No. 767,976. PATENTED AUG. 16, 1904.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED NOV. 24, 1903.

NO MODEL.

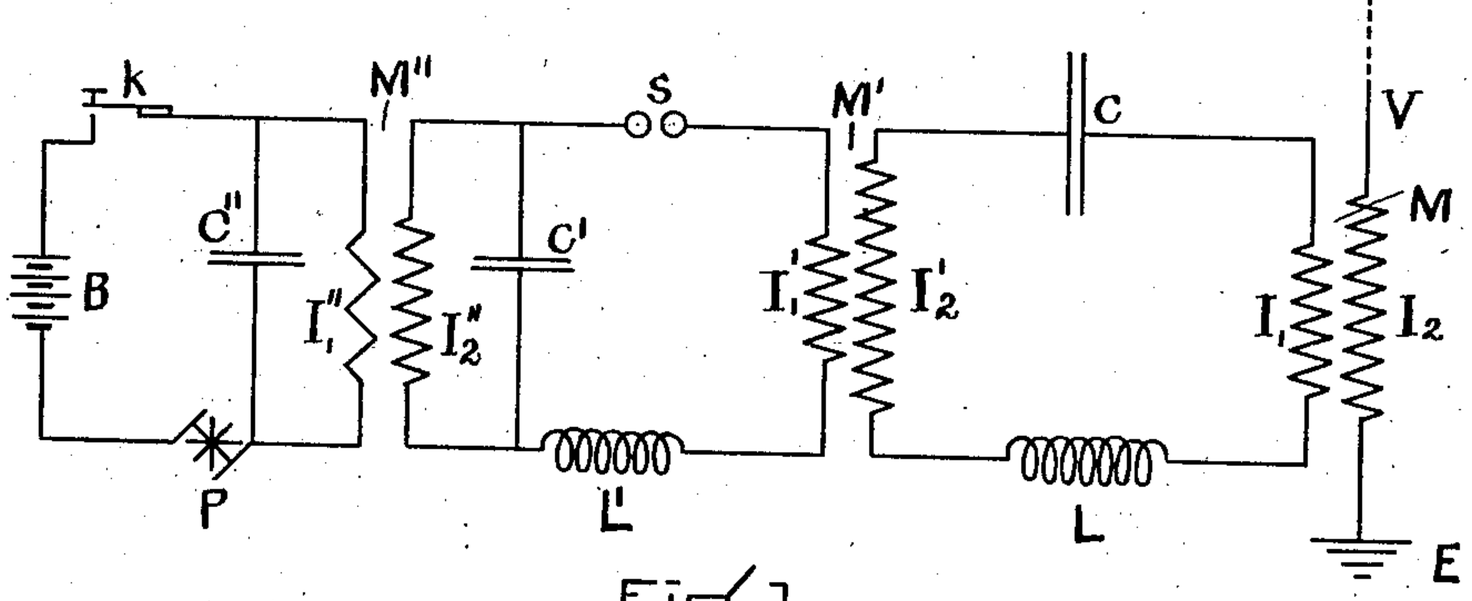

Fig. 1.

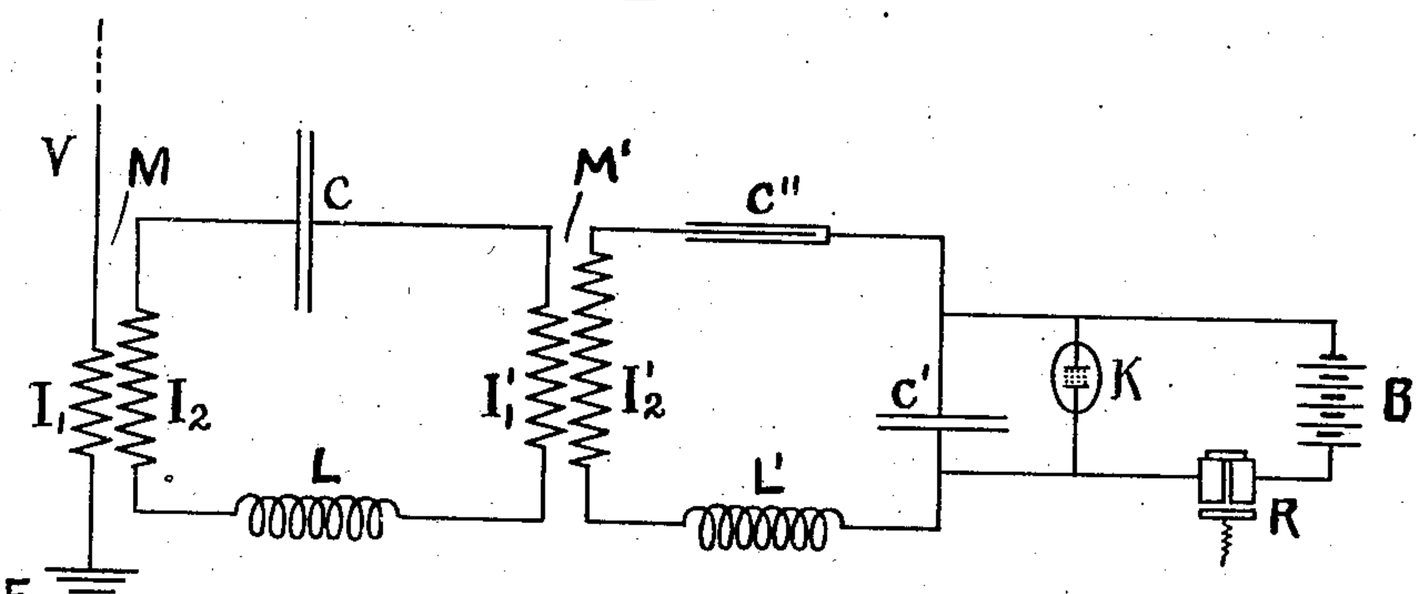

Fig. 2.

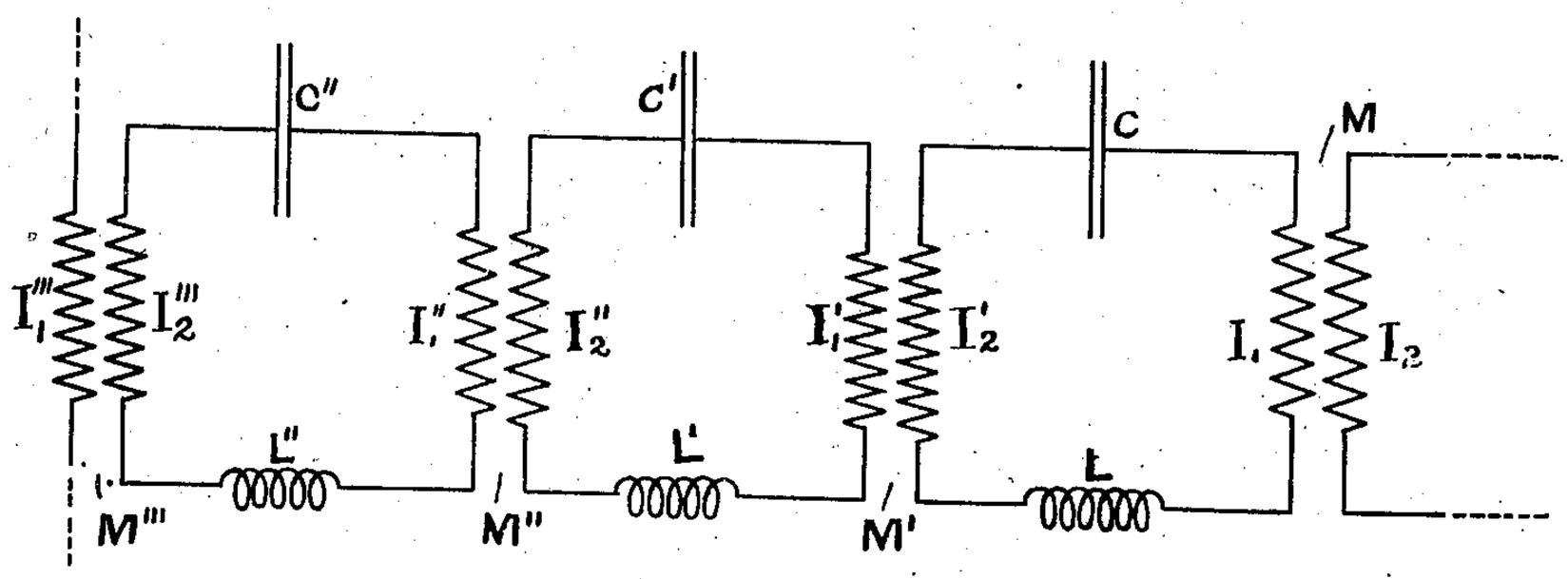

Fig. 3.

WITNESSES.

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No. 767,976. Patented August 16, 1904.

UNITED STATES PATENT OFFICE.

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SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 767,976, dated August 16, 1904.

Application filed November 24, 1903. Serial No. 182,545. (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 the electromagnetic waves are developed by producing electric vibrations or oscillations in an elevated conductor, preferably vertically elevated.

In my Letters Patent Nos. 714,756 and 714,831, dated December 2, 1902, I have described a system of selective electrical signaling by means of such waves, and reference may therefore be had to said Letters Patent for a more detailed description of the apparatus and circuit arrangements shown in this specification, as well as for the construction of parts and the operation thereof, than is necessary to set forth herein.

In the drawings which accompany and form a part of this specification, Figure 1 illustrates diagrammatically a transmitting system. Fig. 2 illustrates diagrammatically a receiving system. Fig. 3 represents a detail of construction common to both transmitting and receiving systems.

In the figures, V represent an elevated conductor. V I_2 E represents an elevated-conductor system. M M′ M″ M‴ are induction-coils or transformers, whose primary and secondary coils are I_1 I'_1 I''_1 I'''_1 and I_2 I'_2 I''_2 I'''_2, respectively. L L′ L″ are auxiliary inductance-coils whose function is to make the product of the inductances of two inductively-related circuits great as compared with the square of the mutual inductance between said circuits, but which absolutely are of exceedingly small inductance, their inductance, in fact, being of the order 10^5 henry or 10^4 centimeters ampere minute-units. C C′ C″ are electrical condensers. B is a battery. P is an automatic circuit-interrupter. *s* is a spark-gap. *k* is a key. K is an electroreceptive device which is herein illustrated as a coherer. R is a relay or signal-indicating device.

The circuit *s* C′ L′ I'_1 is a sonorous or persistently-oscillating circuit adapted to develop simple harmonic electrical oscillations of a definite frequency. The circuit C I'_2 L I_1 is a resonant circuit attuned to the frequency of the electrical oscillations developed by the circuit *s* C′ L′ I'_1.

The transformer M″ is a step-up transformer and is designed to transform the electromotive force in the primary circuit to a very high electromotive force in the secondary.

As the potential difference at the terminals of the secondary I''_2 rises the charge of the condenser C′ increases until the potential difference is sufficient to cause a spark at the spark-gap *s*. When this occurs, the condenser C′ discharges through the spark-gap *s*, primary I'_1, and inductance-coil L′. This discharge is oscillatory in character and of high frequency.

I have explained in my Letters Patent No. 714,832, dated December 2, 1902, that when a spark-gap is included in the elevated conductor itself the amplitude of the oscillations created in said conductor by the disruptive discharge taking place at this gap is limited to the potential difference just sufficient to produce such spark, and I have therein shown a sonorous or persistently-oscillating circuit similar to the sonorous circuit *s* C′ L′ I'_1, herein described, associated with an elevated conductor by means of a step-up transformer. I have found, however, that it is preferable to use a plurality of transformers to increase the potential of the electric oscillations produced by the sonorous circuit and to impress said oscillations upon the elevated conductor at increased potential. I therefore interpose between the sonorous circuit and the elevated conductor a resonant circuit attuned to the frequency of the oscillations developed by said sonorous circuit, as shown in Fig. 1, or a group of resonant circuits so attuned, as shown in Fig. 3, the said circuits being connected

inductively in series by means of transformers all arranged to transform in the same direction and to impress the energy of the sonorous circuit upon the elevated conductor at increased potential. These transformers are lettered in the drawings M M′, &c., and their secondaries I_2 I'_2, &c., comprise a greater number of convolutions than their primaries.

The elevated conductor may or may not have the same fundamental period as the period of the electrical oscillations impressed thereon by the sonorous circuit, and therefore a fundamental period equal to the period of the electromagnetic waves to be transmitted, as I have pointed out in my hereinbefore-mentioned Letters Patent. It is highly desirable, however, that the elevated-conductor system V_2 I_2 E have a fundamental period equal to that of the waves to be transmitted.

In the receiving system illustrated in Fig. 2 a resonant circuit or a plurality of resonant circuits I'_1 C I_2 L, &c., are interposed between the electroreceptive device K and the elevated receiving-conductor. These resonant circuits are each attuned to the same frequency—*i. e.*, to the frequency of the waves the energy of which is to be received by the elevated receiving-conductor—and they are connected inductively in series by means of transformers M M′, &c., which are arranged to transform in the same direction and to convey the electrical oscillations absorbed by the resonant circuits to the electroreceptive device at increased potential or at reduced potential and increased current, according to the characteristics of the particular electroreceptive device employed.

Whereas it has been alleged that it is not possible by means of a single oscillation-transformer to obtain more than a very small ratio of transformation of potential between the circuits containing the windings of said transformer, I desire to herein point out that I have been able to effect in a single transformation, by the means herein described, any desired elevation of potential and that I have successfully employed oscillation-transformers, such as M M′, in Fig. 2, each having a ratio of transformation as great as twenty to one. The reason for this is that the inductance of the auxiliary inductance-coils employed by me for swamping the effect of the mutual inductance between two associated circuits is absolutely small and that the current intensity is practically constant in all parts of the resonant circuits employed by me, as will now be more fully explained.

In my Letters Patent aforesaid I have shown that the oscillations developed in circuit *s* C′ L′ I_1 are approximately simple harmonic in form and are practically unaffected by the inductive association of said circuit with the vertical wire or the resonant circuit I_1 L I'_2 C if by means of the auxiliary inductance-coil L′ the inductance of the circuit in which this coil is included is rendered large compared to the mutual inductance between said circuit and the circuit with which it is associated. Stated in another way, the inductive association of two circuits does not affect the simple harmonic character of the oscillations when the product of the inductances of the associated circuits is great compared to the square of the mutual inductance between the circuits—*i. e.*, if the ratio $\frac{M^2_{12}}{L_1 L_2}$ is small compared to unity where L_1 L_2 are respectively the inductances of the primary and secondary circuits and M_{12} is the mutual inductance between said circuits. On page 6, in lines 51 to 58 of my Letters Patent No. 714,831, I have set forth the form of the term compared to which the inductance of the auxiliary coil must be great, or compared to which, at least, the sum of the natural inductances of the circuit and the auxiliary inductance must be great; but it is to be understood that there is nothing in the instructions set forth herein or in said Letters Patent for designing the auxiliary-inductance coil that would indicate that the auxiliary inductance should be large absolutely rather than large compared with a term which is itself very small in absolute value.

The reason that the intensity of current is practically constant in all parts of the resonant circuits employed by me is because the coils are so designed that their potential energy is small compared to their kinetic energy. For instance, in a special type of coil used by me the inductance per foot of wire is about seven times as great as the inductance per foot of wire in a single-turn coil of the same area of cross-section; but whereas the inductance per foot of wire is greatly increased by being wound in the form of a coil the capacity is also greatly diminished, so that in an infinite length of such coil the velocity of propagation of electric waves in the wire is substantially the same as in a linear wire—*i. e.*, 3×10^{10} centimeters per second—while the ratio of the inductance per unit length of wire to the square of the resistance per unit length of wire is greatly increased, and therefore the selectivity—*i. e.*, $\sqrt{\frac{L}{C R^2}}$—is correspondingly increased. In this instance the inductance is increased in the ratio seven to one and and the capacity is decreased in the ratio one to seven, and therefore the selectivity is increased in the ratio seven to one.

I claim—

1. In a system of space telegraphy, a transmitting system comprising a source of electrical energy, an elevated-transmitting-conductor system and a group of circuits, each attuned to the frequency of the electromagnetic waves to be transmitted by said elevated-conductor system, interposed between said source of energy and said elevated-conductor system

the said circuits being connected inductively in series by means of transformers arranged to transform in the same direction and to impress the energy of said source upon the elevated-conductor system at increased potential.

2. In a system of space telegraphy, a transmitting system comprising a source of electrical energy, an elevated-transmitting-conductor system having a fundamental period equal to the period of the electromagnetic waves to be transmitted, and a group of circuits, each attuned to the frequency of said waves, interposed between said source of energy and said elevated-conductor system, the said circuits being connected inductively in series by means of transformers arranged to transform in the same direction and to impress the energy of said source upon the elevated-conductor system at increased potential.

3. In a system of space telegraphy, a receiving system comprising an elevated conductor, an electroreceptive device and a group of circuits, each attuned to the frequency of the electromagnetic waves the energy of which is to be received by said elevated conductor, interposed between said elevated conductor and said electroreceptive device, the said circuits being connected inductively in series by means of transformers arranged to transform in the same direction and to impress the energy of said source upon the elevated-conductor system at increased potential.

4. In a system of space telegraphy, a receiving system comprising an elevated conductor, an electroreceptive device and a group of circuits, each attuned to the frequency of the electromagnetic waves the energy of which is to be received by said elevated conductor, interposed between said elevated conductor and said electroreceptive device, the said circuits being connected inductively in series by means of transformers arranged to transform in the same direction.

5. In a system for developing electromagnetic signal-waves, an elevated conductor, in combination with a plurality of circuits connected inductively in series and each attuned to the fundamental period of said elevated conductor, an end circuit of said series being associated with said elevated conductor.

6. In a system of space telegraphy, an elevated transmitting-conductor, a source of electrical energy and a group of circuits, each attuned to the fundamental period of said elevated conductor, interposed between said source of energy and said elevated conductor and connected inductively in series by means of transformers all arranged to transform in the said direction and to impress the energy of said source upon the elevated conductor at increased potential, in combination with an elevated receiving-conductor, an electroreceptive device and a group of circuits, each attuned to the frequency of the waves the energy of which is to be received, interposed between said elevated receiving-conductor and said electroreceptive device and connected inductively in series by means of transformers all arranged to transform in the same direction.

7. In a system of space telegraphy, an elevated transmitting-conductor, a source of electrical energy and a group of circuits, each attuned to the same definite frequency, interposed between said source of energy and said elevated conductor and connected inductively in series by means of transformers all arranged to transform in the same direction and to impress the energy of said source upon the elevated conductor at increased potential, in combination with an elevated receiving-conductor, an electroreceptive device and a group of circuits, each attuned to the same definite frequency, interposed between said elevated receiving-conductor and said electroreceptive device and connected inductively in series by means of transformers all arranged to transform in the same direction.

8. In a system of space telegraphy, an elevated transmitting-conductor, a source of electrical energy and a sonorous circuit connected to said elevated conductor by means of a step-up transformer, in combination with an elevated receiving-conductor, an electroreceptive device, and a resonant circuit interposed between said elevated receiving-conductor and said electroreceptive device by means of a step-up transformer.

9. In a system of space telegraphy, a receiving system comprising an elevated receiving-conductor, an electroreceptive device, and a resonant circuit interposed between said elevated conductor and said electroreceptive device by means of a step-up transformer.

10. In a system of space telegraphy, a receiving system comprising an elevated receiving-conductor serially connected with the primary winding of a transformer, a resonant circuit containing the secondary winding of said transformer, said secondary winding comprising a greater number of convolutions than said primary winding, and an electroreceptive device operatively connected with said resonant circuit.

In testimony whereof I have hereunto subscribed my name this 23d day of November, 1903.

JOHN STONE STONE.

Witnesses:
G. A. HIGGINS,
E. B. TOMLINSON.

Corrections in Letters Patent No. 767,976

It is hereby certified that in Letters Patent No. 767,976, granted August 16, 1904, upon the application of John Stone Stone, of Cambridge, Massachusetts, for an improvement in "Space Telegraphy," errors appear in the printed specification requiring correction, as follows: Page 1, line 48, the reference numeral "10^6" should read 10^{-6}; line 48–49, same page, the words "ampere minute-units" should read *a. m. u.*; and that the said Letters Patent should be read with these corrections therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 13th day of September, A. D., 1904.

[SEAL.]

F. I. ALLEN,

Commissioner of Patents.