No. 767,984. PATENTED AUG. 16, 1904.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED NOV. 25, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

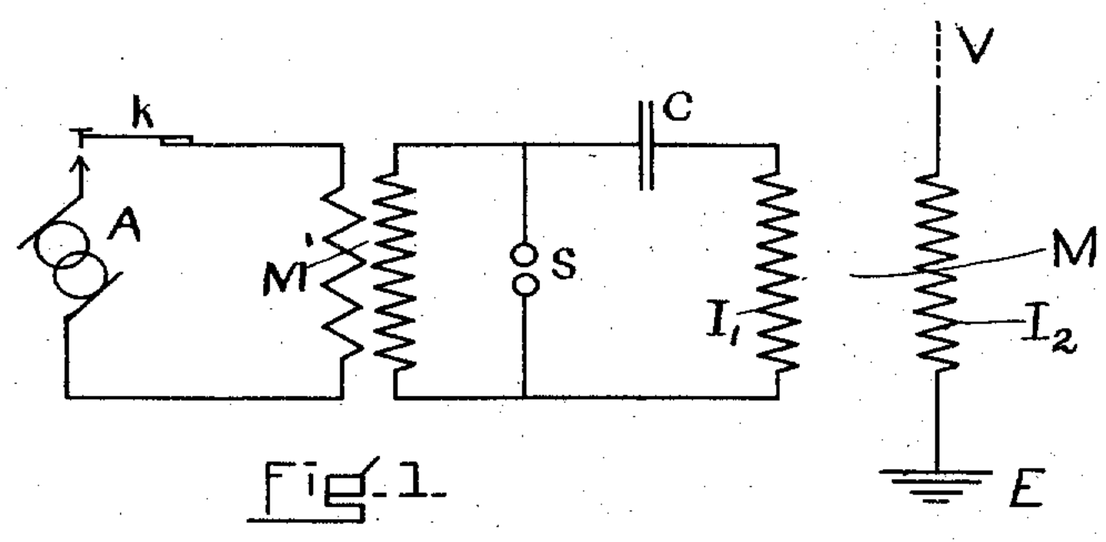

Fig. 1.

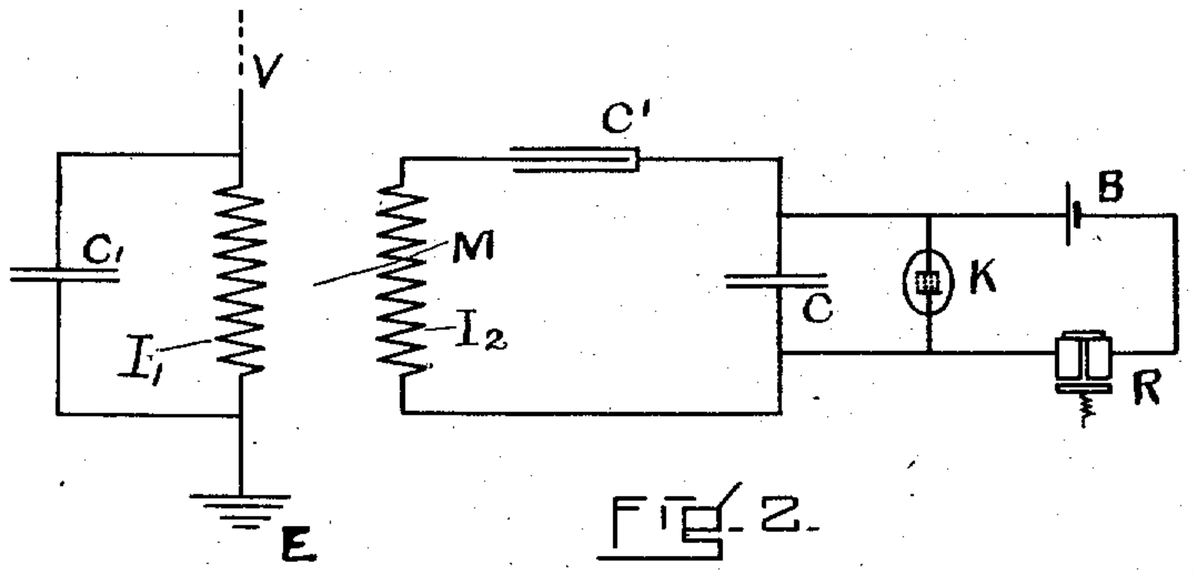

Fig. 2.

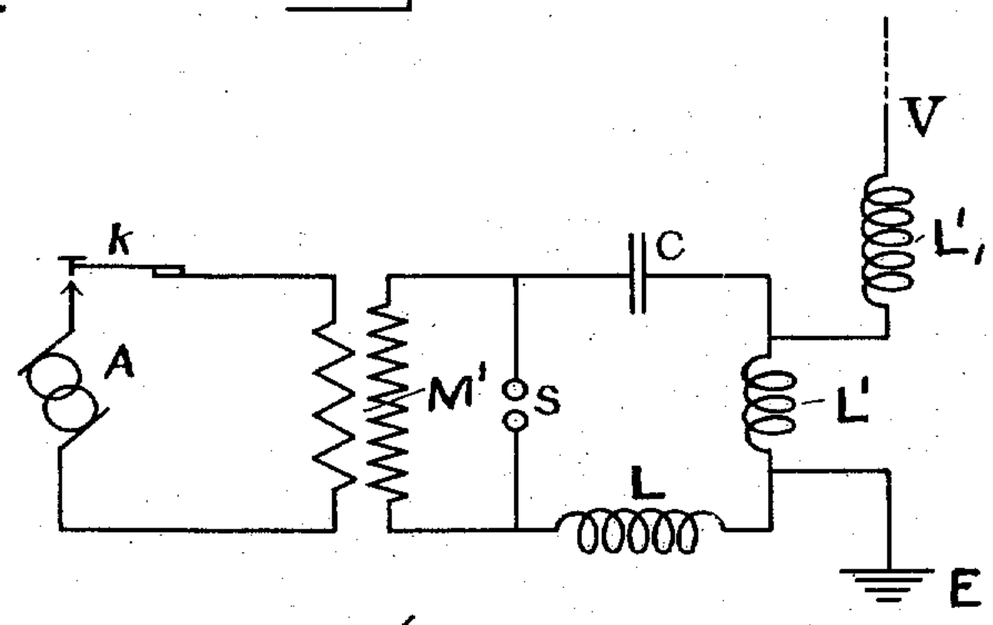

Fig. 3.

WITNESSES.

Braxton D. Judkins

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NO MODEL. 2 SHEETS—SHEET 2.

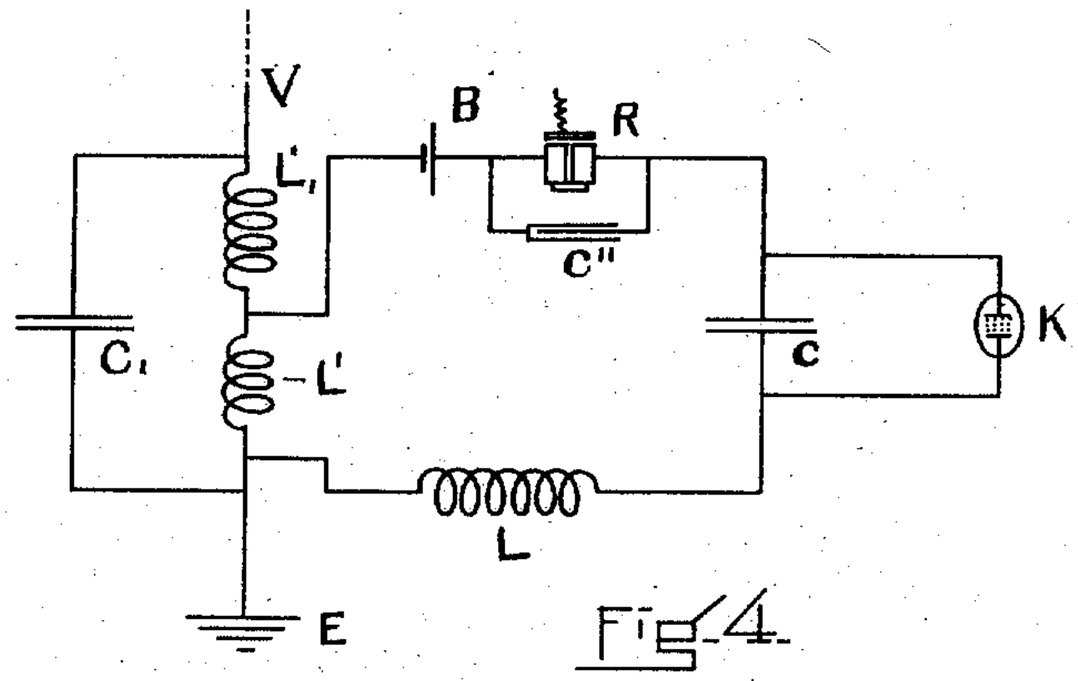

FIG. 4.

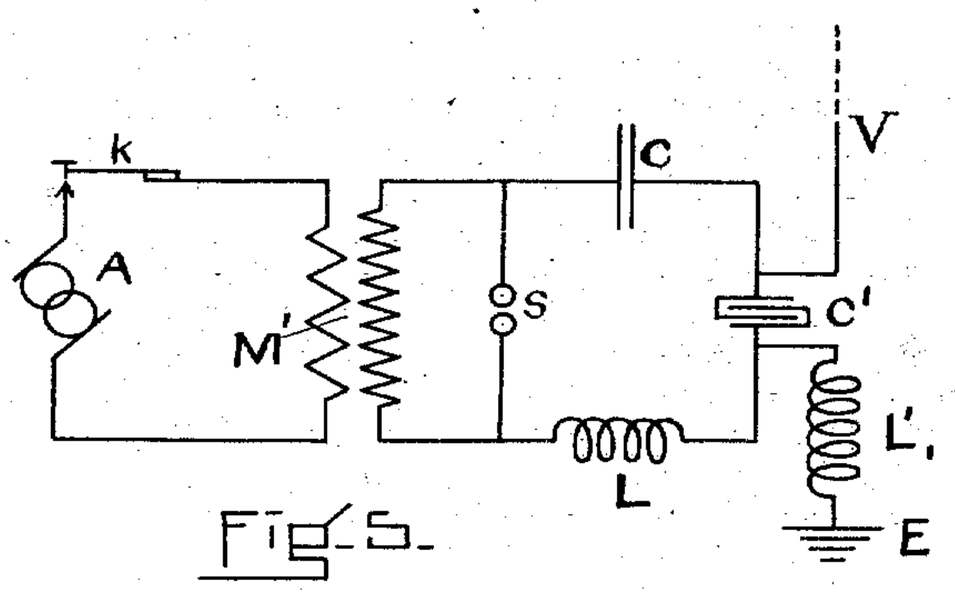

FIG. 5.

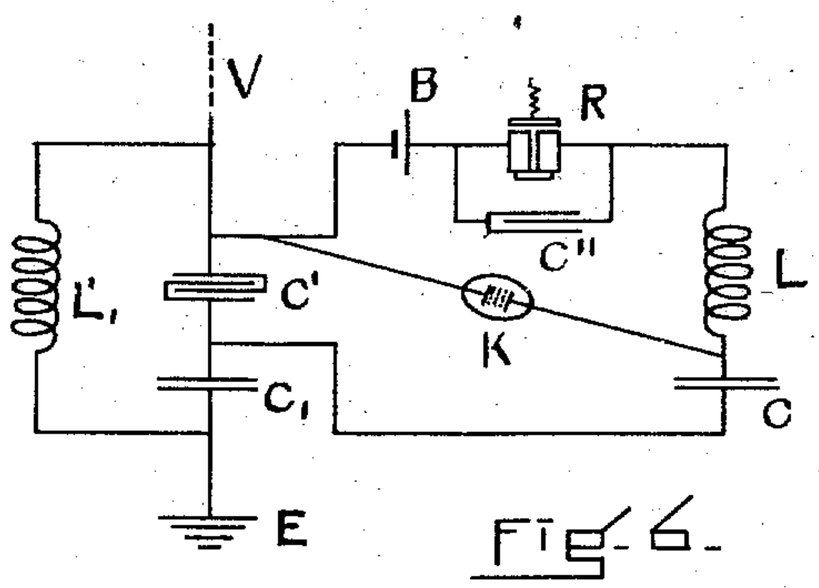

FIG. 6.

WITNESSES.

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Ellen B. Tomlinson

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John Stone Stone.

No. 767,984. Patented August 16, 1904.

UNITED STATES PATENT OFFICE.

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

SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 767,984, dated August 16, 1904.

Application filed November 25, 1903. Serial No. 182,632. (No model.)

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 certain 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 the system of such transmission in which electromagnetic waves are developed by producing electric vibrations in an elevated conductor, preferably vertically elevated.

In my Letters Patent Nos. 714,756 and 714,831, dated December 2, 1902, and in other Letters Patent I have described systems of space telegraphy in which electromagnetic waves substantially simple harmonic in form are transmitted by creating substantially simple harmonic vibrations or oscillations in a sonorous circuit or system of circuits and impressing such vibrations or oscillations upon an elevated conductor. In order that the electric vibrations so impressed upon the elevated conductor, and consequently the electromagnetic waves radiated therefrom, may be simple harmonic in form, I have employed means whereby the individual circuits of a complex of interrelated circuits are made capable of vibrating as circuits of a single degree of freedom. In my Letters Patent Nos. 714,756 and 714,831, and in my Reissued Letters Patent No. 12,149, reissued August 25, 1903, I have described and broadly claimed means whereby such complex of interrelated circuits may be reduced to the equivalent of a number of circuits having a single degree of freedom. I have also specifically claimed therein one of the means whereby this result may be accomplished. The means broadly described and claimed consist in providing each circuit with sufficient auxiliary inductance to render the mutual inductance between it and an associated circuit small compared to the square root of the product of the inductances of the circuits. The specific means therein claimed was an auxiliary inductance-coil in each circuit, whereby the mutual inductance between said circuit and an associated circuit is rendered small compared to the square root of the product of the inductances of the two circuits. Another specific means whereby the same result is accomplished is fully set forth by me in my Letters Patent Nos. 714,832 and 714,833, dated December 2, 1902, wherein I have shown that the function of the auxiliary inductance-coil may be performed by the primary of the transformer connecting the sonorous circuit with the elevated conductor by so proportioning said primary that it shall supply the auxiliary inductance, which in the other specific form of my invention was supplied by means of the auxiliary inductance-coil. This is accomplished by so designing the transformer that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is small compared to unity, which is the opposite course from that in general pursued in constructing a step-up transformer, and is only resorted to in the construction of the so-called "constant-current" transformers, and it may also be accomplished in a plurality of ways set forth in my Letters Patent Nos. 717,467 and 717,515 in the art of wire telegraphy.

In the present specification I confine myself and limit my claims to one of these means—namely, that of so designing the transformer connecting two associated circuits that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is purposely made small compared to unity. In other words, the means herein claimed whereby the complex of circuits is reduced to the equivalent of a system of circuits each of a single degree of freedom is different fron that previously claimed by me in that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is made small compared to unity by making the transformer a constant-current transformer, whereas in the other patents I have claimed means for rendering this ratio small compared to unity consisting of auxiliary inductance-coils. In this case the circuits at the transmitting-station

are a sonorous circuit or closed oscillator, which is a persistently-oscillating poor-radiating circuit, and an elevated transmitting-conductor or linear oscillator, which is a good radiating-circuit, and therefore a poor oscillator. At the receiving-station the circuits are an elevated receiving-conductor or linear oscillator, which is a good absorbing-circuit and a poor oscillator, and a closed resonant circuit, which is a persistently oscillating circuit, and therefore a poor absorbing-circuit, except for the energy of currents of the frequency to which it is attuned. The particular means employed for reducing the aforesaid system of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom is a transformer designed as aforesaid, so that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is made small compared to unity, so that the transformer will have sufficient magnetic leakage to effect the desired result.

In my Letters Patent Nos. 717,467 and 717,515 in the art of wire telegraphy I have described and claimed several specific means of reducing a complex of circuits to the equivalent of a system of circuits each of a single degree of freedom. The underlying principle for accomplishing this result is in all instances that the mutual energy of each circuit with all of the interrelated circuits of the system shall be small compared with the self-energy of said circuit.

The relation of the specific invention herein to be claimed to the broad principle hereinbefore stated may be best understood by having reference to the drawings which accompany and form a part of the present specification.

In the drawings, Figure 1, 3, and 5 represent in diagram apparatus and arrangements of circuits constituting transmitting systems. Figs. 2, 4, and 6 represent in diagram apparatus and arrangements of circuits constituting receiving systems.

In the figures, V is an elevated conductor. M M′ are transformers. L L′ L'_1 are inductances. C C′ C_1 C″ are condensers. I_1 I_2 are respectively the primary and secondary windings of the transformer M. *s* is a spark-gap. A is an alternating-current generator or other source of peridocally-varying electromotive force. B is a battery. R is a relay. K is a receiver, herein illustrated as a coherer. *k* is a key.

In the system illustrated in Figs. 1 and 2 the sonorous circuit *s* C I_1 and the resonant circuit C C′ I_2 are each associated with an elevated conductor V by means of a transformer M with magnetic leakage—*i. e.*, a transformer in which the primary and secondary windings I_1 and I_2 have such spatial interrelation as to so reduce the mutual inductance between the associated circuits that the ratio $\frac{M^2_{12}}{L_1 L_2}$ is small compared to unity, where L^1 L_2 represent the self-inductances of the associated circuits and M_{12} the mutual inductance between said circuits. It will be found that when the primary I_1 is in close inductive relation with the secondary I_2 and is then separated therefrom the amplitude of the oscillations developed in said secondary gradually rises to a maximum and that at this point any further separation of the transformer-windings will have the effect of decreasing this amplitude.

The operation of the apparatus shown in Fig. 1 is the same as that of the apparatus shown in Fig. 5 of my hereinbefore-mentioned patent, No. 714,756, and reference may also be had to the description of the operation of the apparatus shown in the figure of my Letters Patent No. 714,832, the function of the auxiliary inductance-coil (designated by the letter L, shown in those drawings) being performed by the primary coil I_1 of Fig. 1 of the present case. Similarly the operation of the apparatus shown in Fig. 2 is the same as that of the apparatus shown in Fig. 6 of my Letters Patent No. 714,756, the function of the auxiliary inductance-coil (designated by the letter L in that drawing) being performed by the secondary coil I_2 of Fig. 2 of the present case.

In Fig. 3 the elevated conductor is conductively associated with a sonorous circuit *s* C L′ L. In order to impress a simple harmonic electromotive force upon the elevated conductor V, electrical oscillations are produced in the sonorous circuit. These give rise to a corresponding difference of potential at the terminals of the inductance-coil L′ in the elevated-conductor system V L′ E, and corresponding forced simple harmonic electric vibrations result therein. The inductance of the coil L′ being small compared to that of the coil L the oscillations in the sonorous circuit are not materially affected by the association of this circuit with the elevated-conductor system.

In Fig. 4 the elevated conductor is conductively associated with a resonant circuit C L L′. When simple harmonic electric oscillations are set up in the elevated conductor, a corresponding difference of potential is set up at the terminals of the inductance-coil L′, and corresponding forced simple harmonic electric vibrations result in the resonant circuit. If the frequency of these vibrations is the same as that to which the resonant circuit is attuned, said resonant circuit responds energetically and has electrical oscillations of relatively great amplitude developed in it, whereas if the frequency of these vibrations be different from that to which the resonant circuit is attuned the resonant circuit responds but feebly and has electric vibrations of relatively small amplitude developed in it. The inductance of the coil L′ being small compared to that of the coil L the oscillations in the resonant cir-

cuit are not materially affected by the association of this circuit with the elevated conductor.

In Fig. 5 the elevated conductor is again conductively connected to a sonorous circuit s C C′ L. In order to impress a simple harmonic electromotive force upon the elevated conductor V, electrical oscillations are produced in the sonorous circuit. These give rise to a corresponding difference of potential at the terminals of the condenser C′ in the elevated-conductor system V C′ L′$_1$ E and corresponding forced simple harmonic electric oscillations result therein. The capacity of the condenser C′ being large compared to that of the condenser C, the oscillations in the sonorous circuit are not materially affected by the association of this circuit with the elevated-conductor system.

In Fig. 6 the elevated conductor is conductively associated with a resonant circuit C L C′. When simple harmonic electric oscillations are set up in the elevated conductor, a corresponding difference of potential is set up at the terminals of the condenser C′ and corresponding forced simple harmonic electrical vibrations result in the resonant circuit. If the frequency of these vibrations is the same as that to which the resonant circuit is attuned, said resonant circuit responds energetically and has electrical oscillations of relatively great amplitude developed in it, whereas if the frequency of these vibrations be different from that to which the resonant circuit is attuned the resonant circuit responds but feebly and has electric oscillations of relatively small amplitude developed in it. The capacity of the condenser C′ being great compared to that of the condenser C, the oscillations in the resonant circuit are not materially affected by the association of this circuit with the elevated conductor.

No mention has heretofore been made of the function of the condensers C″, as these condensers are not essential to the tuning of the circuits in which they are placed, but merely serve to shunt the relays R out of the resonant circuits. In order that these condensers may not appreciably affect the tuning of the circuits in which they are included, and thereby lower the resonant rise of potential at the plates of the condenser C, they are so constructed as to have large capacities compared to the capacities of the condenser C.

No mention has heretofore been made of the function of the condensers C$_1$ and inductance-coils L′$_1$, as the functions of these elements have been fully described in my applications Serial Nos. 193,371 and 193,372, filed February 13, 1904, and as they form no essential part of the present invention.

I claim—

1. In a system of space telegraphy, an elevated transmitting-conductor serially connected with one winding of a transformer and a sonorous circuit including the other winding of said transformer, said windings being so spatially interrelated as to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

2. In a system of space telegraphy, an elevated receiving-conductor serially connected with one winding of a transformer, and a resonant circuit including the other winding of said transformer, said windings being so spatially interrelated as to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

3. In a system of space telegraphy, an elevated conductor serially connected with one winding of a transformer and a persistently-oscillating circuit including the other winding of said transformer, the separation of said windings being sufficient to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

4. In a system of space telegraphy, a transmitting system comprising a sonorous circuit inductively associated with an elevated conductor by means of a transformer, in combination with a receiving system comprising a resonant circuit attuned to the frequency of the electric oscillations developed in said sonorous circuit and inductively associated with an elevated conductor by means of a transformer, the windings of each of said transformers being so spatially interrelated as to reduce the complex of interrelated circuits constituting the transmitting and receiving systems each to the equivalent of a system of circuits having a single degree of freedom.

5. In a system of space telegraphy, a good oscillator connected with a good radiator or absorber by means of a transformer having sufficient magnetic leakage to reduce the complex of circuits to the equivalent of a system of circuits each having a single degree of freedom.

6. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and a transformer inductively associating said circuits, the mutual inductance between the windings of said transformer being sufficiently small to reduce the complex of interrelated circuits to the equivalent of a system of circuits each having a single degree of freedom.

7. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so associating said circuits that the mutual energy of each circuit with its interrelated circuit is rendered small compared with the self-energy of each circuit.

8. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so in-

ductively associating said circuits that the mutual energy of each circuit with its interrelated circuit is made small compared with the self-energy of each circuit.

9. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

10. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so inductively associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

In testimony whereof I have hereunto subscribed my name this 24th day of November, 1903.

JOHN STONE STONE.

Witnesses:
G. A. HIGGINS,
BRAINERD T. JUDKINS.

Correction in Letters Patent No. 767,984.

It is hereby certified that in Letters Patent No. 767,984, granted August 16, 1904, upon the application of John Stone Stone, of Cambridge, Massachusetts, for an improvement in "Space Telegraphy," an error appears in the printed specification requiring correction, as follows: On page 2, line 66, the symbol "L^1" should read L_1; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of July, A. D., 1905.

[SEAL.]

F. I. ALLEN,
Commissioner of Patents.

ductively associating said circuits that the mutual energy of each circuit with its interrelated circuit is made small compared with the self-energy of each circuit.

9. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

10. In a system of space telegraphy, a persistently-oscillating circuit, a good radiating or absorbing circuit, and means for so inductively associating said circuits that the complex of interrelated circuits is reduced to the equivalent of a system of circuits each having a single degree of freedom without the interposition of auxiliary means.

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