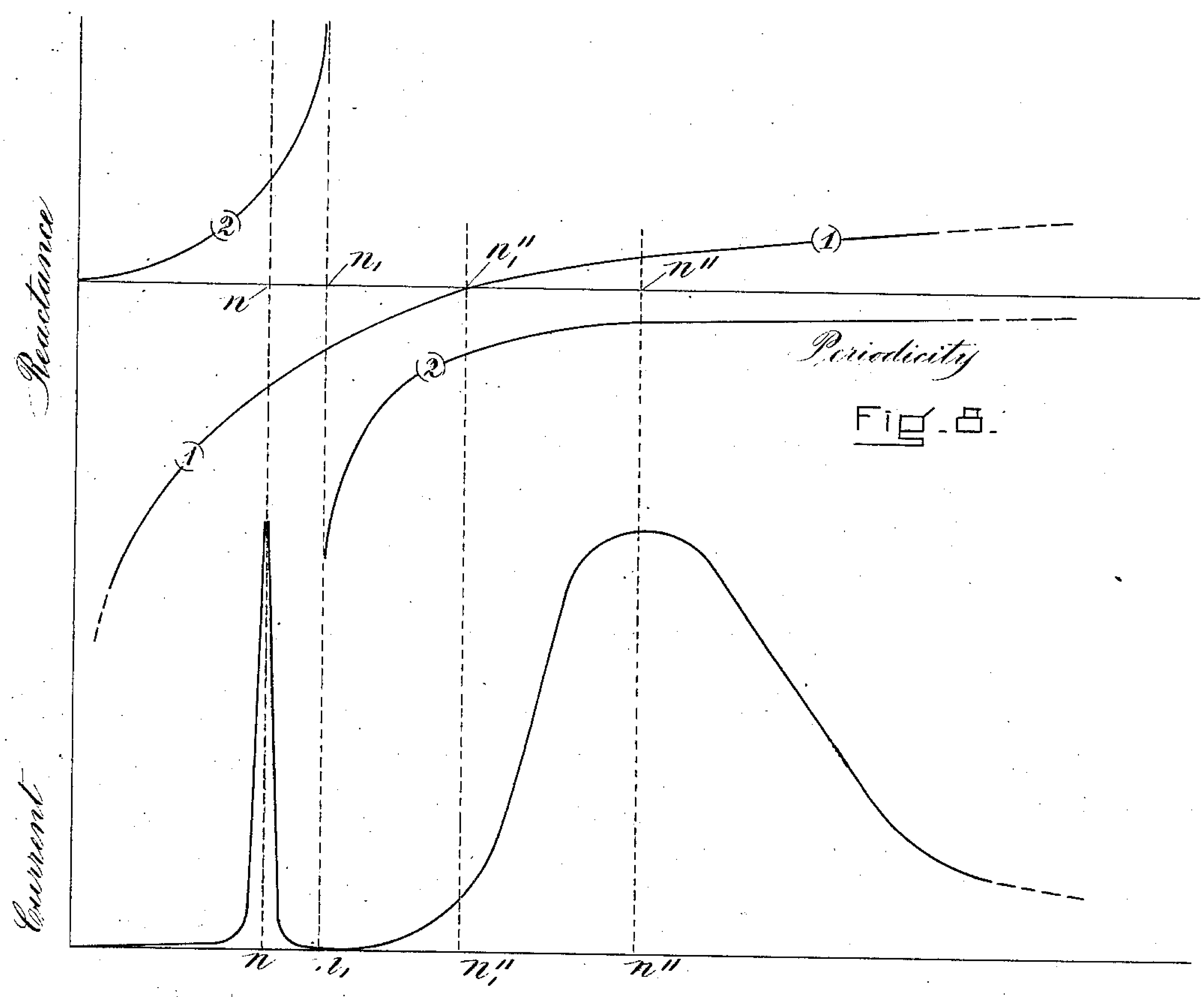

Fig. 8.

Fig. 9.

WITNESSES:
Geo. K. Woodworth.
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SPACE TELEGRAPHY.

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6 SHEETS—SHEET 4.

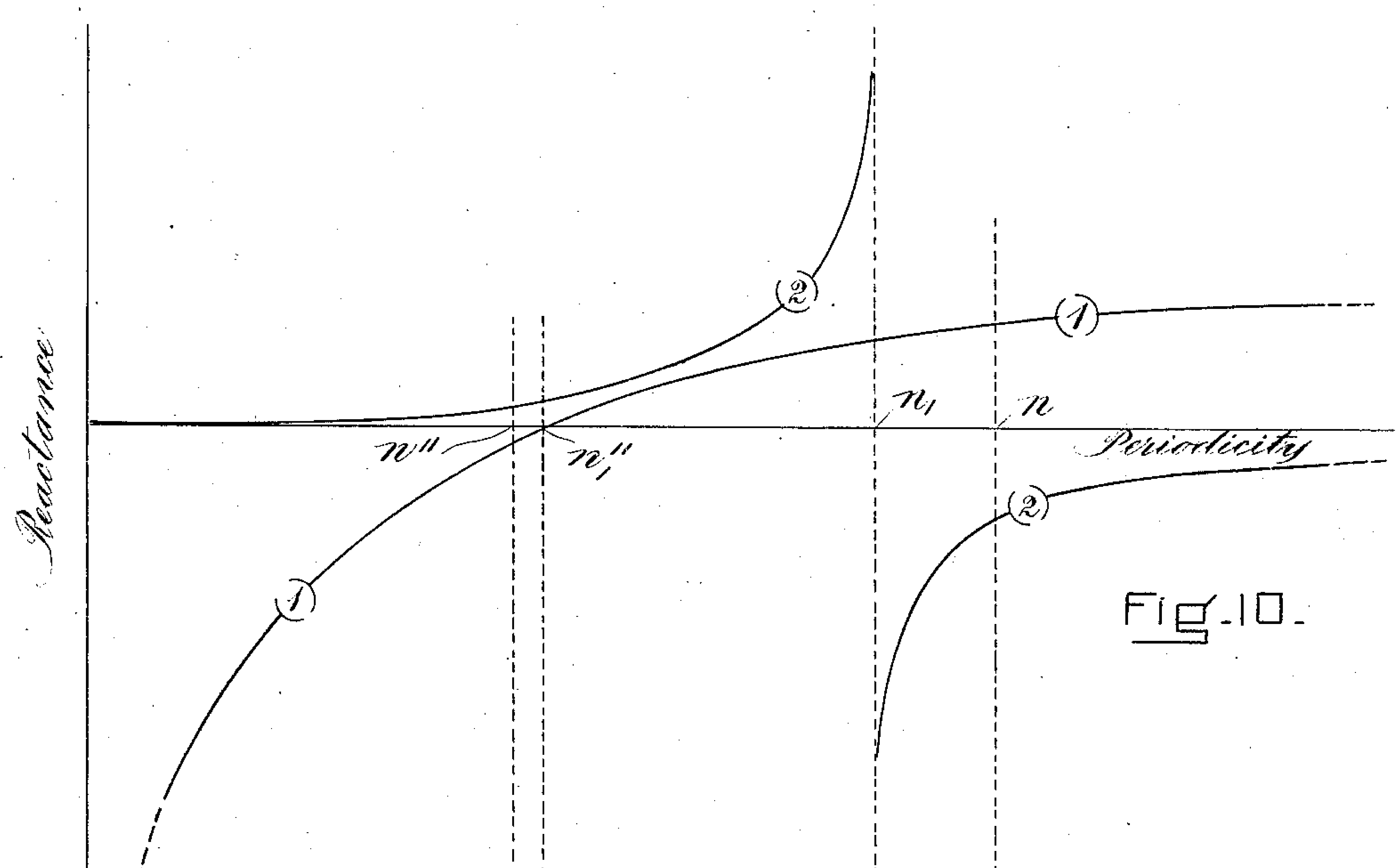

Fig. 10.

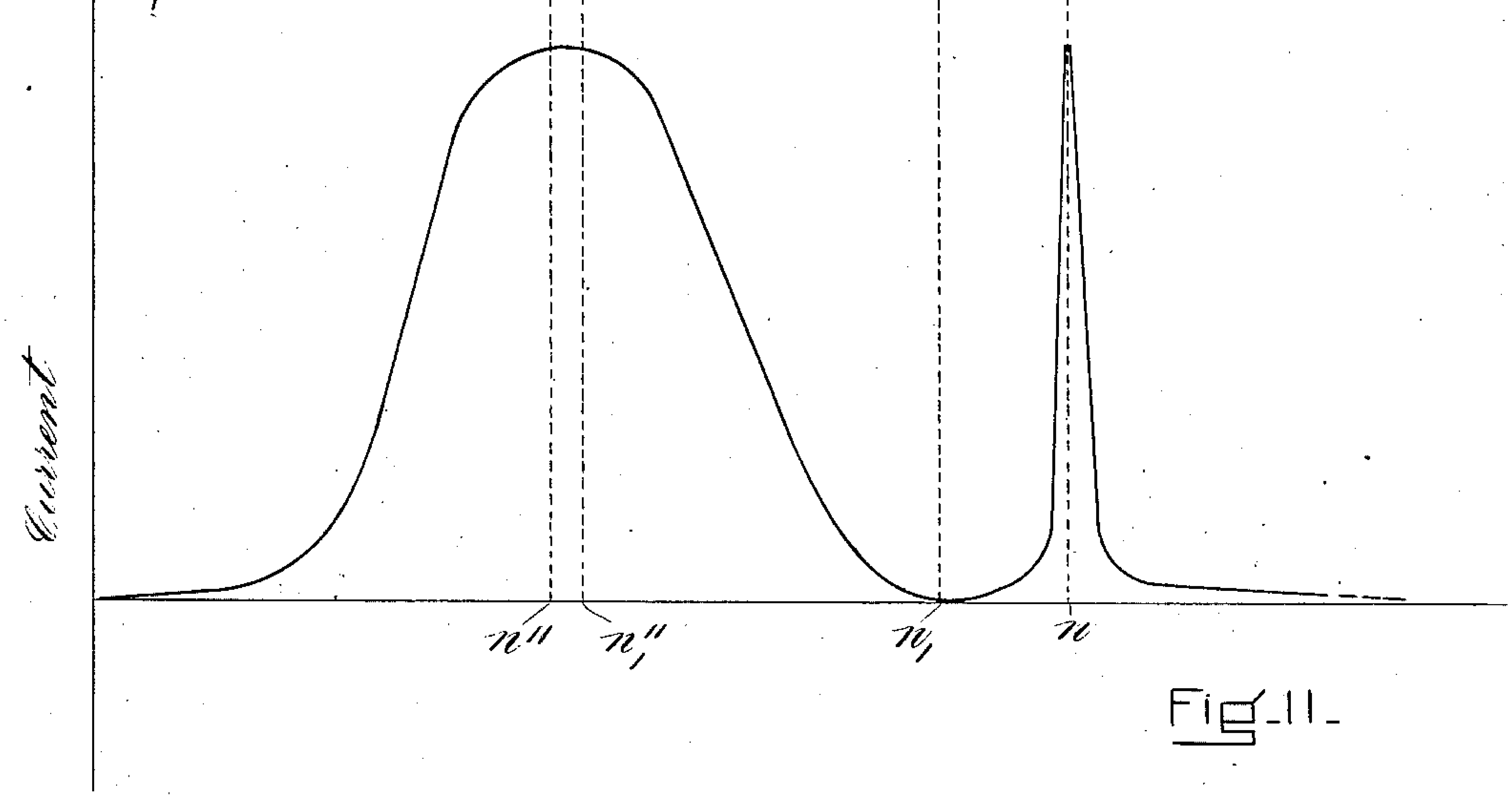

Fig. 11.

WITNESSES:
Geo K Woodworth.
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John Stone Stone
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No. 884,106. PATENTED APR. 7, 1908.

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SPACE TELEGRAPHY.

APPLICATION FILED MAY 7, 1906.

6 SHEETS—SHEET 5.

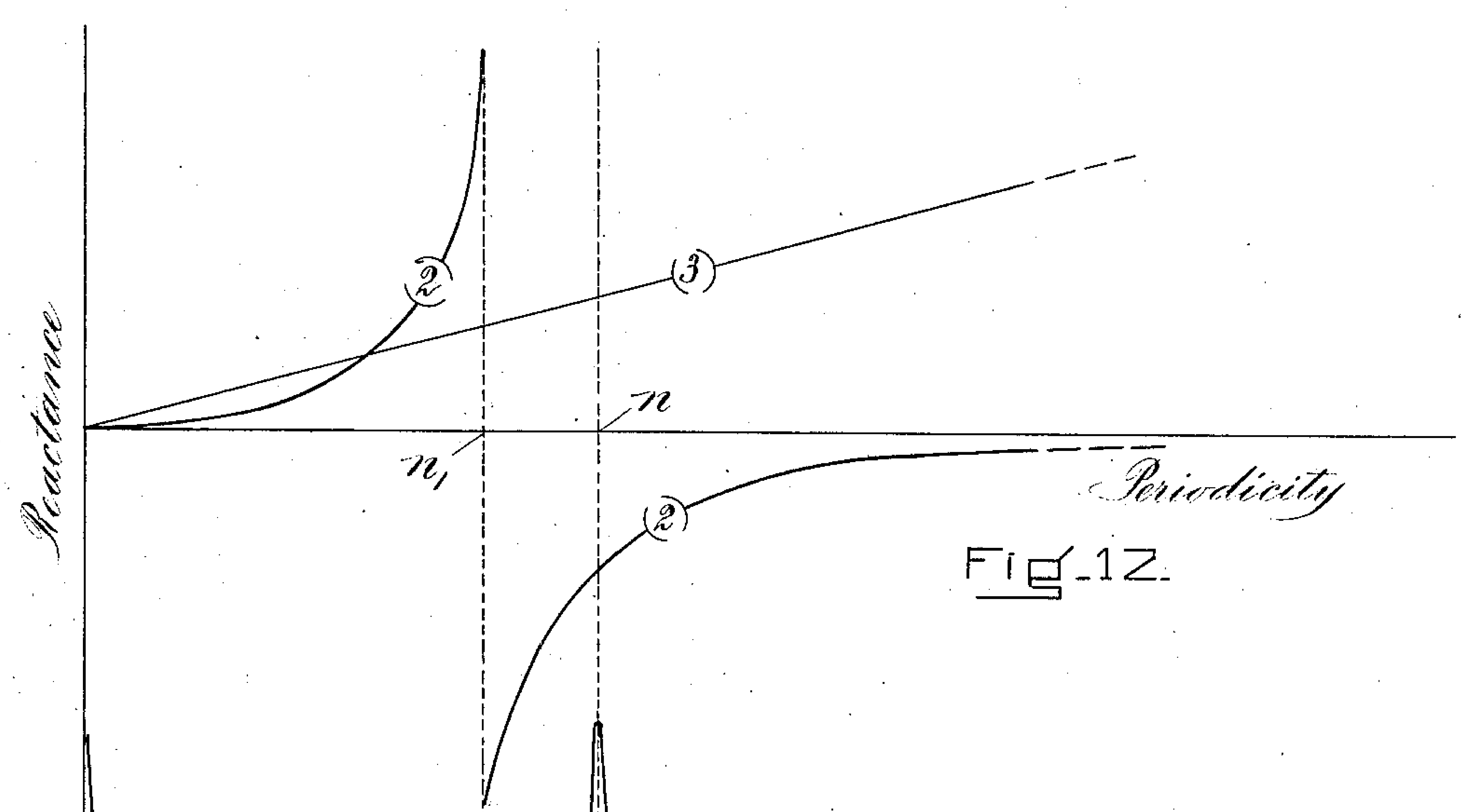

Fig. 12.

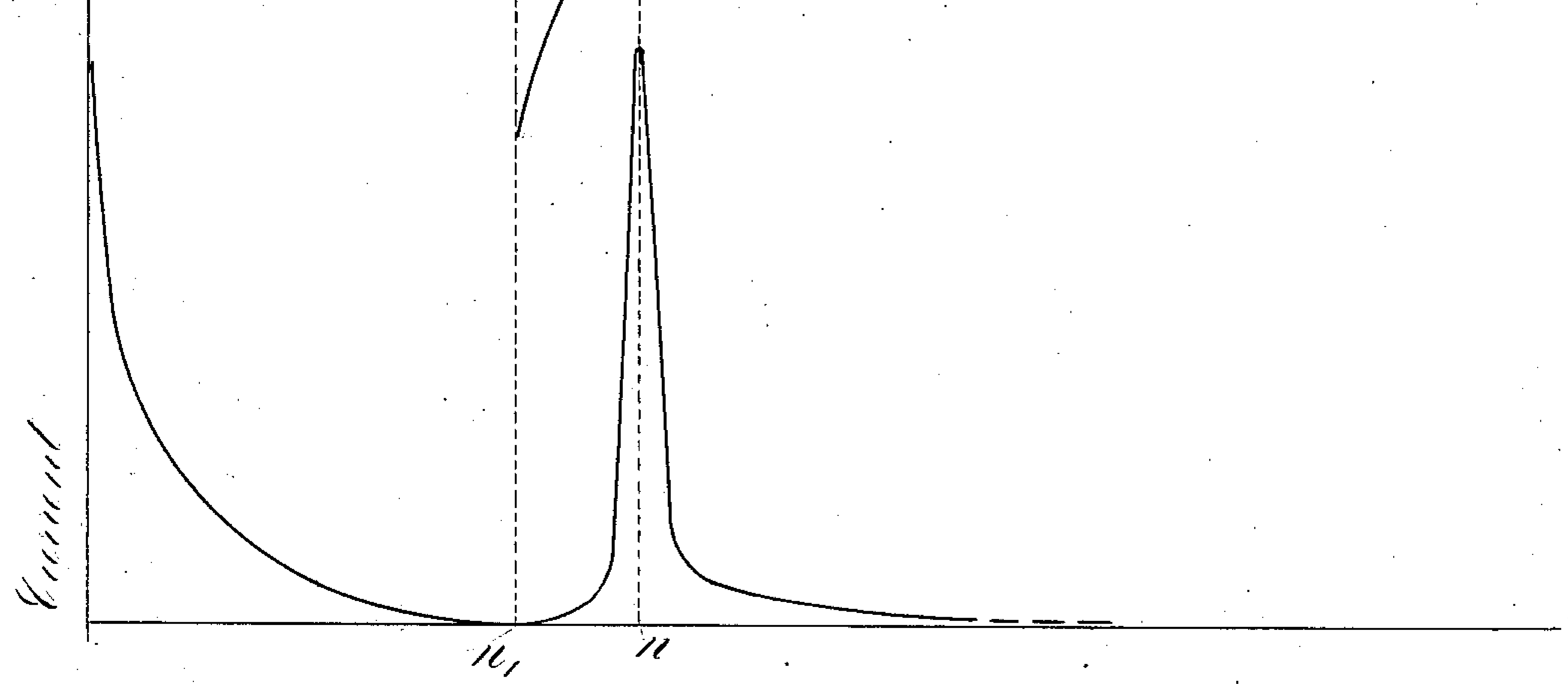

Fig. 13.

WITNESSES:

Geo. K. Woodworth

E. B. Tomlinson

INVENTOR:

John Stone Stone

by Alex. P. Browne

attorney

No. 884,106.

PATENTED APR. 7, 1908.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED MAY 7, 1906.

6 SHEETS—SHEET 6.

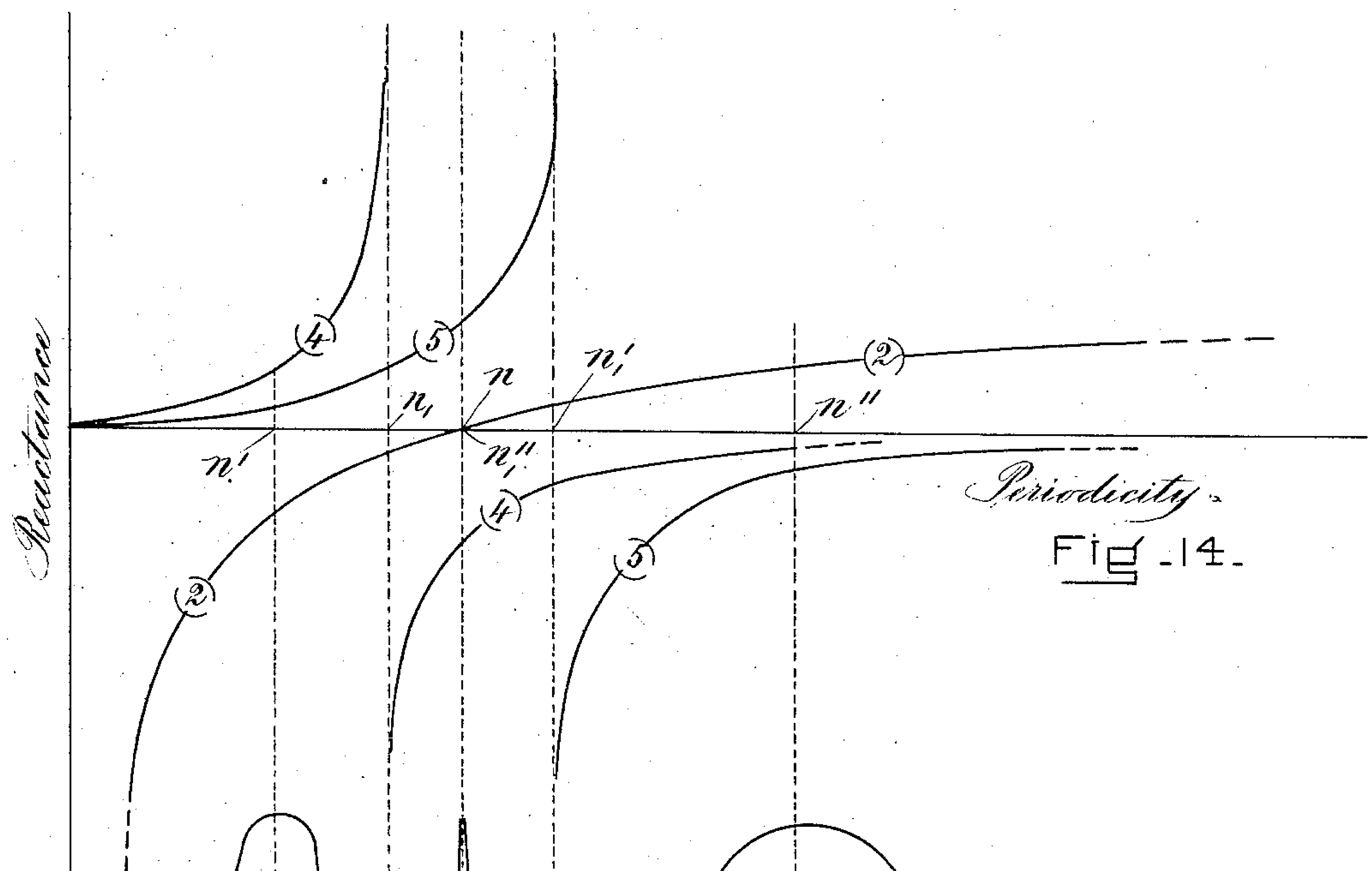

Fig. 14.

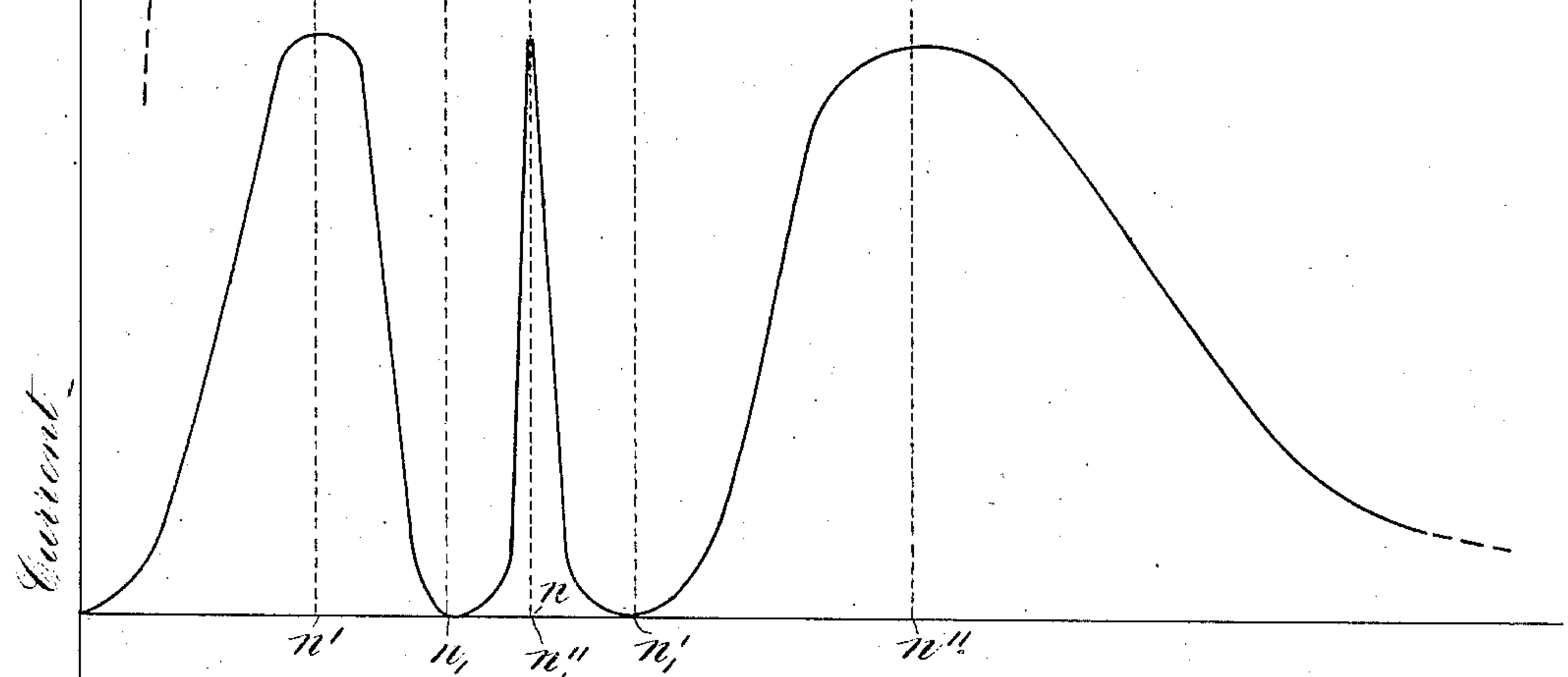

Fig. 15.

WITNESSES:

Geo. K. Woodworth.

E. B. Tomlinson.

INVENTOR:

John Stone Stone

by Alex. P. Browne, attorney

UNITED STATES PATENT OFFICE.

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

SPACE TELEGRAPHY.

No. 884,106. Specification of Letters Patent. Patented April 7, 1908.

Application filed May 7, 1906. Serial No. 315,520.

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.

My 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 increase the selectivity of the circuits which are associated with the elevated conductor system of a space telegraph receiving system. The selectivity of an electrical circuit depends upon the rate of change of the impedance of such circuit with respect to variations in the frequency of the forces acting upon said circuit. In order to make such rate of change of impedance as great as possible, I may include in the circuit in question a parallel branch circuit containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of the circuit. In such case the rate of change with respect to frequency of the reactance of said parallel branch circuit, as measured between its points of connection with the circuit in which it is included, is greater than the rate of change with respect to frequency of the reactance of a serially connected coil or a condenser of like inductance and capacity, respectively; or, in other words, the curve showing the variation with respect to frequency of the reactance of said parallel branch circuit is a steeper curve than the curve showing the reactance-frequency variation of such serially connected coil or condenser. The aforesaid circuit designed so that for a persistent train of electrical oscillations of definite frequency the reactance of its serially connected parallel branch circuit shall balance the reactance of the rest of the circuit, preferably is interposed between the elevated receiving conductor and the resonant receiving circuit; and, by virtue of the proportionment of the electromagnetic constants of such interposed circuit, the latter may be made extremely unresponsive to oscillations of all frequencies except to very persistent trains of electrical oscillations of the frequency to which the associated resonant receiving circuit is attuned. In other words, said interposed circuit may, for a given frequency, be made much stiffer than if it were made highly responsive to persistent trains of electrical oscillations of said frequency by means of a serially connected coil and condenser only.

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

In the drawings, Figure 1 represents a space telegraph receiving system which contains a circuit including a parallel branch circuit, having capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of the circuit in which it is included, and which is interposed between an elevated receiving conductor system and a resonant receiving circuit, the resonant receiving circuit being associated with the inductance branch of the aforesaid parallel branch circuit. Fig. 2 represents a modification in which the resonant receiving circuit is associated with the condenser branch of the parallel branch circuit. Fig. 3 represents a further modification in which the reactance of the parallel branch circuit for a persistent train of electrical oscillations the energy of which is to be received has a negative reactance, the reactance of the rest of the interposed circuit in such case being a positive reactance. Fig. 4 shows a further modification in which a series of circuits, herein shown as two circuits, is interposed between the elevated receiving conductor system and the resonant receiving circuit, each of said interposed circuits including a parallel branch circuit so proportioned as to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of the circuit in which it is included. Fig. 5 shows another modification in which one of the interposed circuits of Fig. 4 is replaced by a resonant weeding-out circuit, which is attuned to the frequency of the waves the energy of which is to be received. Fig. 6 shows still another modification in which the circuit interposed between the elevated receiving conductor system and the resonant weeding-out circuit includes two serially connected parallel branch circuits each containing capacity in one branch and inductance in the other branch and adapted to present for a persistent train of electrical oscillations of the frequency of the waves the energy of which is to be received, equal and opposite reactances. Fig. 7 shows a further modification in which the oscillation responsive device is associated with one of the aforesaid circuits in which the reactance of the parallel branch circuit containing capacity in one branch and inductance in the other branch is, for a persistent train of electrical oscillations of definite frequency, equal and opposite to the reactance of the rest of the circuit which includes the parallel branch circuit. Figs. 8 to 15 inclusive are diagrams hereinafter more fully referred to in explaining the theory of operation and the proportionment of the electromagnetic constants of the systems illustrated in Figs. 1 to 7 inclusive. Figs. 8, 10, 12 and 14 are curves drawn to rectangular coördinates in which the ordinates represent reactance and the abscissæ represents periodicity. Figs. 9, 11, 13 and 15 are curves drawn to rectangular coördinates, in which the ordinates represent current amplitude and the abscissæ represent periodicity.

In the figures, V is an elevated receiving conductor *per se;* V I_1 E and V I_1 C″ E are elevated receiving conductor systems.

M represents a transformer.

I_1 and I_2, respectively, represent the primary and the secondary windings of a transformer.

C represents a condenser.

L represents an inductance coil.

R represents an oscillation responsive device.

The various elements above enumerated are distinguished from each other as to position and function by the use of exponents and subscripts.

A is employed to designate a circuit which includes a parallel branch circuit B and in which the reactance for a persistently applied force of definite frequency is equal and opposite in sign to that of said parallel branch circuit.

D designates a resonant receiving circuit and D′ represents a resonant weeding-out circuit, each of said circuits being attuned to the frequency of the waves the energy of which is to be received.

Referring now to Figs. 8 to 13 inclusive, n_1 is the frequency natural to the parallel branch circuit or loop circuit B when isolated, and the curve (2) shows the mode of variation for progressively increasing frequencies of the reactance on the driving point of said circuit B. n_1'' is the frequency natural to the circuit A when isolated, and the curve (1) represents the mode of variation of the reactance of said circuit A for progressively increasing frequencies. n'' is the frequency natural to the circuit A as affected by its conductive connection with circuit B and n'' represents therefore the most pronounced natural rate of vibration of the system A B, that is to say, n'' represents the frequency at which the system A B tends to vibrate when circuit A is acted upon by abrupt or impulsive electrical forces. n is the frequency of the circuit B as affected by its conductive connection with the circuit A and n represents therefore the frequency to which the system A B is extremely responsive when circuit A is acted upon by persistent trains of electrical oscillations.

The resonant receiving circuits D and the resonant weeding-out circuit D′ of Fig. 5, if employed, are attuned to the aforesaid frequency n, which frequency therefore represents the frequency of the waves the energy of which is to be received.

As shown in Figs. 8, and 10, for persistent trains of electrical oscillations of frequency n the ordinates of the curves (1) and (2) are equal and opposite in sign, so that therefore when persistent trains of electrical oscillations of frequency n act upon the circuit A the reactance of the circuit B, which is included in circuit A, balances the reactance of circuit A. As shown in Fig. 12, for persistent trains of electrical oscillations of frequency n the ordinates of the curves (2) and (3) are equal and opposite in sign, so that therefore when persistent trains of electrical oscillations of frequency n act upon the circuit A_1 the reactance of the circuit B, which is included in the circuit A_1 balances the reactance of circuit A_1. The curves shown in Figs. 9, and 11 represent the variation with persistently applied forces of progressively increasing frequency of the current amplitudes developed in the system A B. The curve shown in Fig. 13 represents the variation with persistently applied forces of progressively increasing frequency of the current amplitudes developed in the system A_1 B. Inasmuch as the rate of change with frequency of the reactances of circuits A and B of Figs. 1 and 2 or A_1 B of Fig. 3 for frequencies in the immediate proximity to frequency n is very large, that is to say, as the curves (1) and (2) or, in Fig. 12, the curves (2) and (3), are quite steep near the point on the axis of abscissæ marked n, it follows that the rate of current-frequency variation in the system A B of Figs. 1 and 2 or A_1 B of Fig. 3 will be large,—in other words that the curves in Figs. 9, 11 and 13 showing such current-frequency variation will be quite steep for frequencies in the immediate proximity to frequency *n*. The curve showing the variation with respect to frequency of the reactance of the parallel branch circuit B being a steeper curve than the curve showing the reactance-frequency variation of a coil,—see curve (3) in Fig. 12,—and steeper than the curve showing the reactance-frequency variation of a condenser, it follows that for frequencies in the neighborhood of frequency *n*, the current-frequency variation curve will have a much greater slope than if the circuit A were made highly responsive to persistent trains of electrical oscillations by means of a serially connected coil and condenser only. Furthermore it follows from the foregoing that for a given frequency *n* a much larger inductance and a much smaller capacity may be employed for making the circuit A extremely unresponsive to oscillations of all frequencies except to very persistent trains of electrical oscillations of the frequency to which the associated resonant receiving circuit is attuned, and in this manner the stiffness of the interposed circuit A, *i. e.*, the ratio of its inductance by its capacity, may be made larger.

As shown in Figs. 8 and 10, there is a second frequency at which the reactance of the system A B is zero, and for a persistently applied force of such frequency n'', other things being equal, the current amplitude in the system A B will be equal to that developed in said system by persistent trains of oscillations of frequency *n*; but the slope of the current-frequency variation curve for frequencies in the neighborhood of frequency n'' is much smaller than the slope of said curve for frequencies in the neighborhood of frequency *n*, and the area inclosed by the curve which has its maximum at the point n'' on the axis of abscissæ is much greater than that inclosed by the curve which has its maximum ordinate at the point *n*. Obviously the resonant receiving circuit might be attuned to the frequency n'', and in some cases it might be desirable so to attune it, but inasmuch as the object of the present invention is to increase the selectivity of the circuits or circuits which are associated with the elevated conductor system, I prefer to attune the resonant receiving circuit to that frequency for which the rate of change of impedance of the system A B with respect to frequency is the greatest.

When the reactance of circuit B as measured between the points of its connection with the circuit A is positive; or is the reactance of an equivalent coil, for persistently applied forces of frequency *n*, as shown in Fig. 8, the amplitude of the current flowing through the inductance branch of circuit B is greater than that flowing through the condenser branch thereof. Accordingly I prefer to associate the resonant receiving circuit D with the inductance branch of the parallel branch circuit B, as shown in Figs. 1, 4, 5 and 6. When the reactance of the branch circuit B is a negative reactance, or is the reactance of an equivalent condenser, for persistently applied forces of frequency *n*, as shown in Fig. 10, the amplitude of the current flowing through the condenser branch of circuit B is greater than that flowing through the inductance branch thereof. Accordingly in such case I prefer to associate the resonant receiving circuit B with the condenser branch of the parallel branch circuit B, as shown in Figs. 2 and 3; but for the purpose of controlling the degree of coupling, it is often convenient to associate the resonant circuit either directly with the coil of circuit A_1 or with the coil of circuit B, even when the reactance of the loop circuit is negative.

It will be noted that when the frequency *n* is lower than that natural to circuit B, the reactance of circuit B is an inductance reactance and the reactance of the circuit A is a capacity reactance; also that when the frequency *n* is higher than that natural to the circuit B, the reactance of the circuit B is the capacity reactance while that of circuit A is an inductance reactance, as shown in Figs. 8 and 10, respectively.

In all cases the coupling between circuit A or A_1 and the elevated conductor system is a loose coupling; in Figs. 1, 2, 3, 4 and 6 the coupling between the resonant receiving circuit and the circuit A_1 or A or A′ interposed between it, directly or indirectly, and the elevated conductor system is a loose coupling. The means whereby such loose coupling is effected have been set forth at length in my prior Letters Patent for example No. 767,984, Aug. 16, 1904, and therefore need not be described herein except to say that in Figs. 2 and 3 the relation between the several condensers C_1, C_2 and C_5 is such that the self energy of each of the interrelated circuits is made large as compared to the mutual energy of each circuit with respect to the other.

Having now explained the design and proportionment of the electromagnetic constants involved in Figs. 1 and 2 by means of the graphical representations in Figs. 8 and 10 respectively, the construction as well as the mode of operation of the systems shown in Figs. 3, 4, 5, 6 and 7 will readily be understood.

In Fig. 3 it will be noted that the circuit A_1 contains no elastic element, and that therefore the variation of its reactance with respect to frequency will be linear as shown by curve (3) in Fig. 12. In such case the frequency for which the capacity reactance of the circuit B is equal to the inductance reactance of circuit A_1 is higher than that natural to circuit B as shown in Fig. 12, and accordingly the resonant receiving circuit had best be associated with the condenser branch of the circuit B.

In Fig. 4 the two interposed circuits A and A′ may or may not be identical as to their electromagnetic constants, but each circuit must be so designed that for frequency n the reactance of its parallel branch circuit balances that of the rest of the circuit. The curves shown in Fig. 8 apply to Fig. 4 as well as to Fig. 1.

In Fig. 5 the circuit D′ made resonant to frequency n is interposed between the system A B and the resonant receiving circuit D. The circuit D′ is a resonant weeding-out circuit, the function of which has been explained by me in my prior Letters Patent, for example No. 714,756, Dec. 2, 1902.

In Fig. 4 the coupling between the circuits A and A′ preferably is a loose magnetic coupling and that between circuits A′ and D may, as shown, be a loose magnetic coupling. In Fig. 5 the coupling between circuit A and circuit D′ preferably is a loose magnetic coupling and that between circuits D′ and D may be a loose magnetic coupling or it may be the equivalent of a loose magnetic coupling, namely, a tight magnetic coupling with coils L″ and L_1'' in each of said resonant circuits, having sufficient inductance to eliminate the effect on the period of circuit D of its tight coupling with circuit D′, as heretofore more fully explained by me in Letters Patent No. 714,756, Dec. 2, 1902.

As shown in the system illustrated in Fig. 6, two parallel branch circuits may be included serially in the circuit A_2 and said circuit may be so designed as to present for a persistent train of electrical oscillations of definite frequency equal and opposite reactances, or one of said circuits may be so designed as to present for a persistent train of electrical oscillations of definite frequency a reactance equal and opposite in sign to the reactance of the rest of the circuit including the parallel branch circuits B″ and B‴. The general principle of operation of the system shown in Fig. 6 may be explained by having reference to Figs. 14 and 15 which illustrate, respectively, the variation of the several reactances and the variation of current amplitude for persistently applied forces of progressively increasing frequency, when the circuits B″ and B‴ are adapted to present for a persistent train of electrical oscillations of frequency n equal and opposite reactances.

Referring particularly to Fig. 14, the curve (2) represents the frequency-reactance variation of circuit A when isolated; and curves (4) and (5) represent, respectively, the frequency-reactance variation of circuits B″ and B‴ when isolated. In this special case, the frequency natural to circuit A when isolated, namely n_1'' is equal to the frequency n of the waves the energy of which is to be received. For persistently applied forces of frequency n the ordinates of curves (4) and (5) are equal and opposite in sign, and inasmuch as the ordinate of curve (2) for said frequency is zero, it follows that the reactance of the system A B″ B‴ is zero for said frequency. For two other frequencies, namely, n' and n'' the reactance of the interposed circuit in Fig. 6 is zero; but it will be noted that the rate of change of impedance with respect to variations in the frequency of the forces acting upon said circuit is much larger for frequencies in the neighborhood of frequency n than for frequencies in the neighborhood of frequencies n' and n'', so that the selectivity of the circuit in question is higher for frequency n than for any other frequency. Accordingly I prefer to attune the resonant receiving circuit D to frequency n although it will be understood that said resonant receiving circuit could be attuned either to frequency n' or to frequency n''.

It will be noted that whereas the two freqencies n_1 and n_1' are shown as quite different in value, nevertheless the two circuits B″ and B‴ preferably are so designed that the two frequencies n_1 and n_1' do not differ greatly in value, in which case the ordinates of the curves (4) and (5) for the frequency n of the waves to be received will be much larger than in the case illustrated in Fig. 14.

It will be understood that inasmuch as my invention broadly speaking consists in increasing the selectivity of a circuit by balancing the reactance of the circuit for a persistent train of electrical oscillations of definite frequency by the reactance of a parallel branch circuit including inductance in one branch and capacity in the other branch, it is not necessary to associate the oscillation-responsive device with a resonant receiving circuit, but that such device may be included in the aforesaid circuit, as shown at R in Fig. 7.

The functions of the parallel branch circuit lettered G have been fully set forth by me in Letters Patent No. 767,994, Aug. 16, 1904, and therefore need not be further explained herein.

I am aware that it has long been known that a parallel branch circuit containing capacity in one branch and inductance in the other branch would present an inductance reactance for forces of certain frequencies and a capacity reactance for forces of certain other frequencies; but so far as I am aware I am the first to employ such a circuit for the purpose of increasing the selectivity of a wireless telegraph receiving circuit in the manner hereinbefore set forth.

It will be obvious that many modifications may be made in the circuit arrangements hereinbefore specifically described for the purpose of more fully disclosing my invention and that therefore I do not wish to be limited to the specific arrangements of circuits and apparatus set forth herein.

I claim,

1. In a space telegraph receiving system, an elevated receiving conductor system; a resonant receiving circuit attuned to the frequency of the waves the energy of which is to be received; and a circuit, interposed between said elevated receiving conductor system and said resonant receiving circuit and including a parallel branch circuit; containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of the aforesaid frequency, the reactance of the rest of such interposed circuit.

2. In a space telegraph receiving system, an elevated receiving conductor system; a resonant receiving circuit attuned to the frequency of the waves the energy of which is to be received; and a circuit, interposed between said elevated receiving conductor system and said resonant receiving circuit and including a condenser and a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to present for a persistent train of electrical oscillations of the frequency to which said resonant receiving circuit is attuned, an inductance reactance equal to the capacity reactance of the rest of such interposed circuit.

3. In a space telegraph receiving system, an elevated receiving conductor system; a resonant receiving circuit attuned to the frequency of the waves the energy of which is to be received; and a series of circuits, interposed between said elevated receiving conductor system and said resonant receiving circuit and each including a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance, each by its reactance for a persistent train of electrical oscillations of the aforesaid frequency, the reactance of the rest of such interposed circuit in which it is included.

4. In a space telegraph receiving system, an elevated receiving conductor system; a circuit associated therewith and including a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of such associated circuit; and a resonant receiving circuit, attuned to said frequency and associated with the inductance branch of said parallel branch circuit.

5. In a space telegraph receiving system, an elevated receiving conductor system; a circuit associated therewith and including a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of frequency lower than that natural to it when isolated, the reactance of the rest of such associated circuit; and a resonant receiving circuit, attuned to said frequency and associated with the inductance branch of said parallel branch circuit.

6. In a space telegraph receiving system, an elevated receiving conductor system; a circuit associated therewith and including a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of such associated circuit; and a resonant receiving circuit, attuned to said frequency and associated with one of the branches of said parallel branch circuit.

7. In a space telegraph receiving system, an elevated receiving conductor system; a receiving circuit constructed to oppose zero reactance to a persistent train of electrical oscillations having the frequency of the waves the energy of which is to be received; and a circuit, interposed between said elevated receiving conductor system and said receiving circuit and including a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of the aforesaid frequency, the reactance of the rest of such interposed circuit.

8. In a space telegraph receiving system, a closed circuit comprising in its construction a parallel branch circuit, containing capacity in one branch and inductance in the other branch and adapted to balance, by its reactance for a persistent train of electrical oscillations of predetermined frequency, the reactance of the rest of said closed circuit.

9. In a space telegraph receiving system, a closed circuit comprising in its construction a parallel branch circuit, containing capacity in one branch and inductance in the other branch, and including a condenser in series with said parallel branch circuit, said parallel branch circuit being so proportioned as to present for a persistent train of electrical oscillations of predetermined frequency an inductance reactance equal to the capacity reactance of the rest of said closed circuit.

10. In a space telegraph receiving system,

an elevated receiving conductor system; and a circuit associated therewith and including a parallel branch circuit containing capacity in one branch and inductance in the other branch and adapted to balance by its reactance for a persistent train of electrical oscillations of definite frequency, the reactance of the rest of said associated circuit.

In testimony whereof, I have hereunto subscribed my name this 2nd day of May 1906.

JOHN STONE STONE.

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