No. 768,004. PATENTED AUG. 16, 1904.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED APR. 11, 1904.

NO MODEL. 2 SHEETS—SHEET 1.

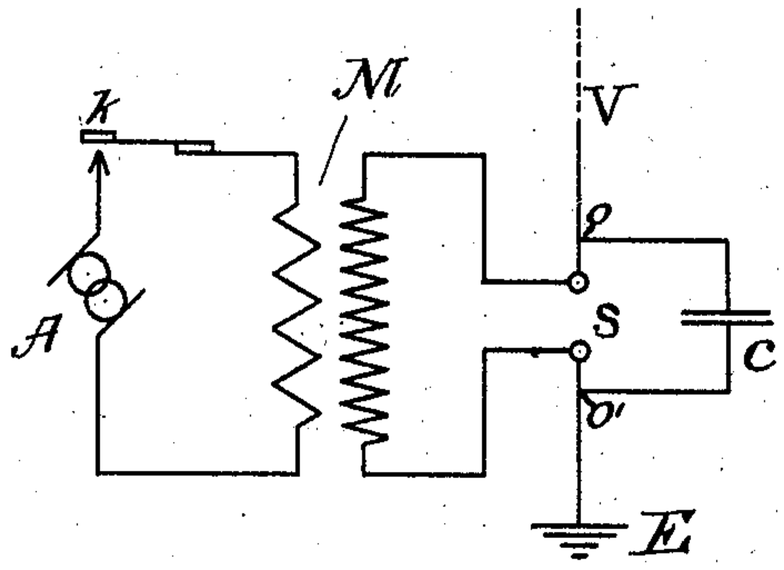

Fig. 1.

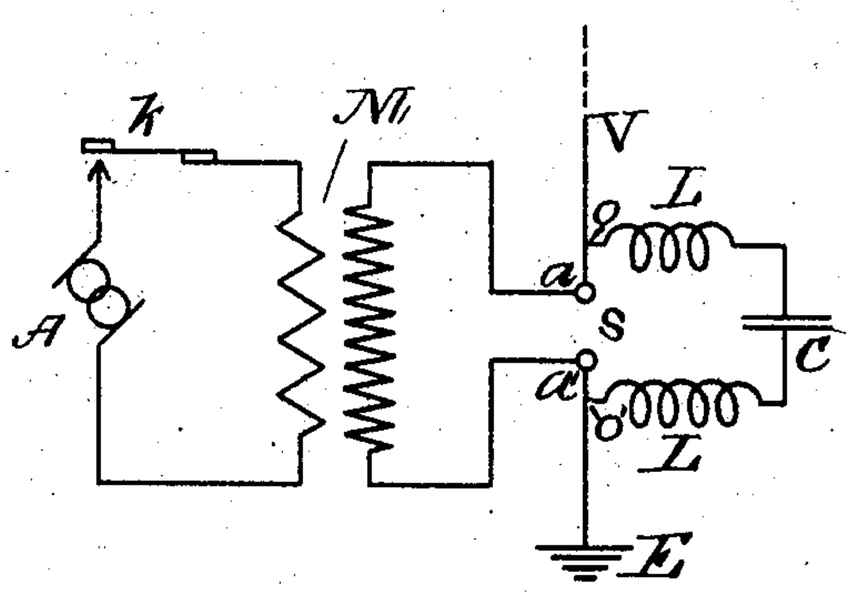

Fig. 2.

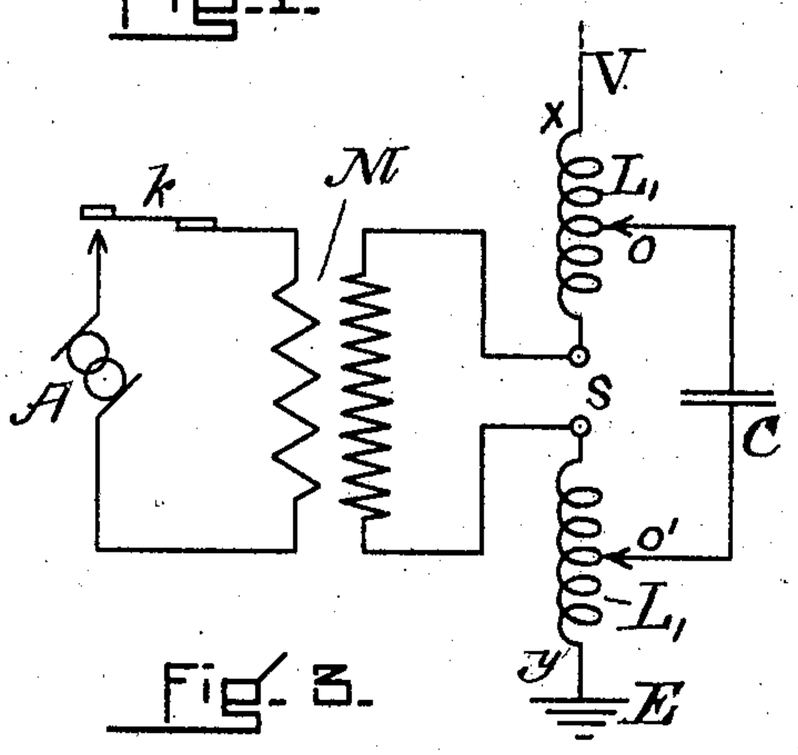

Fig. 3.

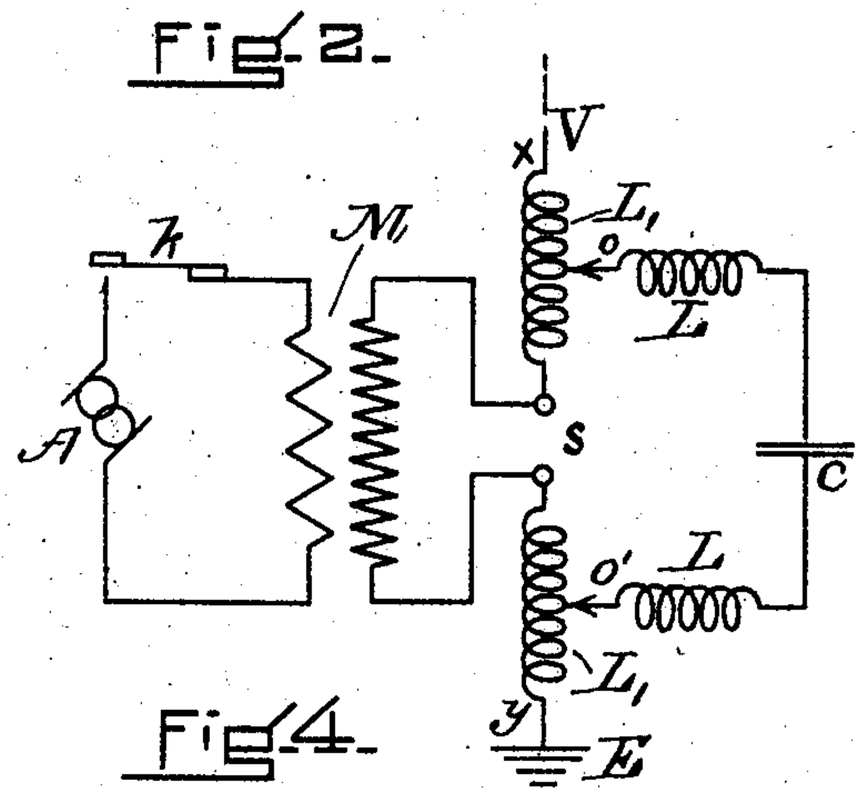

Fig. 4.

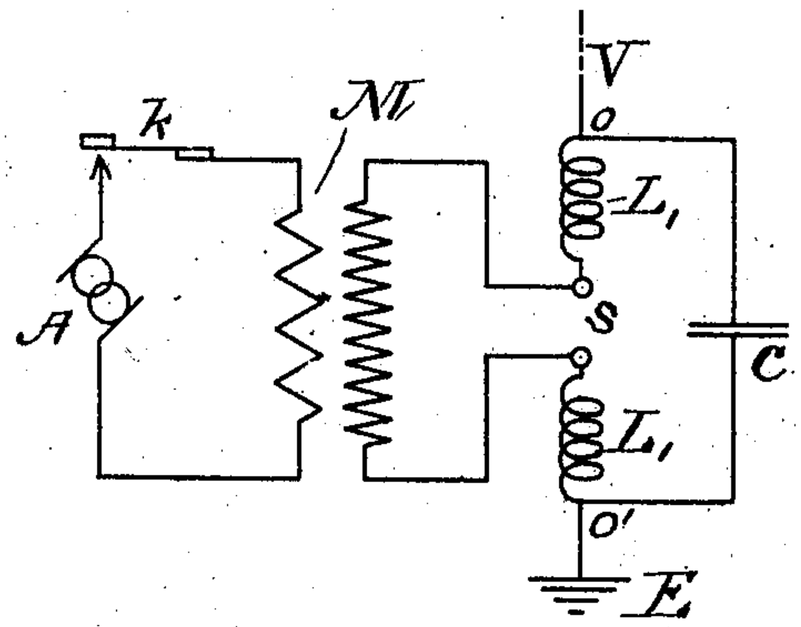

Fig. 5.

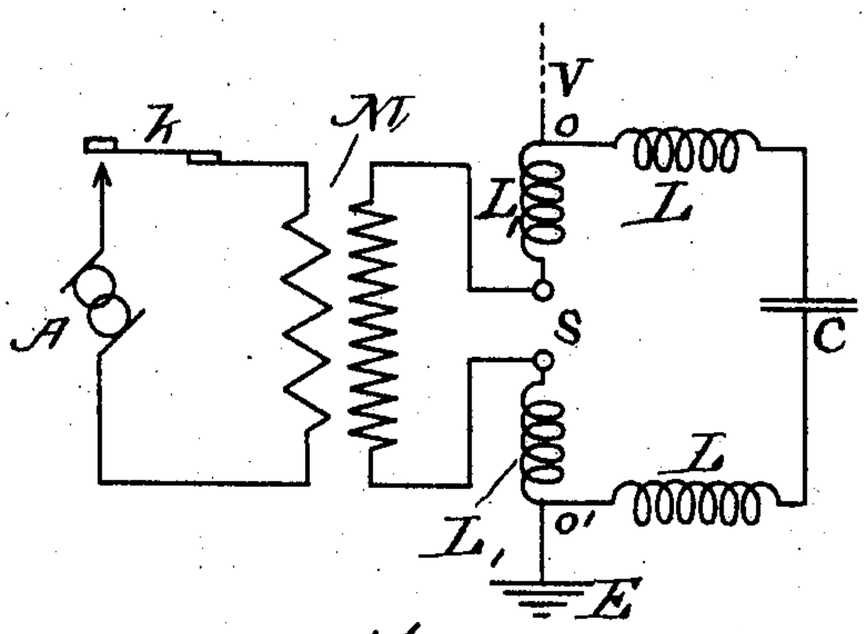

Fig. 6.

WITNESSES.

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NO MODEL. 2 SHEETS—SHEET 2.

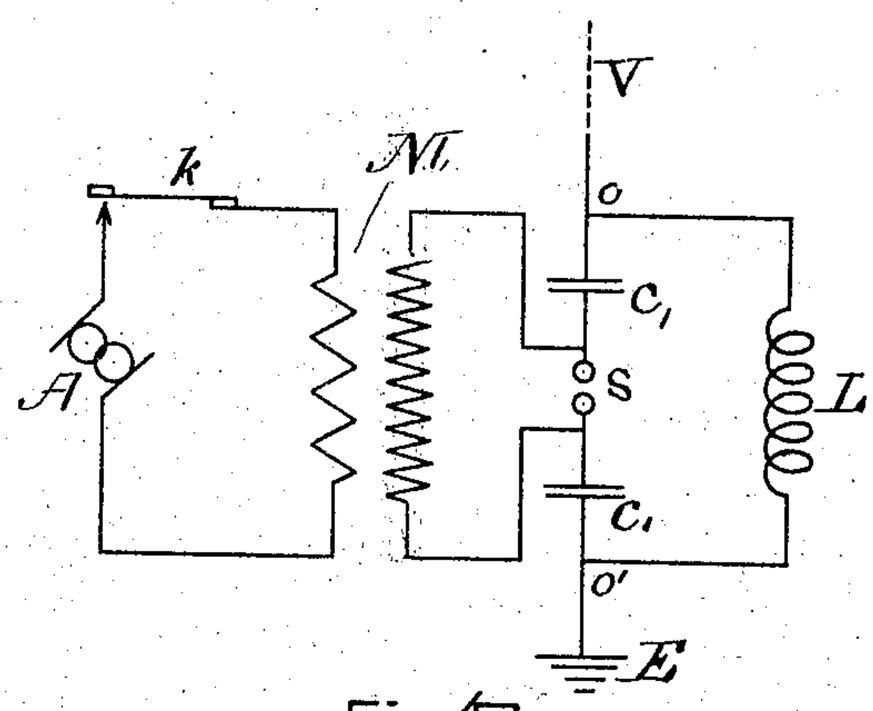

Fig. 7.

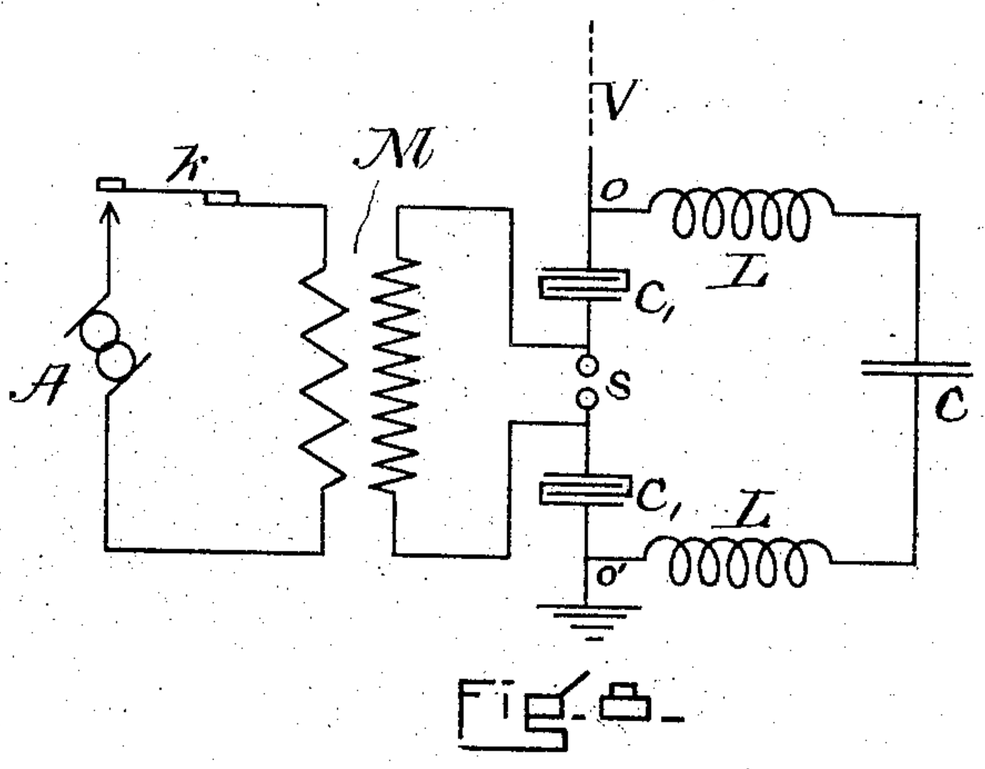

Fig. 8.

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UNITED STATES PATENT OFFICE.

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SPACE TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 768,004, dated August 16, 1904.

Application filed April 11, 1904. Serial No. 202,499. (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 space telegraphy by electromagnetic waves, and it relates more especially to apparatus for generating or transmitting such waves.

My invention may best be understood by having reference to the drawings accompanying and forming a part of this specification, and in which the same letters, as far as may be, represent similar parts in all the figures.

Figures 1 and 2 are diagrammatic illustrations of existing systems hereinafter more fully referred to. Figs. 3, 4, 5, 6, 7, and 8 are diagrammatic representations of six different forms of apparatus and circuit arrangements constituting space-telegraph transmitting systems which embody the present invention.

In the figures, V is an elevated transmitting-conductor. E is an earth connection. C is a condenser. L L_1 are inductances. *s* is a spark-gap. M is a transformer, preferably a step-up transformer. A is a suitable source of vibratory or alternating electromotive force, such, for example, as an alternating-current generator, and *k* is circuit-closing key for modifying said electromotive force in accordance with the signals to be transmitted.

An electrical oscillator of the Hertzian type provided with a condenser in shunt to a spark-gap was first used by Blondot for producing electromagnetic waves. Blondot's oscillator is described in the following publications: *Journal de Physique*, second series, Vol. 10, Paris, 1892, page 549, Blondot; *Comptes Rendus des Séances de l'Academie des Sciences*, Vol. 113, Paris, 1891, page 628, Poincaré; *ibidem*, Vol. 114, Paris, 1892, page 283, Poincaré; *ibidem*, Vol. 117, Paris, 1893, page 543, Poincaré; *Les Oscillations Electriques*, H. Poincaré, Paris, 1894, page 113; *Recherches Experimentales sur les Oscillations Electriques*, A. Turpain, Paris, 1899, page 21; *Génié Civil*, Vol. 41, Paris, September 6, 1902, page 293, Espitallier; *Die Telegraphie ohne Draht*, Righi and Dessau, Brunswick, 1903, page 158, and *La Telegrafia senza Filo*, Righi and Dessau, Bologne, 1903, page 166. An electrical oscillator of a somewhat similar type comprising a condenser in shunt to a spark-gap was also employed by Lodge for the production of electromagnetic waves. The Lodge oscillator is described in the following publications: *Nature*, Vol. 41, London, 1890, page 368, Lodge, and *La Telegrafia senza Filo*, Righi and Dessau, Bologne, 1903, pages 121-134.

An elevated-conductor system of space telegraphy, in which the elevated transmitting-conductor was provided with a Blondot oscillator—*i. e.*, a pair of spark-knobs or balls shunted by a condenser—in lieu of the Righi oscillator before employed was first proposed by Eugene Ducretet, who described in his French Letters Patent No. 272,609, November 29, 1897, and No. 272,284, November 18, 1897, and in his Belgian Letters Patent No. 131,974, November 19, 1897, the use of such oscillator, while in the latter two patents he also described the use of the Lodge oscillator to which reference has been made above. It was also proposed by Dr. Tietz (*Elektrotechnische Zeitschrift*, Vol. 19, August 18, 1898, page 562) to connect a condenser in shunt to a spark-gap included in series with an elevated transmitting-conductor, presumably for the usual purpose for which condensers in such relation had long before been used in connection with spark-producing apparatus—viz., to increase the size of the spark, or, in other words, to obtain what is commonly termed a "fat" spark. Such a system as that proposed by Ducretet and Dr. Tietz is illustrated in Fig. 1. This system possesses very little, if any, advantage over the systems ordinarily employed at that date, in which an elevated transmitting-conductor provided with a spark-gap was alternately charged and discharged by means of a Ruhmkorff coil or other source of high-potential current.

It is well known that the restoration to elec-

trical equilibrium of an electrical system is oscillatory in character only when the energy dissipated either in the form of heat or in the form of long electromagnetic waves radiated from the system does not exceed a certain critical value which depends upon the ratio of the kinetic energy to the potential energy of the system. It is well known also that there is a maximum difference of potential which may be developed at the terminals of a spark-gap of given length separated by a given dielectric medium, such as air at a given pressure. It is possible to increase the potential difference developable at the terminals of a spark-gap by increasing the length thereof; but such increase in length necessarily results in an increase in the resistance of the spark-gap and of the system including the spark-gap, and therefore a point is soon reached at which the energy dissipated in the form of heat at the spark-gap exceeds the critical value aforesaid, and the restoration to electrical equilibrium of the system ceases to be oscillatory and becomes aperiodic. By employing a condenser C in shunt to the spark-gap *s*, as shown in Fig. 1, a relatively large amount of potential energy may be stored up in the condenser, and this energy discharged across the spark-gap will materially reduce the resistance of the latter, as shown by Dr. Louis Duncan in the *Electrical World and Engineer*, October 24, 1903, page 676, thereby permitting the employment of a spark-gap exceeding in length that heretofore employed without a shunting-condenser, and yet not exceeding it in resistance, and therefore not increasing the resistance of the system beyond the aforesaid critical value. By this means the potential energy of the system may be increased, and yet the resistance of the system need not exceed the maximum value permissible in oscillating systems; but whereas such condensers so connected in shunt are theoretically of value, as above explained, it is herein pointed out that such a system as that shown in Fig. 1, in which an elevated-conductor system consisting of one or many vertical wires is provided with a spark-gap in series, is practically aperiodic, producing at most two or three half-oscillations for each prime spark, and that therefore the reduction in the spark-gap resistance effected by the discharge of a condenser across said gap will not materially increase the persistency of the system above that possessed by it when the condenser is not employed. For this reason the potential difference desired to be impressed upon the elevated conductor at the spark-gap might very well be increased by merely increasing the length of the gap, because the resulting increase of resistance will have practically no deleterious effect upon the system, inasmuch as a system having a persistency of three half-oscillations per prime spark is practically equivalent to a system in which but a single half-oscillation is produced by each prime spark, or, in other words, an aperiodic system. Realizing this, it was proposed at a much later date to increase the persistency of oscillation of a system by means of a local circuit attuned to the periodicity used at the sending-station, said circuit consisting of a capacity in the form of a condenser and an inductance formed by the connecting-wires placed in shunt across the spark-gap. To get sufficient inductance for this purpose, the said connecting-wires must be of inconvenient length, and in order to overcome this difficulty the connecting-wires may be coiled in order to increase the inductance per unit length of wire by virtue of the mutual inductance of a given convolution with its adjacent convolutions. Such a system is illustrated in Fig. 2, in which the circuit *s o* L C L *o'* is, indeed, a persistently-oscillating circuit whose oscillatory restoration to electrical equilibrium when abruptly disturbed by the disruptive discharge of the condenser C across the gap *s* is more or less prolonged in inverse proportion to the value of the ratio of the resistance of the circuit by its inductance. If, therefore, an elevated conductor be connected to one of the terminals of one of the elements of such persistently-oscillating circuit and an earth connector be joined to the other terminal of said element, electrical oscillations will be developed in such elevated conductor, and the amplitude of these electrical oscillations will depend upon the difference of potential existing between the terminals of said element. For example, it has been proposed to connect the elevated conductor and the earth connector to the opposite terminals of the condenser C of such persistently-oscillating circuit, and then, again, it has been proposed to make such connections to the opposite terminals of one of the inductance-coils L or to employ only one inductance-coil L and to make the aforesaid connections to the terminals of the latter. In all such cases electrical oscillations of considerable amplitude will be developed in the elevated conductor, especially if the elevated-conductor system so formed has a fundamental or natural rate of vibration equal to that of the persistently-oscillating circuit, because a high difference of potential exists between the terminals of said condenser and between the terminals of said inductance-coil. In like manner it would be possible to connect the elevated conductor and the earth connector between the terminals of a pure ohmic resistance serially included in such persistently-oscillating circuit, because some difference of potential must necessarily exist between the terminals of such resistance. In fact, in the system illustrated in Fig. 2 the elevated conductor V is connected to one terminal of the spark-gap *s*, and the earth connector is joined to the opposite terminal of said spark-gap—that is to say, the elevated-conductor system

is connected to the opposite terminals of a resistance serially included in the persistently-oscillating circuit, such resistance being that of the conductor *o a*, the spark-gap *s*, and the conductor *a' o'*. This resistance, however, is relatively very small and is, in fact, practically negligible during the passage of a spark across the gap *s*, and therefore a practically negligible difference of potential exists between the points *o o'* when the oscillating circuit *s* L C L develops electrical oscillations. In fact, in such a system the first disruptive discharge of the condenser C practically short-circuits the said oscillating circuit so far as the radiating-conductor is concerned, and thereafter the potential energy stored up in the condenser C proceeds to oscillate backward and forward through said circuit, and very little of said energy is utilized in creating currents in the elevated conductor V or in the radiation of electromagnetic waves from said elevated conductor. In order to explain this more fully, I will say that when the electromotive force developed in the secondary winding of the transformer M is rising the elevated conductor V and the condenser C are both being charged, and that when the potential difference at the terminals of the spark-gap becomes sufficiently high to rupture the dielectric medium intervening between said terminals the potential energy of the elevated conductor is converted into kinetic energy and a half-wave is radiated from said elevated conductor in the usual manner. At the same time the potential energy of the condenser C is converted into kinetic energy in the circuit *s* L C L and said kinetic energy is immediately reconverted into potential energy by the "overdischarge" of the condenser C, which then becomes charged in the opposite sense to that in which it was formerly charged. By virtue of the capacity and inductance or the elasticity and inertia of this closed circuit many oscillations take place before the electrical equilibrium of the circuit is restored, but very little of the energy of the electrical oscillations thereby developed in said circuit is conveyed to the elevated-conductor system even when the latter is attuned to the former on account of the practically negligible potential difference developable between the points *o o'*. When, however, the potential energy of the condenser C falls below the value necessary to maintain sparking at the gap *s*, then the entire residual energy of said condenser proceeds to oscillate up and down the elevated-conductor system, which is now the system V *o* L C L *o'* E. Such energy, however, is of very small amplitude and is quite insufficient for the purpose of radiating electromagnetic signal-waves over commercially-important distances.

Figs. 1 and 2 represent two steps in the development of space-telegraph transmitting systems employing elevated conductors provided with spark-gaps, and I shall now proceed to describe my improvements to such systems whereby an elevated conductor may be metallically discontinuous and yet be made the source of a persistent or prolonged train of electromagnetic waves of appreciable amplitude, which may be of any desired value.

In order to make the system shown in Fig. 2 operative for the purpose of radiating persistent or prolonged trains of electromagnetic waves, it is necessary only to increase the potential difference which may be developed between the points *o o'*, and this in turn I effect by connecting the circuit containing the condenser C on either side of the spark-gap through suitable reactances, which may be be inductances, Figs. 3, 4, 5, and 6, or condensers, Fig. 8, or I may omit the condenser C and substitute therefor an inductance-coil and connect said inductance-coil to either side of the spark-gap through condensers, Fig. 7.

In Fig. 3 the closed persistently-oscillating circuit comprises the condenser C and any desired portion of the inductances L_1 L_1. In Fig. 5 the closed persistently-oscillating circuit comprises the condenser C and the inductances L_1 L_1. It should be understood, of course, that the use of two inductances L_1 L_1 is not absolutely essential and that one only may be employed and likewise that in Figs. 7 and 8 only one condenser C_1 may be used. In Fig. 3 the connection of the circuit of the condenser C to points intermediate the ends of the inductances L_1 L_1 produces an arrangement equivalent to the Thomson autoconverter, in which that portion of the inductances between the points *o o'* serves as the primary, and that portion thereof between the points *x y* serves as the secondary, of the converter, thereby exalting the potential of the electrical oscillations impressed upon the elevated-conductor system over that value which would be obtained were the elevated conductor V and the earth connector connected to the points *o o'*, as in Fig. 5.

In Fig. 5 a difference of potential as great as we please is developed between the points *o o'* due to the reactances of the coils L_1 L_1, and electrical oscillations of corresponding potential are therefore developed in the elevated conductor V. In Fig. 3 by means of the adjustable connections of the condenser-circuit to the inductances L_1 L_1 electrical oscillations of greatly-increased amplitude may be developed in the elevated conductor V.

In Figs. 3 and 5 the coils L_1 L_1 are selected so as to give the elevated-conductor system V L_1 *s* L_1 E the desired natural period of vibration, and in Fig. 3 the points *o o'* are determined so as to give the desired amplification of potential; and then in both figures by means of the adjustable condenser C an adjustment of the complex of conductively-connected circuits is found at which a maximum of potential or current is obtained in the ele-

vated-conductor system. Inasmuch as the systems of Figs. 3 and 5 are of course systems of at least two degrees of freedom, it follows that every change in the period of the persistently-oscillating circuit produces a corresponding change in the period of the elevated-conductor system. Furthermore, the waves radiated by such systems are not simple harmonic in form, but are multiperiodic. It is not necessary, however, that the complex of conductively-connected circuits shown in Figs. 3 and 5, vibrate as systems of a plurality of degrees of freedom or that the radiated waves be not simple harmonic in form, because by adding to the circuit of the condenser C auxiliary inductance-coils L L or one auxiliary inductance-coil of inductance great as compared to the inductance of those parts of the coils L_1 L_1 included in the condenser-circuit the aforesaid condenser-circuit may be reduced to the equivalent of a system having but a single degree of freedom and the radiated waves will then be substantially simple harmonic in form.

Such systems in which the condenser-circuits are the equivalent of systems of but a single degree of freedom and by means of which simple harmonic electromagnetic waves may be radiated are illustrated in Figs. 4 and 6, in which the coils L are of inductance great as compared to that portion of the coils L_1 L_1 included in the condenser-circuit. Such auxiliary inductance-coils have the further function of greatly increasing the persistency of the closed oscillating circuits and the persistency of the trains of electromagnetic waves radiated from the elevated conductors. These figures illustrate the preferred forms of my invention. In each of these figures the coils L_1 L_1 are selected so as to give the elevated-conductor system V L_1 *s* L_1 E the desired natural or fundamental period of vibration, and in Fig. 4 the points *o o'* are determined so as to give the desired amplification of potential, and then in both figures by means of the adjustable condenser C or the adjustable coils L the period of the persistently-oscillating or sonorous circuits *s o* L C L *o'* is accurately adjusted to accord with the natural or fundamental period of the elevated-conductor system V L_1 *s* L_1 E, any change in the constants of the persistently-oscillating or sonorous circuits producing no appreciable effect on the fundamental or natural period of said elevated-conductor system.

In Fig. 7 I have illustrated a system equivalent in all respects to the system shown in Fig. 5 except that in lieu of the inductance-coils L_1 L_1, I have employed condensers C_1 C_1 in order to obtain the desired difference of potential between the points *o o'*. These condensers, besides performing the function of permitting an appreciable difference of potential to be developed at the points *o o'*, also perform the function of the condenser C in Figs. 3, 4, 5, and 6—*i. e.*, they supply the necessary elasticity to the oscillating circuit. In this case it is necessary to supply an inductance L in order to give the oscillating circuit the necessary inertia. The condensers C_1 C_1 are selected so as to give the elevated conductor system V C_1 *s* C_1 E the desired natural period of vibration and then by means of the adjustable coil L an adjustment of the complex of conductively-connected circuits is found at which a maximum of potential or current is obtained in the elevated conductor, the system like those illustrated in Figs. 3 and 5 being a system of a plurality of degrees of freedom and the waves radiated therefrom being not simple harmonic in form. It is not necessary, however, that the complex of conductively-connected circuits shown in Fig. 7 vibrate as a system of a plurality of degrees of freedom or that the radiated waves be not simple harmonic, because by adding to the closed oscillating circuit an auxiliary condenser C of capacity small as compared to the resultant capacity of the condensers C_1 C_1 the aforesaid closed oscillating circuit may be reduced to the equivalent of a circuit having but a single degree of freedom, and the radiated waves will then be substantially simple harmonic in form. Such a system in which the closed oscillating circuit is the equivalent of a circuit of but a single degree of freedom and by means of which simple harmonic electromagnetic waves may be radiated is illustrated in Fig. 8, in which the capacity of the condenser C is small as compared to the resultant capacity of the condensers C_1 C_1 or small as compared to the capacity of a single condenser C_1 if but one be employed. In this figure the condensers C_1 C_1 are selected, so as to give the elevated-conductor system V C_1 *s* C_1 E the desired natural or fundamental rate of vibration, and then by means of the adjustable condenser C or the adjustable coils L, or both, the period of the persistently-oscillating or sonorous circuit *s* C_1 *o* L C L *o'* C_1 is accurately adjusted to accord with the natural or fundamental period of the elevated-conductor system V C_1 *s* C_1 E, any change in the constants of the persistently-oscillating or sonorous circuit aforesaid producing no appreciable effect on the fundamental or natural period of said elevated-conductor system.

In each of the systems herein described it is to be noted that the spark-gap is serially included in the elevated-conductor system and that by means of such systems the persistency of the oscillations developed in said elevated-conductor system is not so great as that of the electrical oscillations developed in the metallically continuous elevated conductor of the system described in my Letters Patent No. 714,756, December 2, 1902, and consequently the persistency of the trains of waves radiated from the metallically-discontinuous

elevated conductors of the systems herein described is not so great as that of the trains of waves produced by the system described in my prior patent aforesaid.

I claim—

1. In a system of space telegraphy, an elevated-conductor system provided with a spark-gap, a persistently-oscillating circuit conductively connected to the terminals of said spark-gap through capacity or inductance reactances, or a capacity or inductance reactance, serially included in said elevated-conductor system and sufficient for the frequency employed to permit the development in said elevated-conductor system of electrical oscillations of appreciable amplitude, a source of electromotive force, and means for varying said electromotive force in accordance with the signals to be transmitted.

2. In a system of space telegraphy, an elevated transmitting-conductor, an inductance-coil connected at one terminal to the lower terminal of said elevated conductor, an electrical connection from the other terminal of said inductance-coil to one terminal of a spark-gap, a second inductance-coil, an electrical connection from one terminal of said second inductance-coil to the other terminal of said spark-gap and an electrical connection from the other terminal of said second inductance-coil to earth, in combination with a condenser, an electrical connection from one terminal of said condenser to a point intermediate the terminals of said first-mentioned inductance-coil, an electrical connection from the other terminal of said condenser to a point intermediate the terminals of said second-mentioned inductance-coil, a source of vibratory or alternating electromotive force connected to the terminals of said spark-gap and means for varying said electromotive force in accordance with the signals to be transmitted.

3. In a system of space telegraphy, an elevated transmitting-conductor, an inductance-coil connected at one terminal to the lower terminal of said elevated conductor, an electrical connection from the other terminal of said inductance-coil to one terminal of a spark-gap and an electrical connection from the other terminal of said spark-gap to earth, in combination with a condenser, an electrical connection from one terminal of said condenser to a point intermediate the terminals of said inductance-coil, an electrical connection from the other terminal of said condenser to that terminal of the spark-gap which is connected to earth, a source of electromotive force for said condenser and means for varying said electromotive force in accordance with the signals to be transmitted.

4. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, reactances serially included in said system, one on either side of said spark-gap, a circuit including a condenser conductively connected with said spark-gap through such reactances, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

5. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, a reactance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through said reactance, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

6. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through said inductance, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

7. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through said inductance, a source of vibratory or alternating electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

8. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through a portion of said inductance, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

9. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor and a spark-gap, an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through a portion of said inductance, a source of vibratory or alternating electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

10. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and comprising a radiating-conductor and a spark-

gap, an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a persistently-oscillating circuit including a condenser and said inductance and conductively connected to said elevated-conductor system, said persistently-oscillating circuit having a natural period of vibration equal to that of said elevated-conductor system, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

11. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and comprising a radiating-conductor and a spark-gap, and inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a persistently-oscillating circuit including a condenser and a portion of said inductance and conductively connected to said elevated-conductor system, said persistently-oscillating circuit having a natural period of vibration equal to that of said elevated-conductor system, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

12. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and including a spark-gap, in combination with a persistently-oscillating circuit attuned to the same natural period and connected across the terminals of said spark-gap through an inductance-coil serially connected with said elevated-conductor system and said spark-gap, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

13. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and serially including an inductance-coil and a spark-gap, in combination with a persistently-oscillating circuit attuned to the same natural period and serially including said spark-gap and said inductance-coil, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

14. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and serially including an inductance-coil and a spark-gap, in combination with a persistently-oscillating circuit attuned to the same natural period and serially including said spark-gap and a portion of said inductance-coil, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

15. In a system of space telegraphy, a sonorous or persistently-oscillating circuit including a condenser, a spark-gap and an inductance-coil on either side of said spark-gap, a radiating-conductor electrically connected to one terminal of one of such inductance-coils, an earth connector electrically connected to one terminal of the other of said inductance-coils, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

16. In a system of space telegraphy, a sonorous or persistently-oscillating circuit including a condenser, a spark-gap and an inductance-coil, one terminal of said coil being electrically connected to one terminal of said spark-gap, a radiating-conductor electrically connected to the other terminal of said inductance-coil, an earth connector electrically connected with the other terminal of said spark-gap, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

17. In a system of space telegraphy, a sonorous or persistently-oscillating circuit including a condenser, a spark-gap and a portion of an inductance-coil, one terminal of said coil being electrically connected to one terminal of said spark-gap, a radiating-conductor electrically connected to the other terminal of said inductance-coil, an earth connector electrically connected with the other terminal of said spark-gap, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

18. In a system of space telegraphy, an elevated-conductor system serially including a spark-gap and an inductance-coil on either side of said spark-gap, a circuit including a condenser connected across said spark-gap through said inductance-coils and an auxiliary inductance-coil of inductance great as compared to said first-mentioned inductance-coils serially included in said circuit, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

19. In a system of space telegraphy, an elevated-conductor system provided with a spark-gap, a persistently-oscillating circuit conductively connected to the terminals of said spark-gap through capacity or inductance reactances, or a capacity or inductance reactance, serially included in said elevated-conductor system and sufficient for the frequency employed to permit the development in said elevated-conductor system of electrical oscillations of appreciable amplitude, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

20. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor, a spark-gap and a reactance serially included in said system on either side

of said spark-gap, a circuit including a condenser conductively connected with said spark-gap through such reactances, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

21. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor, a spark-gap and a reactance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through said reactance, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

22. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor, a spark-gap and an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through said inductance, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

23. In a system of space telegraphy, an elevated-conductor system comprising a radiating-conductor, a spark-gap and an inductance serially included in said system between one terminal of said spark-gap and said radiating-conductor, a circuit including a condenser electrically connected with said spark-gap through a portion of said inductance, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

24. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and including a spark-gap, in combination with a persistently-oscillating circuit attuned to the same natural period and connected across the terminals of said spark-gap through an inductance-coil, serially connected with said elevated-conductor system and said spark-gap, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

25. In a system of space telegraphy, an elevated-conductor system having a definite natural or fundamental period of vibration and serially including an inductance-coil and a spark-gap, in combination with a persistently-oscillating circuit attuned to the same natural period and serially including said spark-gap and a portion of said inductance-coil, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

26. In a system of space telegraphy, a sonorous or persistently-oscillating circuit including a condenser, a spark-gap, and an inductance-coil, one terminal of which is electrically connected to one terminal of said spark-gap, a radiating-conductor electrically connected to the other terminal of said inductance-coil, an earth connector electrically connected with the other terminal of said spark-gap, means for reducing the complex of conductively-connected circuits to the equivalent of a system of circuits each having a single degree of freedom, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

27. In a system of space telegraphy, a metallically discontinuous elevated transmitting-conductor, in combination with means for causing the radiation therefrom of a persistent or prolonged train of electromagnetic waves.

28. In a system of space telegraphy, a metallically discontinuous elevated transmitting-conductor, means for causing the radiation therefrom of a persistent or prolonged train of electromagnetic waves, a source of electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

29. In a system of space telegraphy, a metallically discontinuous elevated transmitting-conductor, means for causing the radiation therefrom of a persistent or prolonged train of electromagnetic waves, a source of alternating or vibratory electromotive force and means for varying said electromotive force in accordance with the signals to be transmitted.

30. In a system of space telegraphy, a metallically discontinuous elevated transmitting-conductor, in combination with means for causing the radiation therefrom of a persistent or prolonged train of simple harmonic electromagnetic waves.

In testimony whereof I have hereunto subscribed my name this 9th day of April, 1904.

JOHN STONE STONE.

Witnesses:

BRAINERD T. JUDKINS,

G. ADELAIDE HIGGINS.