No. 802,427. PATENTED OCT. 24, 1905.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED JUNE 20, 1905.

2 SHEETS—SHEET 1.

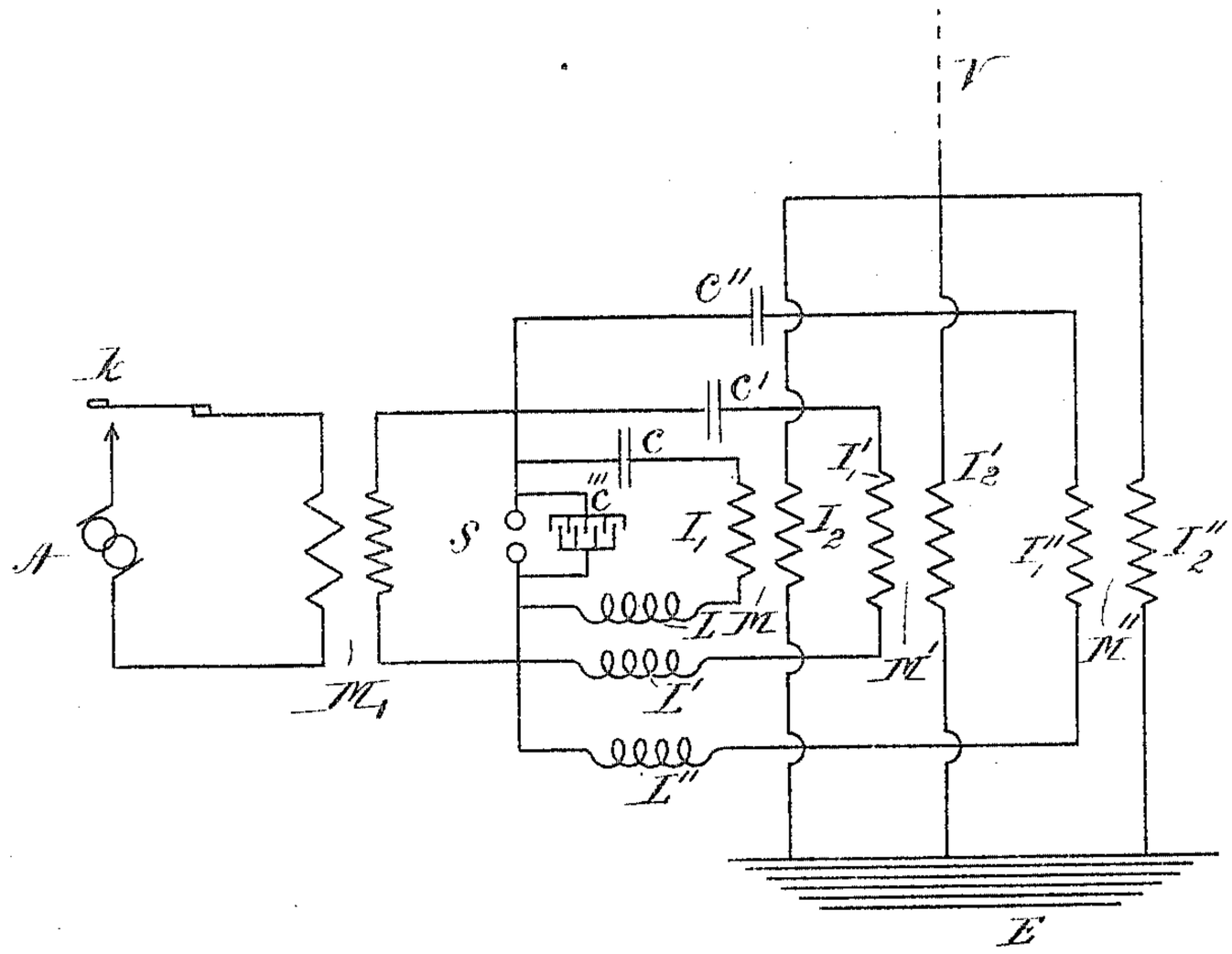

Fig. 1.

WITNESSES

Brainerd T. Jackson

Georgia A. Higgins.

INVENTOR

John Stone Stone

by Alex. P. Browne.

attorney

No. 802,427. PATENTED OCT. 24, 1905.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED JUNE 20, 1905.

2 SHEETS—SHEET 2.

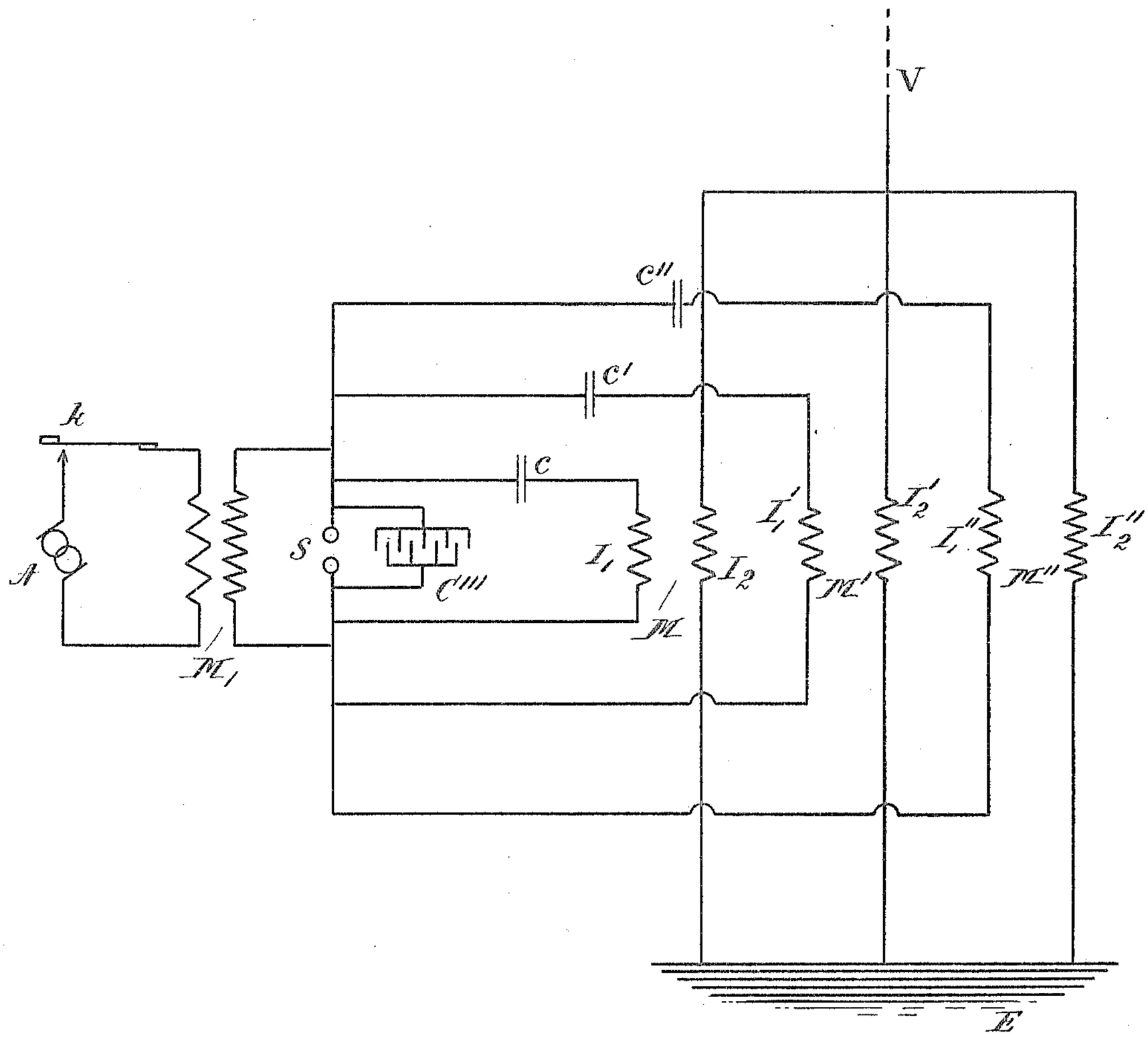

Fig. 2.

WITNESSES

Braman T. Jenkins

Georgia A. Higgins

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 BOSTON, MASSACHUSETTS.

SPACE TELEGRAPHY.

No. 802,427. Specification of Letters Patent. Patented Oct. 24, 1905.

Application filed June 20, 1905. Serial No. 266,159.

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.

The object of the present invention is to increase the amount of energy that may be radiated in the form of simple harmonic electromagnetic waves by means of the systems of the type described in my U. S. Letters Patent Nos. 714,756 and 714,832, dated Dec. 2, 1902, and 767,984, dated Aug. 16, 1904, in each of which a sonorous or closed persistently oscillating circuit is associated with an elevated transmitting conductor system which is attuned as to its fundamental or one of its odd harmonics to the frequency of the forced simple harmonic electrical oscillations developed therein by said sonorous circuit; and this object I effect by employing a plurality of sonorous or persistently oscillating circuits which are preferably identical, and, in the manner hereinafter more fully described, simultaneously disturbing the electrical equilibrium of said circuits.

The invention may best be understood by having reference to the drawings which accompany and form a part of this specification, and which conventionally illustrate two arrangements of apparatus and circuits whereby the hereinbefore stated object of the invention may be realized.

In the drawings,

Fig. 1 represents a space telegraph transmitting system, which structurally is of the general type described in my Letters Patent No. 714,756.

Fig. 2 represents a space telegraph transmitting system which structurally is of the general type described in my Letters Patent Nos. 714,832 and 767,984.

Each figure illustrates a complex of inductively related circuits which is reduced to the equivalent of a system of circuits each having a single degree of freedom by so designing or arranging the circuits that the mutual energy of each circuit with respect to the interrelated circuits is small compared to the self energy of each circuit, and this in turn I accomplish by making the ratio $\frac{M_{12}^2}{L_1 L_2}$ small compared to unity, where M_{12} represents the mutual inductance between the two inductively related circuits, and L_1 and L_2 represent, respectively, the total self-inductance of the two circuits, as more fully explained in my Letters Patent above referred to.

In the figures,

V is an elevated transmitting conductor.

E is an earth connection.

M_1 M M′ M″ are transformers.

C C′ C″ are condensers.

L L′ L″ are auxiliary inductance coils.

I_1 I_1' I_1'' are the primaries and I_2 I_2' I_2'' are the secondaries of the transformers M M′ M″ respectively.

A is an alternating current generator or other suitable source of vibratory current.

s is a spark gap.

k is a key.

In Fig. 1 the circuits *s* C I_1 L, *s* C′ I_1' L′ and *s* C″ I_1'' L″ are sonorous circuits preferably having identical electromagnetic constants and therefore adapted to develop electrical oscillations of the same definite frequency when the electrical equilibrium of the circuits is disturbed by any suitable means, which means is herein shown as the spark gap *s*, common to the three circuits and hence adapted to simultaneously disturb the electrical equilibrium thereof. By means of the auxiliary inductance coils L L′ L″ which are designed according to the specifications contained in my hereinbefore mentioned Letters Patent, each sonorous circuit is rendered the equivalent of a circuit having a single degree of freedom, so that its natural oscillatory restoration to electrical equilibrium is simple harmonic in character and therefore the oscillations created in the elevated transmitting conductor are forced simple harmonic oscillations, equal in frequency to that of the natural simple harmonic oscillations developed in the sonorous circuit and independent of the geometrical or electrical constants of

the elevated conductor system, the elevated conductor *system* being attuned as to its fundamental or as to one of its odd harmonics to the frequency of the forced simple harmonic electrical oscillations developed therein, as pointed out in my Letters Patent Nos. 714,756 and 767,975.

In Fig. 1 each sonorous circuit includes a primary I_1 of one of the transformers M whose secondaries I_2 are connected in parallel, and the elevated conductor is serially connected with said secondaries.

It will be obvious that by the system shown in Fig. 1 the potential energy of the system of sonorous circuits is equal to the sum of the potential energies of the three circuits comprising such system and is, therefore, three times greater than that of a single one of said circuits or, in general, if n identical sonorous circuits are connected with a common spark gap the energy drawn from the prime source of energy and discharged across said gap will, *cæteris paribus*, be n times greater than could be drawn from said prime source and discharged across said gap by a single one of said circuits, while the frequency of the oscillations developed by said circuits will remain unchanged. The electrical energy absorbed by the elevated conductor system and the energy radiated in the form of electromagnetic waves by said system will therefore be proportional to the number of identical sonorous circuits employed, while the frequency of the oscillations developed in the elevated conductor system and of the radiated waves will be independent of the number of such circuits.

The potential energy of a single sonorous circuit including a spark gap, a condenser and the primary of a transformer, such as shown in Fig. 1, may be increased n times by employing n identical condensers connected in parallel and n identical transformer primary coils connected in parallel without altering the natural period of the circuit, provided that the coils so connected in parallel have no mutual inductance, so that their resultant inductance will be $1/n^{th}$ of that of a single coil; but this increase in energy will be obtained at the expense of the persistance of the sonorous circuit which, as I have shown in a paper read before the Electrical Section of the Canadian Society of Civil Engineers, Montreal, Canada, March 9, 1905, and published in the Electrical Review, New York, March 25, 1905, is proportional to $\sqrt{\frac{L}{C R^2}}$; whereas if n separate circuits be employed, each containing a condenser and the primary of the transformer, the increase in potential energy can be attained without reducing the persistance of the system.

In Fig. 2 I show another arrangement for realizing the object of the present invention, namely, increasing the potential energy of the sonorous circuit system n times by employing n identical sonorous circuits without decreasing the persistance or altering the frequency and simple harmonic character of the oscillations developed. In Fig. 2 the coils of the transformers M M′ M″ are so spatially interrelated as to render the mutual energy of each circuit of the system with respect to the other circuits of the system small compared to the self energy of said circuit and, therefore, to render each sonorous circuit the equivalent of a circuit having a single degree of freedom as more fully described in my Letters Patent Nos. 714,832 and 767,984. In other words, such spatial interrelation of the transformer coils enables the primary of each transformer to perform the functions of the auxiliary coils L of Fig. 1, as well as its function of impressing the oscillations of the sonorous circuit upon the elevated conductor.

The condenser C‴ is a condenser having capacity very large compared to the capacity of each of the condensers C C′ C″ and its function is to increase the persistency of the oscillations developed in each sonorous circuit without altering the frequency of such oscillations as more fully set forth in my Letters Patent No. 767,975.

It is to be observed that the system shown in Fig. 2 is identical with that of Fig. 1, except that the secondaries of the transformers M M′ M″ are so spatially related to their respective primaries as to render each sonorous circuit the equivalent of a system having a single degree of freedom. This spatial relation is, for the purpose of convenience of illustration, shown as a transverse separation of each secondary coil I_2 from its primary coil I_1 although in practice I generally place it above or below such primary, in which positions it will be so spatially related thereto, or in such loose inductive relation therewith, as to constitute with its primary a transformer having sufficient magnetic leakage to render the mutual energy of each of the interrelated circuits small compared with the self energy of each circuit, and thereby to reduce the complex of inductively related circuits to the equivalent of a system of circuits each having a single degree of freedom.

When the secondary I_2 is so related with its primary, the latter will be enabled to perform the functions of the auxiliary coils L of Fig. 1, as pointed out in my Letters Patent No. 714,832, because in such case the mutual energy between the primary and secondary circuits is relatively small compared to the self energy of each circuit, the magnetic leakage of such transformer being relatively large and, therefore, the ratio $\frac{M_{12}^2}{L_1 L_2}$ being relatively small compared to unity. This mode of rendering the mutual energy of each circuit with its interrelated circuit small com-

pared to the self energy of each circuit is the equivalent of employing an auxiliary loading coil such as shown in Fig. 1, and I have broadly defined such "loosely coupled" system in which the transformer windings are so arranged as one in which the transformer has sufficient magnetic leakage, or has its windings so spatially interrelated, as to reduce the complex of interrelated circuits to the equivalent of the system of circuits each having a single degree of freedom, or to render the sonorous circuit the equivalent of a circuit having a single degree of freedom.

I make no claim in the present application to the method which may be carried into effect by the apparatus hereinafter claimed as such method forms the subject matter of a divisional application Serial No. 267,483 filed June 29, 1905.

I claim—

1. In a system for developing simple harmonic electromagnetic signal waves of definite frequency, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of said definite frequency, means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, and means associated with all of said sonorous circuits for converting the energy of the resulting electrical oscillations into electro-radiant energy.

2. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of the same definite frequency and all connected in parallel to a common spark gap, a radiating conductor inductively associated with all of said sonorous circuits and a source of periodically varying electro-motive force connected to said spark gap.

3. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of the same definite frequency, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor associated with all of said sonorous circuits.

4. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop electrical oscillations of the same definite frequency and each comprising a condenser and the primary of a transformer, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor serially connected with the secondary of each transformer, such secondaries being connected in parallel between the elevated conductor and earth.

5. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop electrical oscillations of the same definite frequency and each comprising a condenser and the primary of a transformer, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor serially connected with the secondary of each transformer, such secondaries being connected in parallel between the elevated conductor and earth, and means for rendering each sonorous circuit the equivalent of a circuit having a single degree of freedom.

6. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop electrical oscillations of the same definite frequency and each comprising a condenser and the primary of a transformer, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor serially connected with the secondary of each transformer, such secondaries being connected in parallel between the elevated conductor and earth and each secondary being so spatially related to its primary as to render its sonorous circuit the equivalent of a circuit having a single degree of freedom.

7. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop electrical oscillations of the same definite frequency and each comprising a condenser and the primary of a transformer, and a spark gap common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor serially connected with the secondary of each transformer, such secondaries being connected in parallel between the elevated conductor and earth and each secondary constituting with its primary a transformer having sufficient magnetic leakage to render its sonorous circuit the equivalent of a circuit having a single degree of freedom.

8. In a space telegraph transmitting system, a plurality of closed persistently oscillating circuits, each adapted to develop electrical oscillations of the same definite frequency, means common to said persistently oscillating circuits for simultaneously disturbing the electrical equilibrium thereof, a good radiating circuit and means for so associating said good radiating circuit with all of said persistently oscillating circuits that the mutual energy of each circuit of the system with respect to all of the interrelated circuits of the system is rendered small compared to the self energy of each circuit.

9. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of the same definite frequency, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an ele-

vated transmitting conductor inductively associated with all of said sonorous circuits.

10. In a space telegraph transmitting system, an elevated transmitting conductor and means associated therewith for developing electrical oscillations of definite frequency therein, said means consisting of a plurality of sonorous circuits, each containing a condenser and an inductance coil and all connected in parallel to a common spark gap, and means for rendering the mutual energy of each circuit with respect to all of the interrelated circuits of the system small compared to the self energy of each circuit.

11. In a space telegraph transmitting system, means for developing electrical oscillations of definite frequency, said means consisting of a plurality of sonorous circuits, each adapted to develop electrical oscillations of the same definite frequency and all connected in parallel to a common spark gap, a radiating conductor associated with all of said sonorous circuits, and means for rendering the product of the inductance of each sonorous circuit by the inductance of the radiating conductor large compared to the square of the mutual inductance between each sonorous circuit and said radiating conductor.

12. In a space telegraph transmitting system, a plurality of sonorous circuits, adapted to develop simple harmonic electrical oscillations of the same definite frequency, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor attuned as to its fundamental or one of its odd harmonics to the aforesaid definite frequency and associated with all of said sonorous circuits.

13. In a system for developing simple harmonic electromagnetic signal waves of definite frequency, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of said definite frequency, means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, and a radiating conductor associated with all of said sonorous circuits.

14. In a space telegraph transmitting system, a plurality of sonorous circuits, each adapted to develop simple harmonic electrical oscillations of the same definite frequency, and means common to said sonorous circuits for simultaneously disturbing the electrical equilibrium thereof, in combination with an elevated transmitting conductor associated with all of said sonorous circuits.

In testimony whereof I have hereunto subscribed my name this 16th day of June, 1905.

JOHN STONE STONE.

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