No. 802,426. PATENTED OCT. 24, 1905.

J. S. STONE.

SPACE TELEGRAPHY.

APPLICATION FILED MAY 10, 1905.

4 SHEETS—SHEET 1.

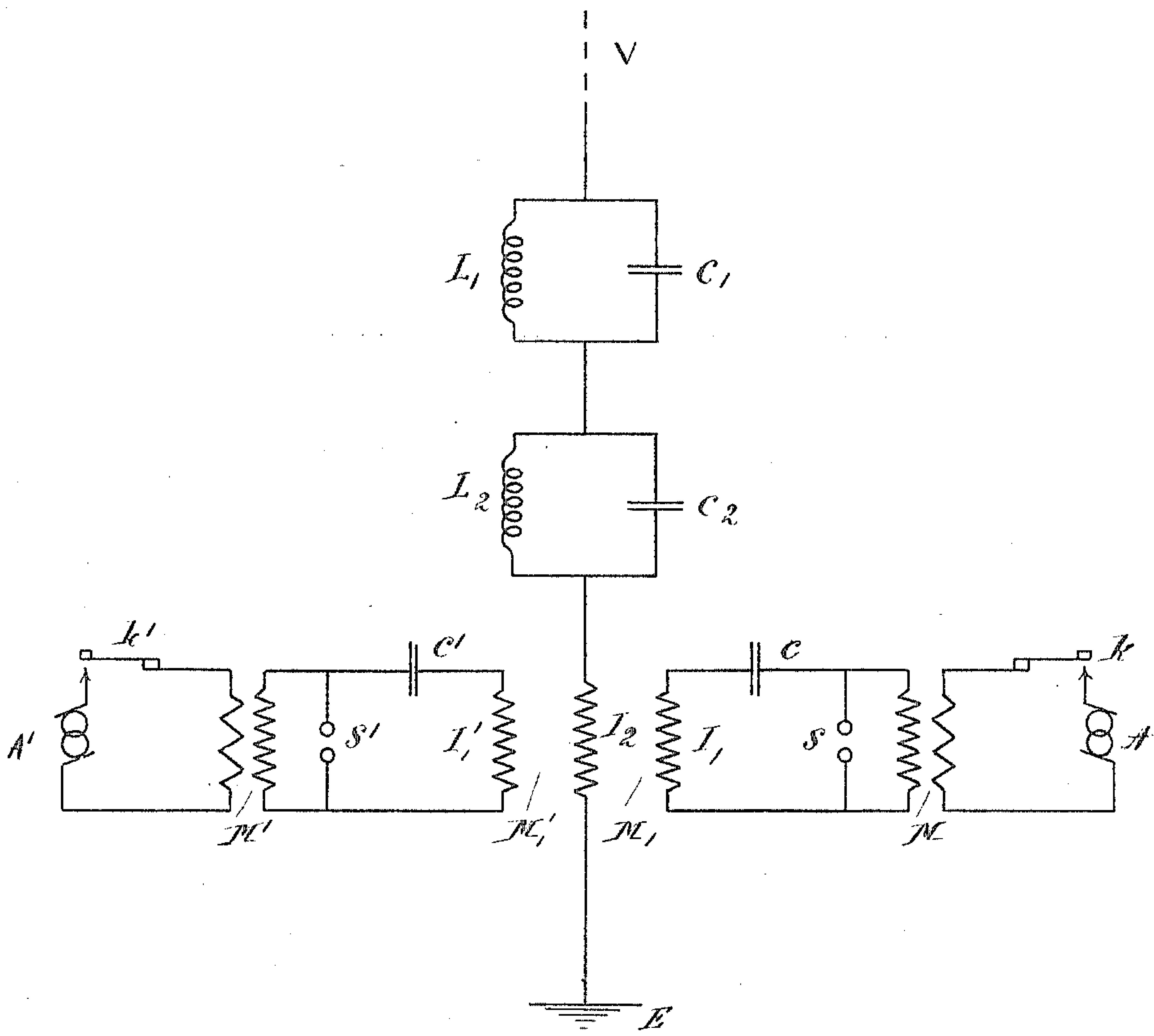

Fig. 1.

WITNESSES:
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G. A. Higgins

INVENTOR:
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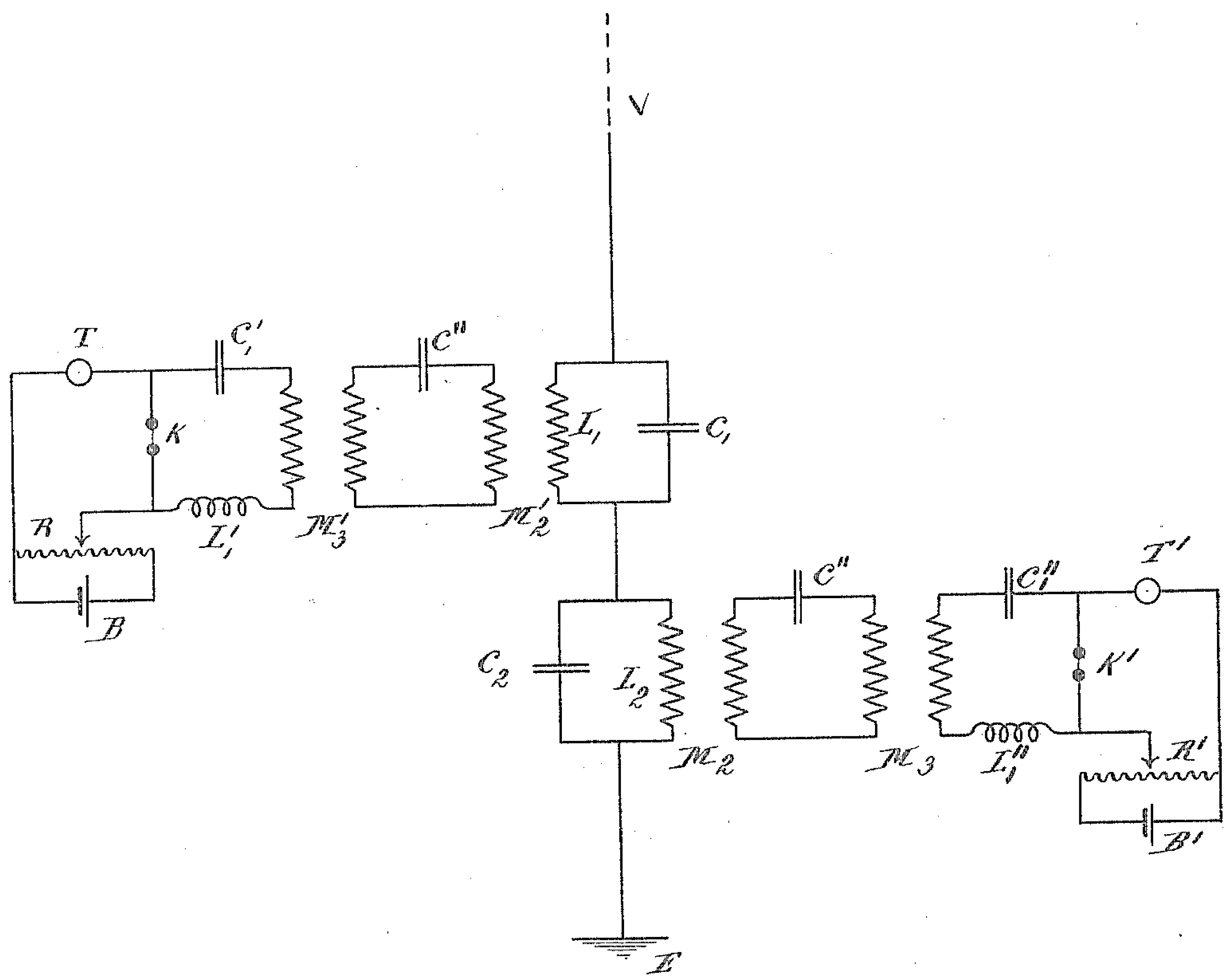

Fig. 2.

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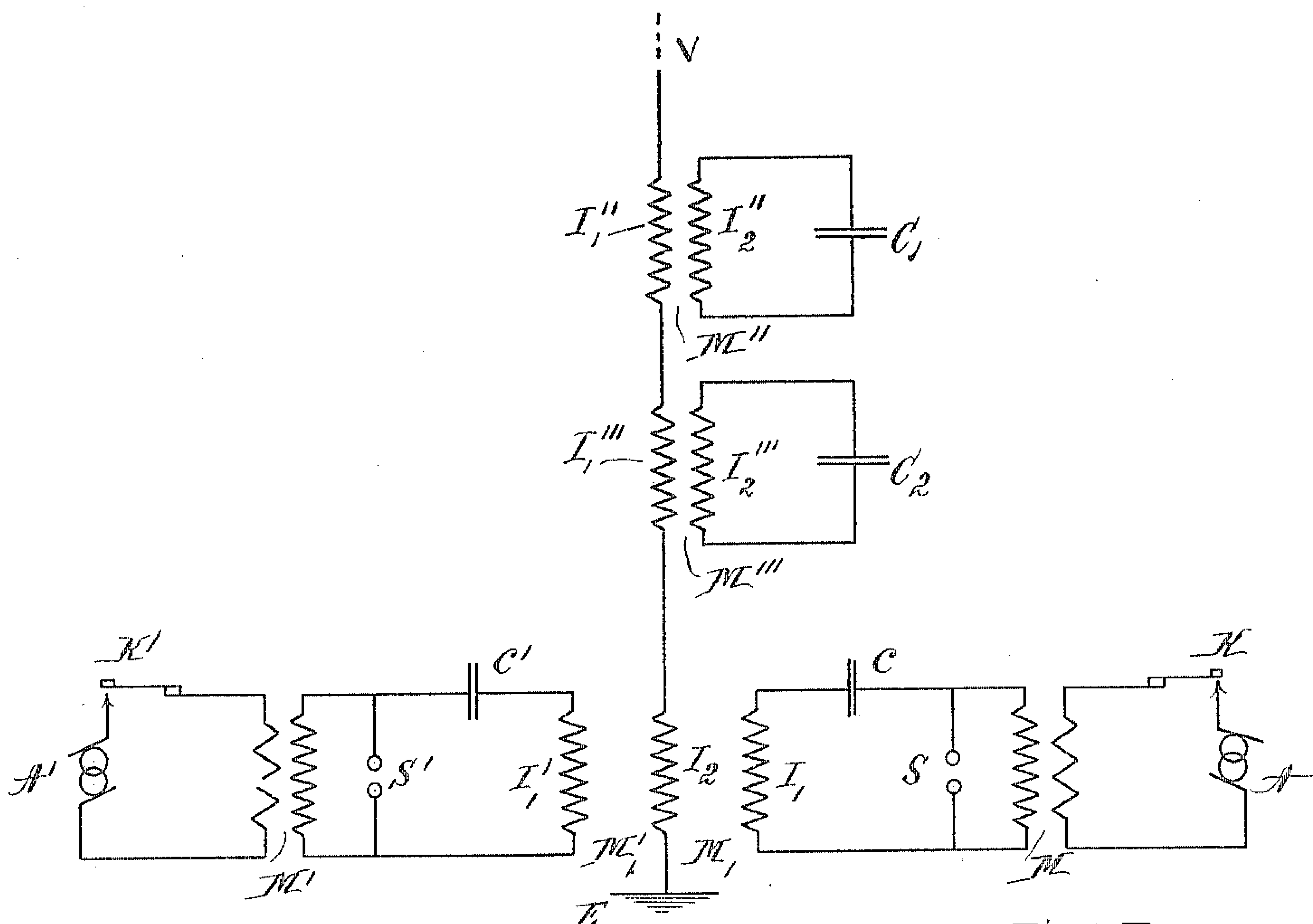

Fig. 3.

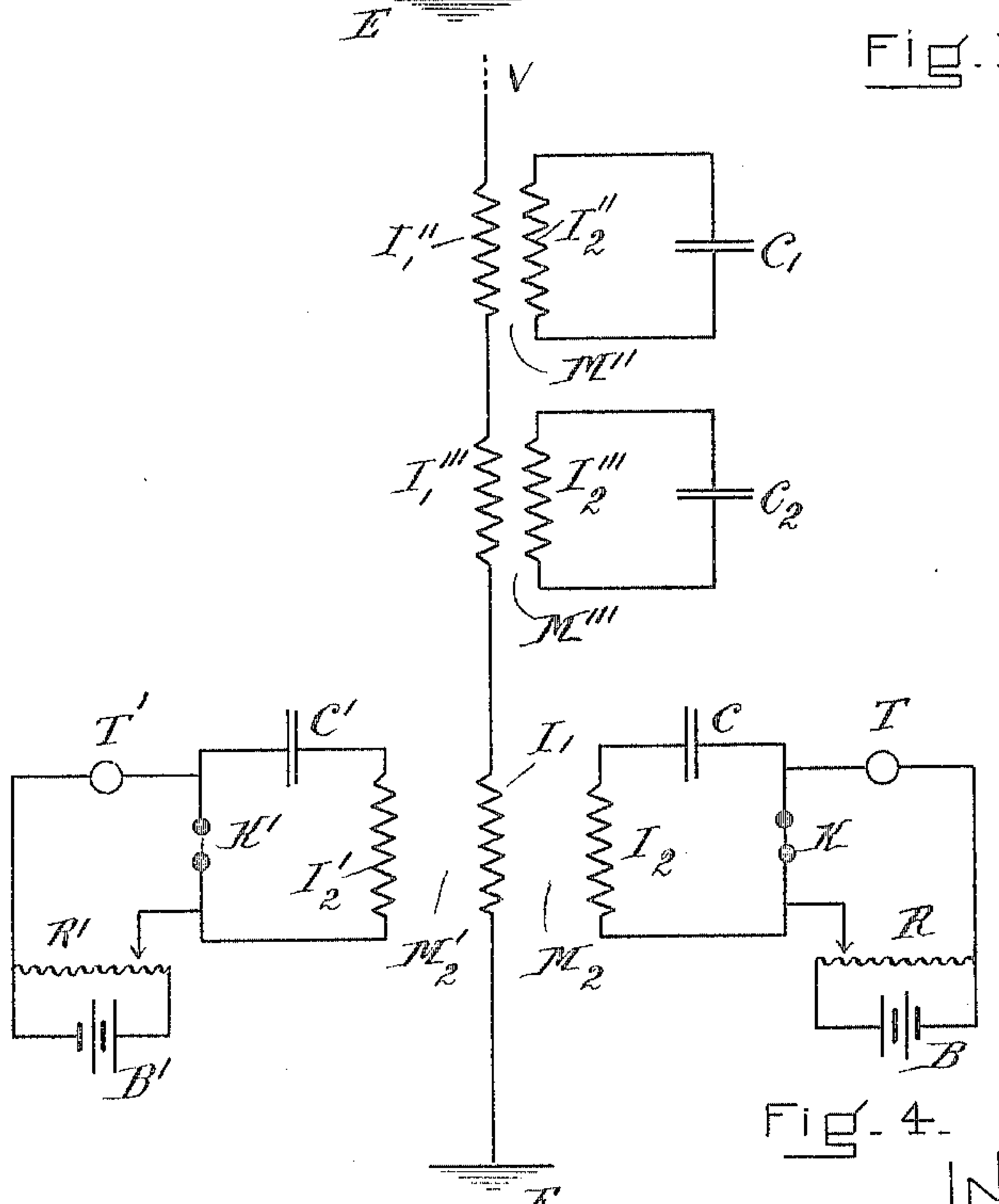

Fig. 4.

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4 SHEETS—SHEET 4.

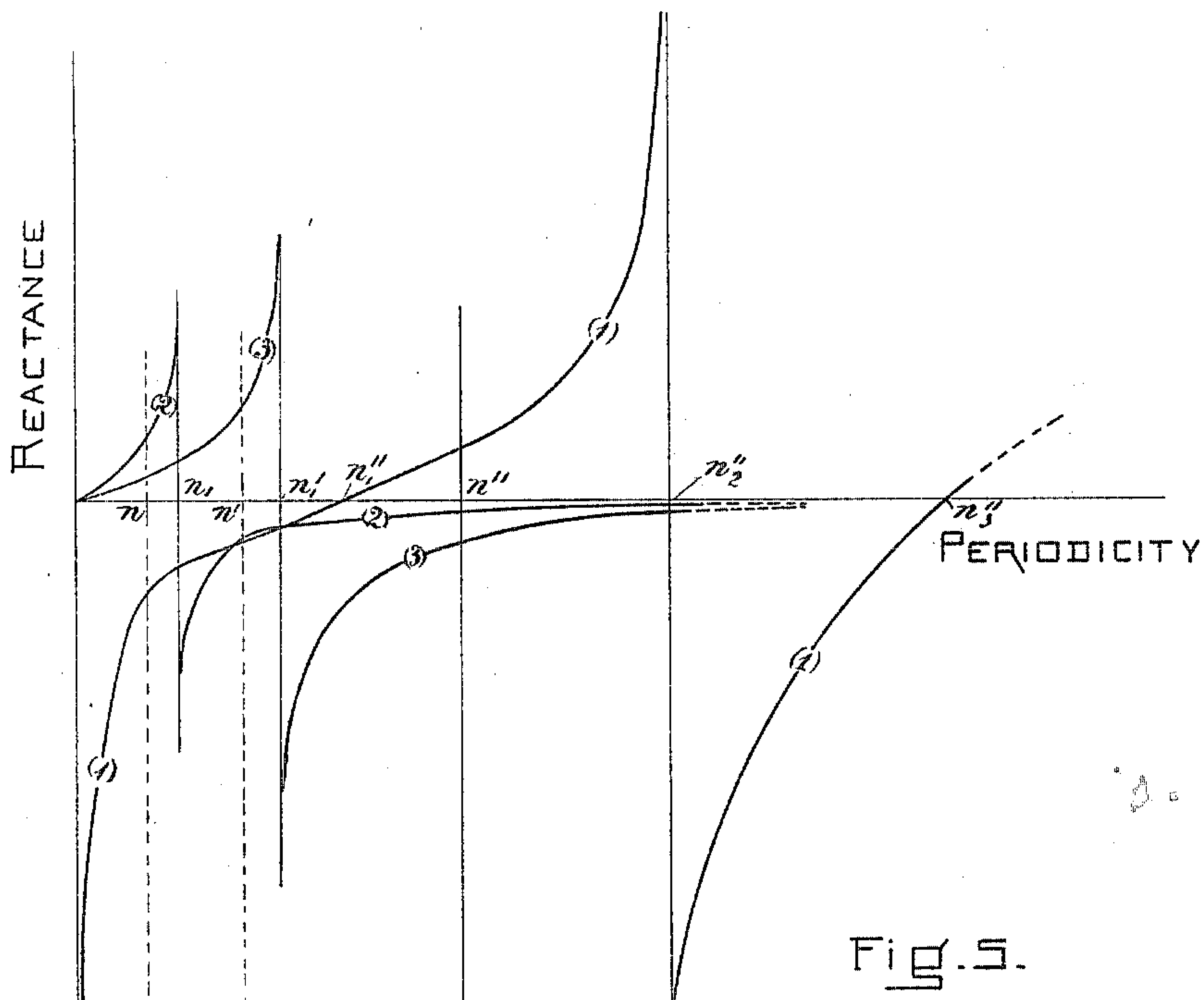

Fig. 5.

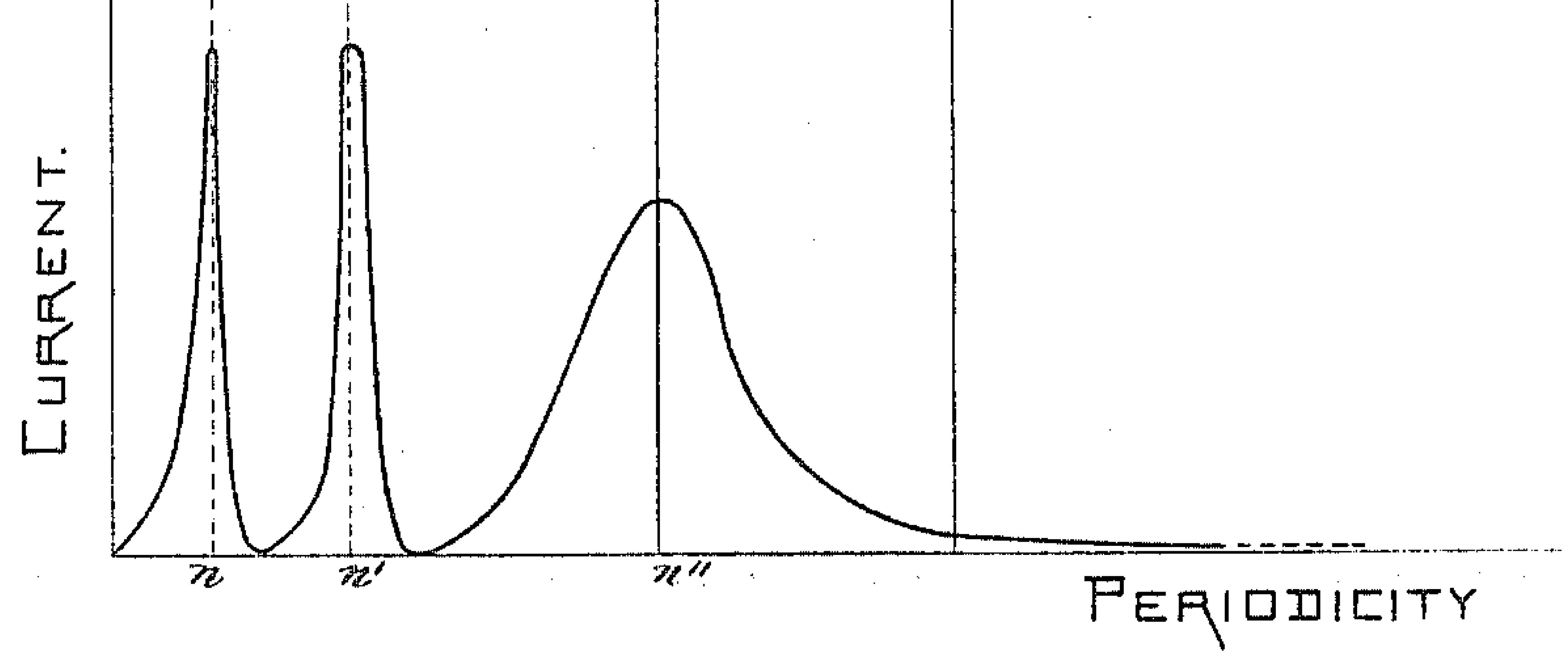

Fig. 6.

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UNITED STATES PATENT OFFICE.

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

SPACE TELEGRAPHY.

No. 802,426. Specification of Letters Patent. Patented Oct. 24, 1905.

Application filed May 10, 1905. Serial No. 259,841.

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 general object of the present invention is to realize a multiplex system of space telegraphy in which the transmitting stations may selectively transmit their signals each to a particular receiving station simultaneously or otherwise without mutual interference; and it comprises improvements in electrical apparatus and circuit arrangements whereby methods of electrical selection and distribution may be carried into effect. By means of such apparatus and circuit arrangements electromagnetic waves of different definite frequencies or rates of vibration, free or unguided except by the surface of the earth, may be simultaneously or individually developed and the energy of said waves selectively absorbed and utilized.

The fundamental underlying principles of the present invention have been fully set forth in my Letters Patent Nos. 714,756, 737,170 and 767,994, to which reference may be had for a more detailed description of the broad principles involved, as well as for the general construction of the apparatus employed, than is necessary to set forth herein.

For selectively transmitting and receiving the energy of electromagnetic signal waves of different definite frequencies simultaneously or individually, I associate with the transmitting and receiving elevated conductors closed persistently-oscillating circuits, each attuned to a different one of said frequencies, in the manner more fully described in my aforesaid Letters Patent No. 714,756 and illustrated in Figs. 13, 14, 15, 16 and 17 thereof, and in Letters Patent No. 737,170 and illustrated in Figs. 1, 2, 3 and 4 thereof. These closed persistently-oscillating circuits when used for developing persistent trains of simple harmonic electromagnetic signal waves are termed sonorous circuits, and when they are used for selectively absorbing the energy of the oscillations resulting from the impingement of such waves upon an elevated receiving conductor they are termed resonant circuits. As pointed out in my Letters Patent Nos. 714,756 and 767,975, in order that the oscillations developed in an elevated transmitting conductor may be of great amplitude, the frequency of the impressed force may be made to correspond to the fundamental or to the odd harmonics of the elevated transmitting conductor system and, in order that abrupt or impulsive electric forces impinging upon an elevated receiving conductor may not cause a response of the associated resonant receiving circuit, the elevated receiving conductor system may be given natural rates of vibration which are different from that to which said associated resonant receiving circuit is attuned by any of the means disclosed in my Letters Patent No. 767,994, or in my application serial number 194,649, filed Feb. 23, 1904, which means, in general, comprise circuits containing capacity and inductance associated with the receiving conductor and which for the frequency of a persistent train of waves the energy of which is to be received have a reactance equal but opposite in sign to the reactance of the elevated conductor *per se*.

The particular object of the present invention consists in increasing the efficiency of multiplex systems of the general type illustrated in my Letters Patent above referred to. In other words, whereas heretofore with this organization of circuits I have used an aperiodic elevated conductor, I find that it is of advantage to employ an elevated conductor system which is selectively responsive to impressed forces of the several frequencies employed in the multiplex transmission.

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

In the drawings,

Figs. 1 and 3 represent in diagram multiplex space-telegraph transmitting systems.

Figs. 2 and 4 represent in diagram multiplex space-telegraph receiving systems.

Figs. 5 and 6 are curves hereinafter referred to in the explanation of the theory of operation of the systems shown in Figs. 1, 2, 3 and 4.

In the figures,

V is an elevated conductor.

E is an earth connection.

$C\ C'\ C_1\ C_2\ C''\ C_1''$ are condensers.

$L_1\ L_2\ L_1'\ L_1''$ are inductance coils.

$M\ M'\ M_1\ M_1'\ M_2\ M_2'\ M''\ M'''$ are transformers which may be step-up transformers or step-down tranformers as desired, though in general in the transmitting system the transformers $M_1\ M_1'$ are step-up transformers, and in the receiving system the transformers $M_2\ M_2'$ are either step-up or step-down transformers.

$I_1\ I_1'$ &c. are transformer primaries.

$I_2\ I_2'$ &c. are transformer secondaries.

K K' are electro-receptive devices herein shown as bolometer fine wires or strips.

T T' are electric translating or signal-indicating devices which may be telephone receivers.

B B' are batteries.

A A' are alternating current generators or other suitable sources of vibratory current.

k k' are keys.

s s' are spark gaps.

The circuits $s\ C\ I_1$, $s'\ C'\ I_1'$ are sonorous or persistently oscillating circuits at the transmitting station adapted to develop in the elevated transmitting conductor system forced simple harmonic electrical oscillations of different definite frequencies, and the circuits $K\ C\ I_2$, $K'\ C'\ I_2'$, $K\ C'_1\ L'_1$, $K'\ C_1''\ L_1''$, are resonant or persistently oscillating circuits at the receiving station adapted to selectively respond to oscillations of said definite frequencies. Each of the aforesaid sonorous or resonant circuits is made the equivalent of a circuit having a single degree of freedom by any of the methods described in my prior patents. In the particular embodiments of the present invention which are illustrated in Figs. 1, 3 and 4, the particular method employed for rendering each sonorous or resonant circuit the equivalent of a circuit having a single degree of freedom consists in so associating such circuits with the respective elevated conductors by means of a transformer of large magnetic leakage that the mutual energy of each circuit with respect to the other circuits of the system is made small compared with the self energy of said circuit in the manner described in my prior patents, although it is to be understood that any of the other methods previously described by me for effecting such loose inductive coupling of the closed and open oscillators may be employed, for example that of swamping the effect of the mutual inductance between such closed and open oscillators by means of an auxiliary loading coil.

In that embodiment of my invention shown in Fig. 2, the circuits $C''M_2'\ M_3'$ and $C''M_2\ M_3$ are resonant weeding out circuits such as described in my aforesaid prior patents and each is attuned to the frequency to which its associated resonant receiving circuit is made resonant.

In Figs. 1 and 2 the circuits $L_1\ C_1$ and $L_2\ C_2$ are parallel branch circuits such as described in my Letters Patent No. 767,994, each of which, as shown, contains a condenser in one branch and an inductance coil in the other branch, although I am not limited to this particular form of parallel branch circuit, but may employ one having a plurality of condensers and coils in each branch as set forth more fully in said patent. As more particularly pointed out in Letters Patent No. 767,994, the reactance of the loop circuits $L_1\ C_1$ and $L_2\ C_2$ as measured at their points of connection with the elevated conductor system will vary with the frequency of the oscillations developed in such system, being for certain frequencies the reactance of an "equivalent condenser" and for other frequencies the reactance of an "equivalent coil."

Reference may now be had to Fig. 5, which consists of curves drawn to rectangular coordinates, in which the ordinates represent reactance and the abscissæ represent frequency. The curves (1) (2) and (3) respectively, represent the variation with frequency of the reactances of the elevated conductor *per se*, the loop circuit $C_1\ L_1$ and the loop circuit $C_2\ L_2$. For a more comprehensive interpretation of this figure and of Fig. 6 than need be given in this specification reference may be had to my Letters Patent No. 767,994. It should be understood that the curves shown in Figs. 5 and 6 are not drawn to scale but are based upon computations made for actual circuits which I have employed and that such computations have been checked experimentally.

It will be observed that for two frequencies n and n' the algebraic sum of the ordinates of the curves (1), (2), (3) is zero, and therefore the elevated conductor system will be highly responsive to persistent oscillating electric forces of said frequencies, as shown at n and n' in Fig. 6, which is a curve drawn to rectangular co-ordinates in which the ordinates represent current amplitude and the abscissæ represent frequency.

In Fig. 5, n_1 represents the frequency to which the circuit $C_1\ L_1$ responds when isolated; n_1' represents the frequency to which the circuit $C_2\ L_2$ responds when isolated; and n_1'', n_2'', n_3'', respectively represent the fundamental, the first even harmonic and the first odd harmonic of the elevated conductor *per se* when isolated. n'' represents the pronounced natural rate of vibration of the elevated conductor system and the curve in Fig. 6 shows the maximum corresponding to this frequency at n'' on the axis of abscissæ. Currents of this frequency n'' are developed in the elevated conductor system when abrupt or impulsive forces impinge upon the vertical and this frequency represents therefore one, and the most pronounced, natural rate of vibration of the elevated conductor system for such forces. The maximum at n'' in the curve shown in Fig. 6 need not be considered when the elevated conductor system is employed for transmitting electromagnetic waves; and, as more fully pointed out in Letters Patent No. 767,994, when the elevated conductor system is employed for absorbing the energy of electromagnetic waves, any abrupt or impulsive electric forces which may impinge upon the vertical create natural oscillations in the elevated conductor system which do not effect the response of the associated resonant receiving circuit because a by far greater amount of energy is absorbed and redistributed by said natural oscillations as shown by the far greater area inclosed between the curve whose maximum ordinate is shown at n'' and its abscissæ, and because such natural oscillations are of frequencies different from those to which the resonant receiving circuit or circuits is attuned. In other words, referring more particularly to Fig. 2, when impulsive forces act upon the vertical wire, the latter tends to respond only to its own natural rates of vibration as affected by the associated circuits, that is to say, it tends to oscillate at periodicity n'' and at the upper harmonics. Such forces acting upon the vertical wire have little tendency to develop oscillations of the natural periods of the loop circuits as affected by *their* connection with the vertical, namely, the periods n and n', and the receivers which are associated respectively with said loop circuits are therefore protected from the effects of such impulsive forces.

From the foregoing description of Figs. 1 and 2 and the discussion of Figs. 5 and 6, it will be obvious that by depressing either key k or k', persistent trains of simple harmonic electrical oscillations of frequencies n and n' will be developed in the elevated transmitting conductor system, and that the reactance of the elevated transmitting conductor system will be zero for both of these frequencies. Also it will readily be apparent that when the keys k and k' are simultaneously depressed and the persistent trains of simple harmonic electrical oscillations are simultaneously developed in the elevated transmitting conductor system, the reactance of the elevated transmitting conductor system will be zero for both of these frequencies.

When persistent trains of simple harmonic electromagnetic waves of frequency n or n' impinge upon the elevated receiving conductor and create therein persistent trains of simple harmonic electrical oscillations of corresponding frequency, it will be obvious that the reactance of the elevated receiving conductor system will be zero for both of these frequencies, and that if the resonant receiving circuits be attuned to either one of said frequencies the electro-receptive devices K or K' will be operated. Also it will readily be apparent that if such persistent trains of simple harmonic electrical oscillations of said frequencies be simultaneously developed in the elevated receiving conductor system, the reactance of the elevated receiving conductor system will be zero for both of these frequencies, and that the electro-receptive devices K and K' included in the resonant receiving circuits will simultaneously be operated, each by the oscillations to the frequency of which the resonant circuit including it is attuned.

If, however, abrupt or impulsive electric forces impinging upon the elevated receiving conductor cause the elevated receiving conductor system to execute natural oscillations, these oscillations will be of frequencies ill adapted to effect the response of either resonant receiving circuit because, as above explained, the frequencies of such natural oscillations will be different from the frequencies to which the resonant receiving circuits respectively are attuned.

Although for the purposes of illustrating my invention I have shown and described two persistently oscillating circuits and two loop circuits associated with the elevated conductor system, it is to be understood that I am not limited to such construction because a larger number of persistently oscillating circuits may be employed and for each such circuit so employed a loop circuit may be associated with the elevated conductor system.

Although I have herein shown and described the persistently oscillating circuits inductively associated with the elevated conductor system, it is to be understood that I am not limited to such construction because such circuits may be conductively connected thereto in the manner described in my prior patents.

In Figs. 3 and 4 I have shown, for the purpose of more completely disclosing the invention, a modification of the systems above described, and this modification consists in inductively associating the loop circuits L_2'' C_1 and L_2''' C_2 with the elevated conductor by means of the transformers M'' and M''' respectively. The principle involved in this arrangement of circuits has been fully set forth in my application Serial Number 194,649, filed Feb. 23, 1904, and therefore need not be repeated herein, it being sufficient to state that said circuits so inductively react upon the elevated conductor system that the reactance of the transmitting elevated conductor system is rendered zero for the persistent trains of simple harmonic electrical oscillations of the frequencies impressed thereon by the sonorous circuits $s\ C\ I_1$ and $s'\ C'\ I'_1$; and that the reactance of the receiving elevated conductor system is rendered zero for persistent trains of simple harmonic electrical oscillations of the frequencies developed therein by persistent trains of simple harmonic electromagnetic waves to the frequency of which the resonant receiving circuits $K\ C\ I_2$ and $K'\ C'\ I'_2$ respectively, are attuned.

It will be readily apparent that, as in the systems illustrated in Figs. 1 and 2, the oscillations may be simultaneously developed in the elevated conductor systems of Figs. 3 and 4, as well as individually.

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. 266,858, filed June 24, 1905.

It will be understood that many variations and modifications may be made in the systems herein specifically described without departing from the spirit of my invention and therefore I do not limit my claims to the specific embodiments of the present broad invention disclosed; but

I claim broadly as my invention—

1. In a space telegraph transmitting system, an elevated conductor system, means for developing forced electrical oscillations of definite frequency therein and a circuit associated therewith and containing such capacity and inductance as to balance by its reactance for persistent trains of oscillations of said definite frequency the reactance of the rest of the elevated conductor system.

2. In a space telegraph system, an elevated conductor system, a plurality of persistently oscillating circuits associated therewith and attuned respectively to different definite frequencies, and circuits, associated with the elevated conductor and containing such capacity and inductance as to render the reactance of the elevated conductor system zero for persistent trains of oscillations of said definite frequencies.

3. In a space telegraph system, an elevated conductor system, a plurality of persistently oscillating circuits associated therewith and attuned respectively to different definite frequencics, and means for rendering the reactance of the elevated conductor system zero for persistent trains of electrical oscillations of said definite frequencies.

4. In a space telegraph system, an elevated transmitting conductor system, means for developing therein forced electrical oscillations of different definite frequencies and means for rendering the reactance of the elevated conductor system zero for persistent trains of oscillations of said definite frequencies.

5. In a space telegraph system, an elevated transmitting conductor system, a plurality of sonorous circuits associated therewith and adapted to develop therein electrical oscillations of different definite frequencies, and means for rendering the reactance of the elevated conductor system zero for persistent trains of electrical oscillations of said definite frequencies.

6. In a space telegraph system, an elevated transmitting conductor system, a sonorous circuit associated therewith and adapted to develop therein electrical oscillations of definite frequency, and a circuit associated with the elevated conductor and containing such capacity and inductance as to balance by its reactance for persistent trains of oscillations of said definite frequency the reactance of the rest of the elevated conductor system.

7. In a space telegraph system, an elevated transmitting conductor system, means for developing therein forced electrical oscillations of different definite frequencies and circuits associated with the elevated conductor and containing such capacity and inductance as to render the reactance of the elevated conductor system zero for persistent trains of oscillations of said definite frequencies.

8. In a space telegraph system, an elevated receiving conductor system, resonant circuits associated therewith and attuned respectively to different definite frequencies, and means for rendering the reactance of the elevated conductor system zero for persistent trains of electrical oscillations of said definite frequencies.

9. In a space telegraph system, an elevated receiving conductor system, resonant circuits associated therewith and attuned respectively to different definite frequencies, and circuits associated with the elevated conductor system and containing such capacity and inductance as to render the reactance of the elevated conductor system zero for persistent trains of electrical oscillations of said definite frequencies.

10. In a space telegraph elevated conductor system, the combination with an elevated conductor of means connected and arranged to render the reactance of the elevated conductor system zero for persistent trains of electrical oscillations of a plurality of different definite frequencies.

11. In a space telegraph elevated conductor system, the combination with an elevated conductor of a plurality of circuits having such capacity and inductance as to render the reactance of the elevated conductor

system zero for persistent trains of electrical oscillations of a plurality of different definite frequencies.

12. In a space telegraph elevated conductor system, the combination with an elevated conductor of a plurality of parallel branch circuits each containing capacity in one branch and inductance in the other branch and being so constructed and arranged as to balance by their combined reactances for persistent trains of electrical oscillations of a plurality of different definite frequencies the reactance of the rest of the elevated conductor system.

13. In a multiplex space telegraph system, a transmitting system comprising an elevated transmitting conductor, means for developing a multiperiodic oscillatory electric current in said elevated conductor, and means associated with said elevated conductor for giving the elevated conductor system rates of vibration equal respectively to the frequencies of the simple harmonic components of said multiperiodic current.

14. In a multiplex space telegraph system, a transmitting system comprising an elevated transmitting conductor and means for developing a multiperiodic oscillatory electric current therein, in combination with a receiving system comprising an elevated receiving conductor, resonant receiving circuits associated therewith and each attuned to the frequency of a different one of the simple harmonic components of said multiperiodic current, and circuits, one for each of said resonant receiving circuits, associated with said receiving conductor and each containing such capacity and inductance as to present, for a persistent train of electrical oscillations of the frequency to which its corresponding resonant receiving circuit is attuned, a reactance equal and opposite to the reactance of the rest of the elevated receiving conductor system.

15. In a multiplex space telegraph system, a transmitting system comprising an elevated transmitting conductor, means for developing a multiperiodic oscillatory electric current therein, and means associated with said elevated conductor for giving the elevated conductor system rates of vibration equal respectively to the frequencies of the simple harmonic components of said multiperiodic current, in combination with a receiving system comprising an elevated receiving conductor, resonant receiving circuits associated therewith and each attuned to the frequency of a different one of the simple harmonic components of said multiperiodic current, and means associated with said elevated receiving conductor for giving the elevated conductor system, for persistent trains of electrical oscillations of the frequencies to which the resonant receiving circuits respectively are attuned, rates of vibration equal respectively to the frequencies of said simple harmonic components of said multiperiodic current.

16. In a multiplex space telegraph system, a receiving system comprising an elevated receiving conductor, resonant receiving circuits associated therewith and each attuned to the particular frequency of the electromagnetic waves the energy of which it is to receive, and circuits, one for each of said resonant receiving circuits, associated with said elevated receiving conductor and each containing such capacity and inductance as to present, for a persistent train of electromagnetic waves of the frequency to which its corresponding resonant receiving circuit is attuned, a reactance equal and opposite to the reactance of the rest of the elevated receiving conductor system.

17. In a multiplex space telegraph system, a receiving system comprising an elevated receiving conductor, resonant receiving circuits associated therewith and each attuned to the particular frequency of the electromagnetic waves the energy of which it is to receive, and means associated with said elevated receiving conductor for giving the elevated receiving conductor system, for persistent trains of electromagnetic waves of the frequencies to which the resonant receiving circuits respectively are attuned, rates of vibration equal respectively to said frequencies.

18. In a multiplex space telegraph system, a receiving system comprising an elevated receiving conductor, resonant receiving circuits associated therewith and each attuned to the particular frequency of the electromagnetic waves the energy of which it is to receive, and means associated with said elevated conductor for giving the elevated conductor system rates of vibration equal respectively to the frequencies to which said resonant receiving circuits are attuned.

In testimony whereof I have hereunto subscribed my name this 2d day of May, 1905.

JOHN STONE STONE.

Witnesses:

BRAINERD T. JUDKINS,
MARSHALL P. THOMPSON.