No. 803,199. PATENTED OCT. 31, 1905.

J. S. STONE.

SPACE TELEPHONY.

APPLICATION FILED JUNE 20, 1905.

2 SHEETS—SHEET 1.

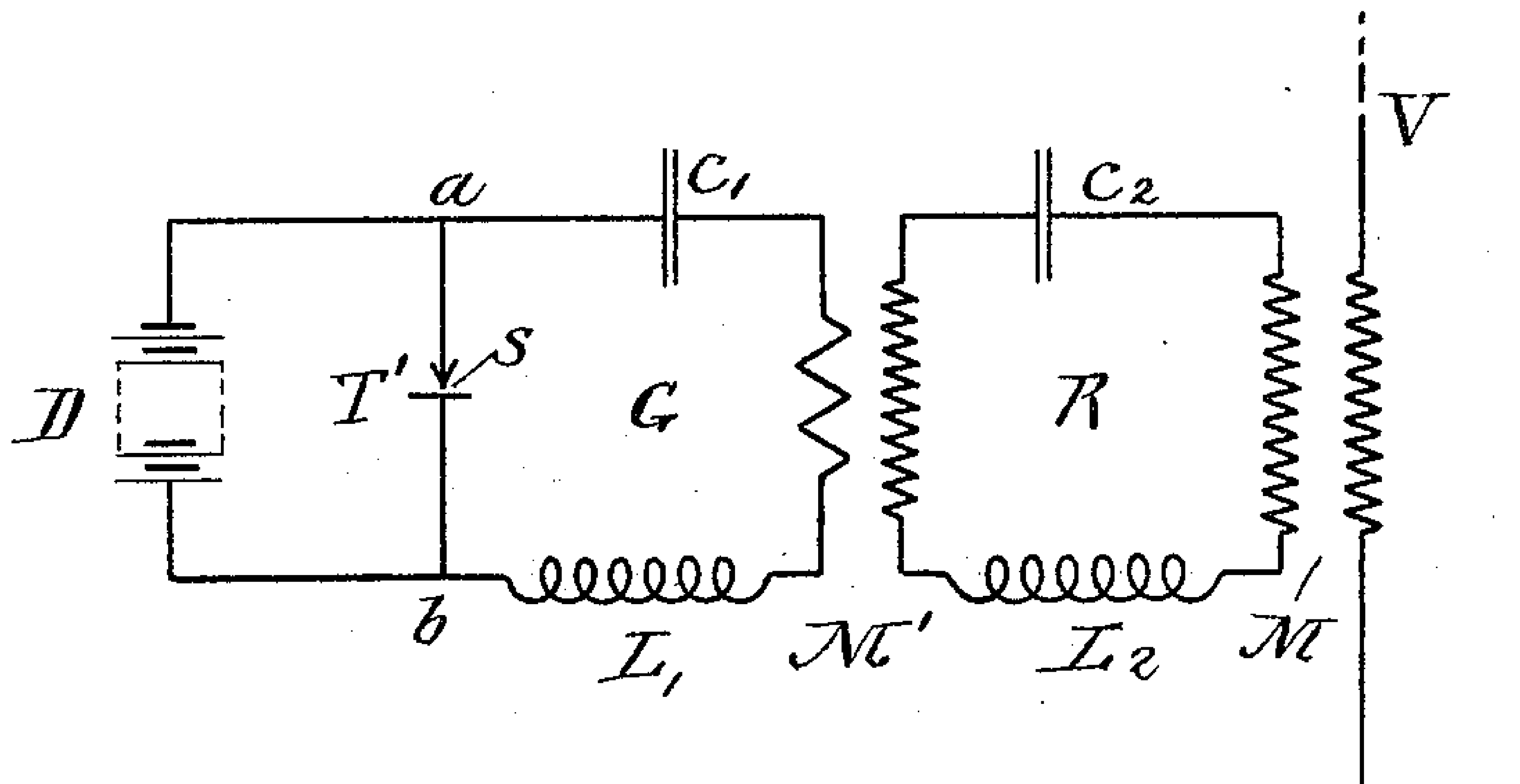

Fig. 1.

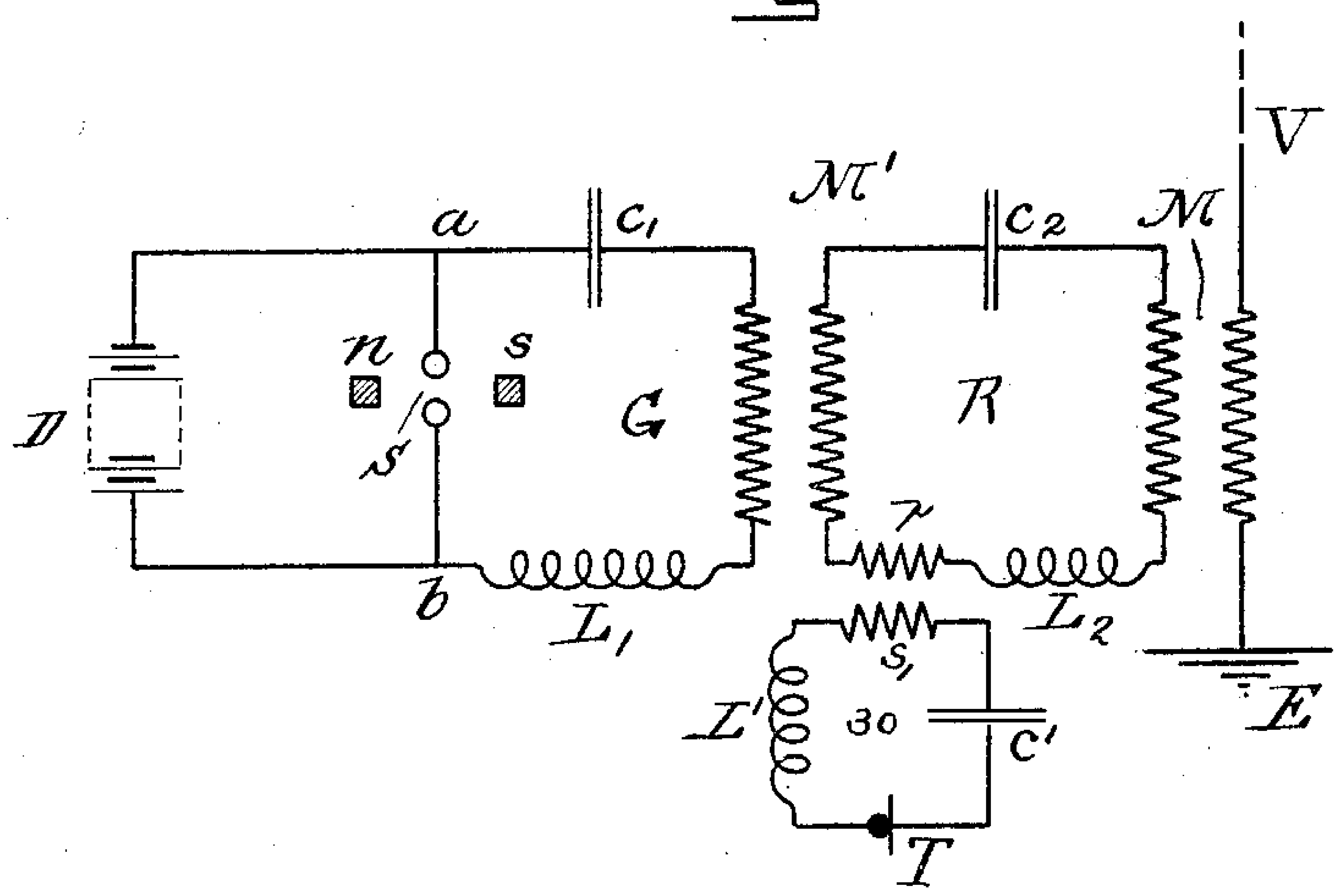

Fig. 2.

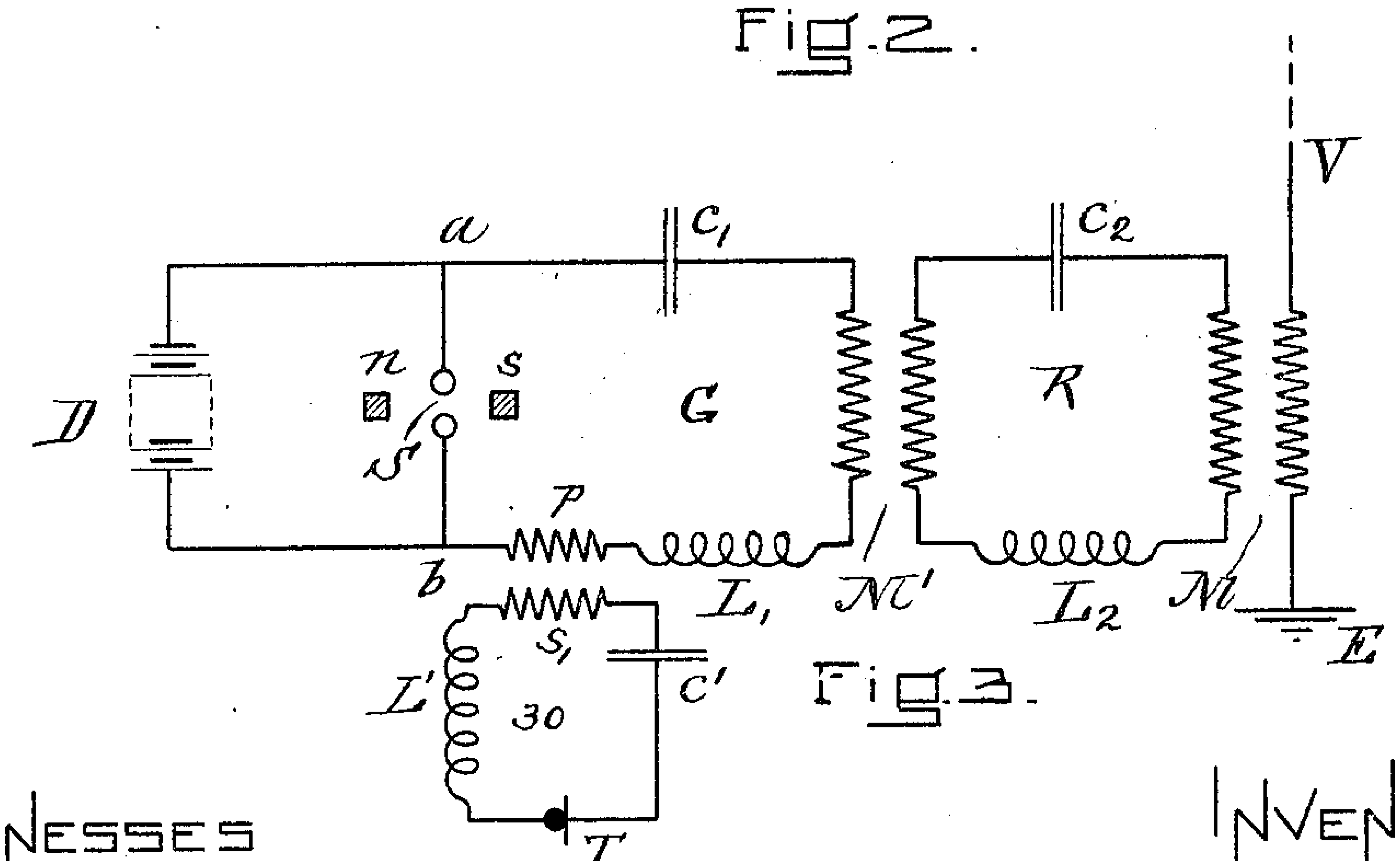

Fig. 3.

WITNESSES

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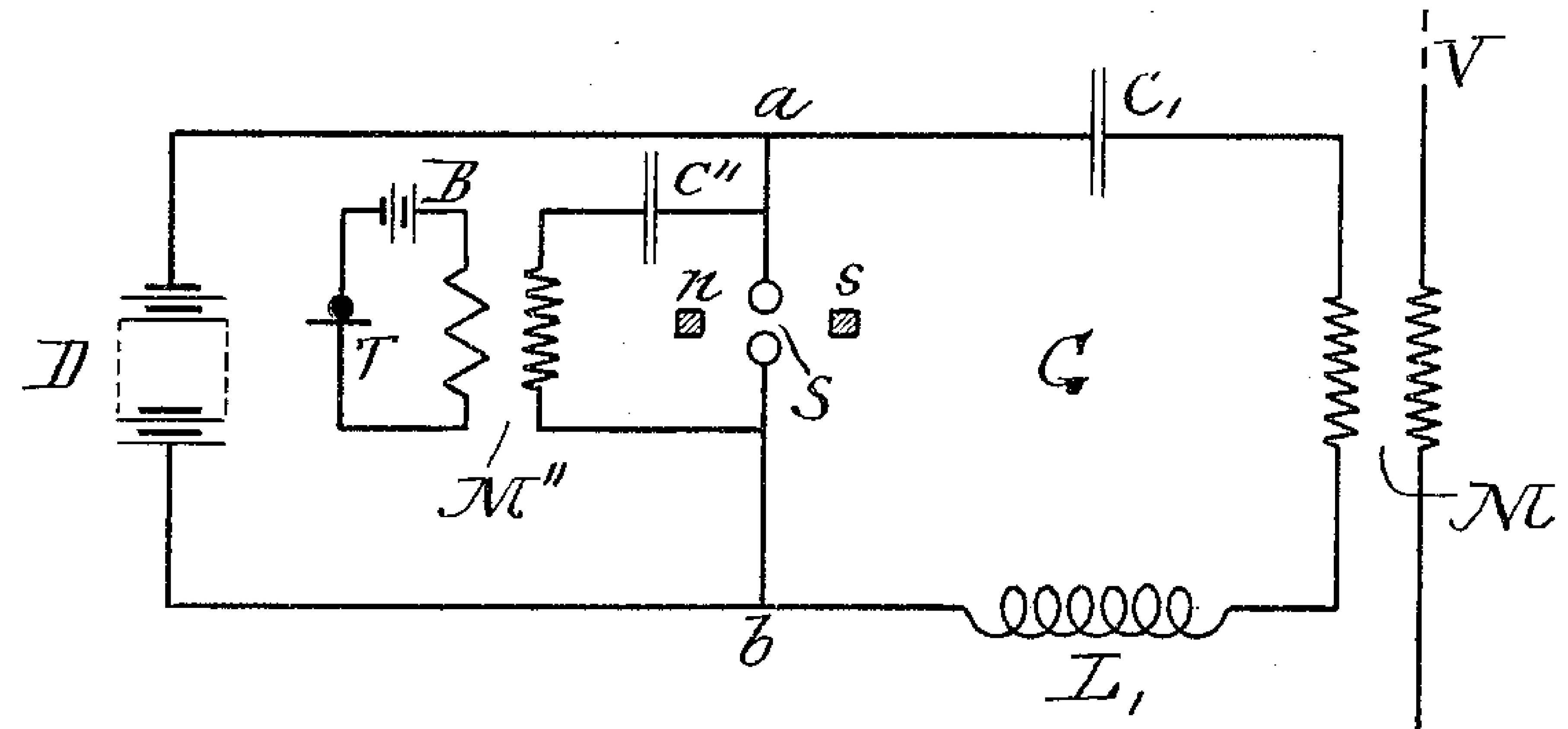

Fig.4.

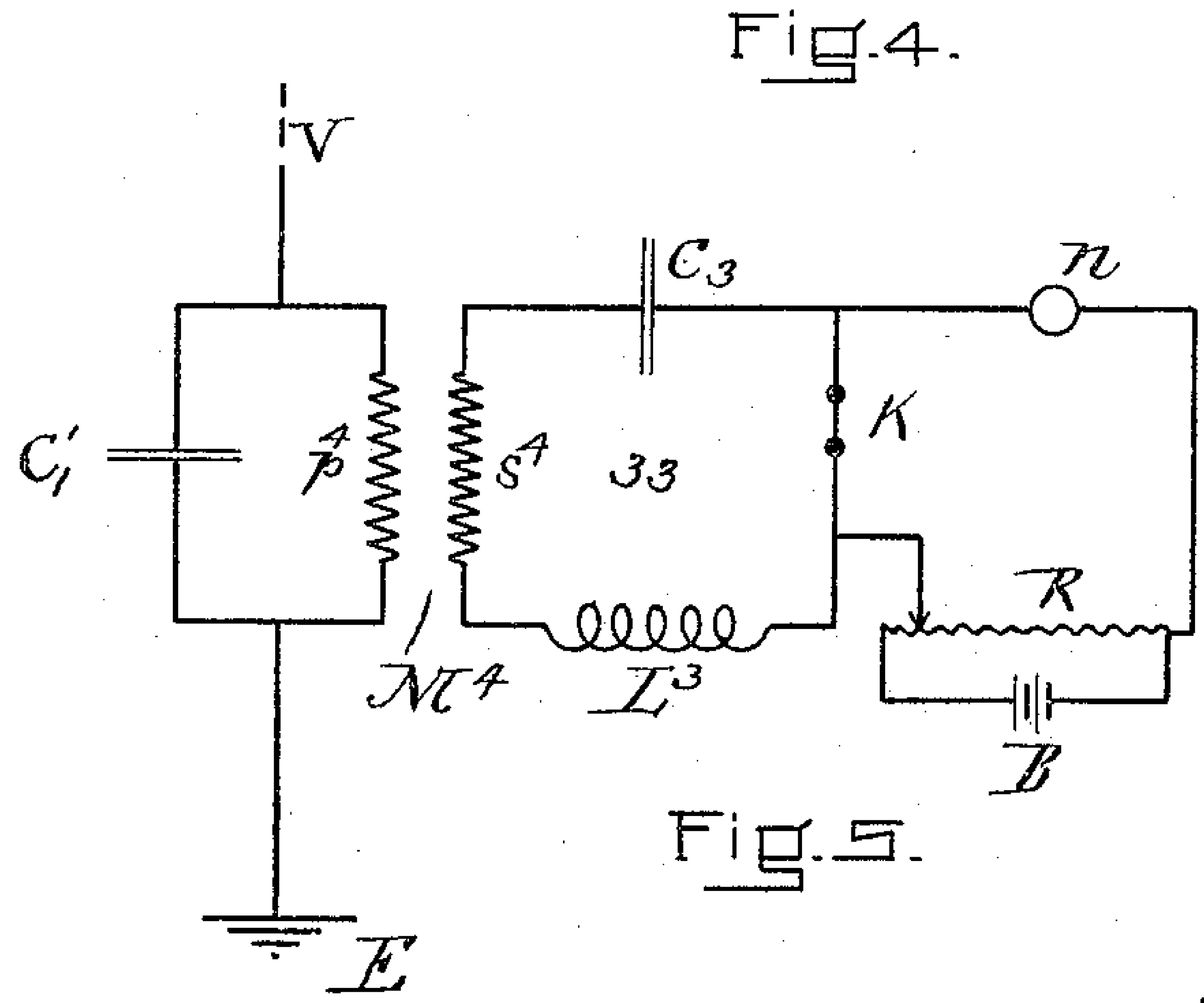

Fig.5.

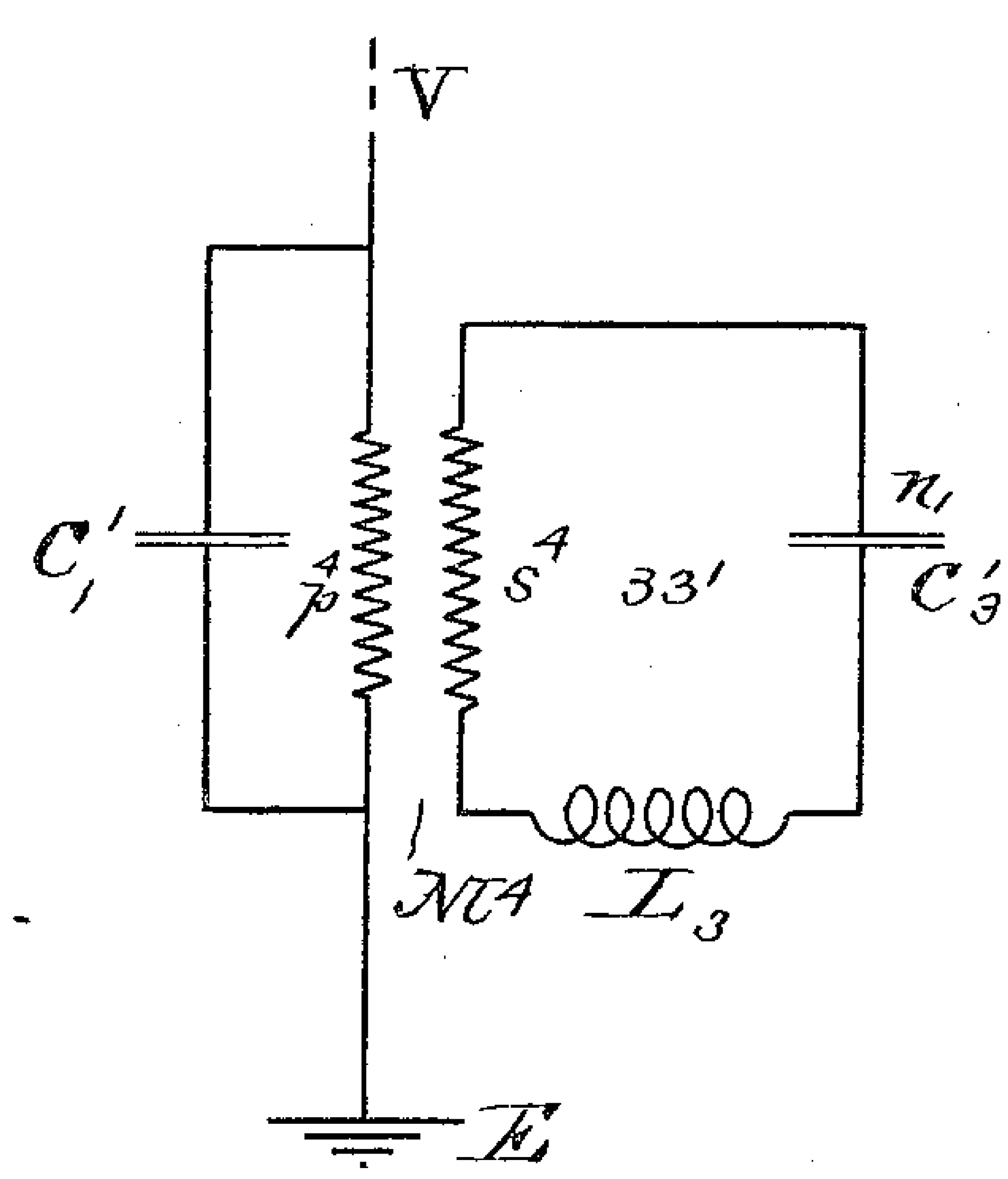

Fig.6.

WITNESSES

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SPACE TELEPHONY.

No. 803,199. Specification of Letters Patent. Patented Oct. 31, 1905.

Application filed June 20, 1905. Serial No. 266,158.

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 Telephony, of which the following is a specification.

This invention relates to the art of transmitting vocal or other sounds, including articulate speech, 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 art and apparatus whereby the electromagnetic waves are developed by producing electrical vibrations or oscillations in an elevated conductor, preferably vertically elevated, in accordance with the vibrations of the air accompanying such vocal or other sounds. It also relates to a receiving system by means of which the energy of such waves so modified may be selectively received and the energy of the resulting electrical oscillations converted into sonorous vibrations corresponding to the sounds produced at the transmitting station.

Certain of the fundamental or underlying principles of the invention have been fully set forth in my prior Letters Patent, among others Letters Patent Nos. 714,756, 737,170 and 767,994, to which reference may be had for a more detailed description of these principles, as well as for the general construction of the apparatus and circuit arrangements employed, than is necessary to set forth herein.

The invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which diagrammatically represent various forms of apparatus and circuit arrangements whereby the hereinbefore stated objects may be realized.

In the drawings,

Fig. 1 represents a transmitting system in which the amplitude of a practically continuous train of electrical oscillations may be modified in accordance with the vibrations of the air which accompany the sound to be reproduced at the receiving station.

Fig. 2 represents another form of transmitting system by which the objects of the present invention may be effected.

Fig. 3 represents a modification of the transmitting system shown in Fig. 2.

Fig. 4 represents still another form of space telephone transmitting system.

Figs. 5 and 6 represent two forms of receiving system by which the energy of simple harmonic electromagnetic waves of definite frequency may be selectively received and the energy of the resulting electrical oscillations converted into sound waves by means of electro-receptive devices quantitatively responsive to said electrical oscillations.

In the figures

D is a generator of unidirectional electromotive force.

S is a spark gap.

n—s is a magnet.

C' C_1 C_2 C_3 C_3' and C_1' are condensers.

L' L_1 L_2 L_3 are inductance coils.

T T' are transmitters.

M M' M^4 are transformers.

B is a battery.

R is an adjustable resistance.

K is an electro-receptive device herein shown as a bolometer fine wire or strip.

n_1 is an electro-receptive device herein shown as a condenser telephone receiver.

n is a magnetic telephone receiver.

In Figs. 1, 2, 3 and 4 the circuits lettered G are continuously oscillating circuits of the general type described in my Letters Patent No. 767,983, and each is adapted to develop a continuous train of electrical oscillations of definite frequency and substantially constant amplitude, as more fully set forth in said Letters Patent. In these figures D are direct current generators, and the circuits a D b are circuits of large electro-motive force and high resistance. A permanent magnet n–s may be associated in the usual way with each spark gap S and perform the usual function of such magnet in connection with the spark gap, namely, that of extinguishing the arc. In Figs. 2, 3 and 4 the spark gap may be a multiple spark gap whose discharging surfaces or metallic parts are of large conductibility for heat, as set forth in the Letters Patent to Elihu Thomson No. 444,678, dated January 13, 1891, in which case the arc is self-extinguishing, thereby rendering the employment of the magnet unnecessary, or the electrodes may be hollow metallic bodies, each provided with a vent and filled with water, in which case the temperature of such electrodes cannot exceed that of the boiling point of water. The circuits lettered R are resonant or resonator circuits each attuned to the frequency of the continuous trains of electrical oscillations developed by the circuits G and, being interposed each between the elevated conductor and the generator circuit to which it is attuned, render the oscillations impressed upon the elevated conductor simple harmonic in form and increase the amplitude of such oscillations by the cumulative effect of electrical resonance.

In Fig. 1 the required variations or modifications in the amplitude of the electrical oscillations developed in the continuously oscillating circuit G, are obtained by varying the length of the spark gap S, at which the disruptive discharge of the condenser C_1 takes place. A convenient means for so varying the length of the spark gap consists in employing the transmitter diaphragm as one terminal of said spark gap. One concrete embodiment of this form of transmitter T' is illustrated in Fig. 2 of U. S. Letters Patent 638,152, granted Nov. 28, 1899, upon my application filed Dec. 15, 1896. The potential difference to which the plates of the condenser C_1 may be charged before a disruptive discharge takes place across the spark gap S, depends upon the length of said gap, and the current necessary to charge the condenser is proportional to this potential difference between the plates. It follows that by varying the length of this air gap I may vary the amplitude of the oscillatory current in the primary circuit $a\ C_1\ L_1\ b$. By talking into the transmitter diaphragm which forms one of the spark gap terminals, the length of the spark gap is varied in a manner corresponding to the sonorous vibrations accompanying the voice waves and such variations are reproduced in the amplitude of the oscillations developed in the resonant circuit R and in the amplitude of the oscillations impressed by said resonant circuit upon the radiating conductor V and, therefore, in the amplitude of the electromagnetic waves radiated by said conductor. The resonant circuit R may, however, be omitted and the primary circuit G associated directly with the elevated conductor system. It is to be understood that I do not limit myself in any case to the inductive association of a transmitting or a receiving circuit with the elevated conductor system, but may employ the modes of conductively connecting the closed and open oscillating circuits which are described in my Letters Patent 767,989 and 767,990.

In Fig. 2 the means whereby the required variations or modifications in the amplitude of the electrical oscillations developed in the elevated conductor system are effected consist of the resonator circuit 30 and the variable resistance transmitter T. By means of the generator circuit G electrical oscillations are developed in the resonator circuit R, and said electrical oscillations experience an impedance in passing the primary winding p included in the resonator circuit, the magnitude of said impedance depending, according to well known principles, upon the impedance which the corresponding secondary winding s_1 and its circuit offer to electro-motive forces of the particular frequency to which such secondary circuit is attuned. Since the current of any given frequency which flows in a resonator circuit depends upon the impedance of the circuit to the electro-motive force vibrations of that frequency, we may say that the impedance offered by a given primary helix to current components of any given frequency depends upon the current of that particular frequency induced by it in the secondary. The secondary helix s_1 develops in the resonator circuit 30, currents which are practically simple harmonic and therefore any variation in the electromagnetic constants of such secondary resonator circuit will produce a corresponding variation in the impedance of the primary helix. Such impedance variation produces a corresponding variation in the intensity of the oscillations developed in the resonator circuit R, and therefore a corresponding variation in the amplitude of the resulting electromagnetic waves radiated by the elevated conductor V.

A third embodiment of the present invention is illustrated in Fig. 3, in which the circuit 30 is inductively associated with the generator circuit G, and is adjusted to a condition of maximum efficiency. By the variation of the resistance of the transmitter T, the impedance of the primary p is correspondingly varied and this produces a corresponding variation in the amplitude and also in the frequency of the resulting oscillations in circuit G. Hence the response of the resonant circuit R and the elevated conductor system to such electrical oscillations is likewise correspondingly varied. This results in the radiation of a practically continuous train of electromagnetic waves modified as to their amplitude in accordance with the sonorous vibrations accompanying the sounds uttered before the diaphragm of the transmitter T. It is to be observed that in the system of Fig. 3 in which the *frequency* as well as the amplitude of the electrical oscillations developed in the sonorous circuit G is varied by varying the natural period and impedance of said circuit, the ultimate result is the same as in Figs. 1 and 2, namely, that the amplitude of a practically continuous train of electromagnetic waves of substantially uniform amplitude is modified in accordance with the sonorous vibrations of articulate or other sounds, because any variation in the *frequency* of the natural oscillations developed in said sonorous circuit affects a corresponding variation in the *amplitude* of the forced oscillations developed by said sonorous circuit in the resonant circuit R, which is attuned to a predetermined, definite frequency, being the normal frequency of the circuit G, and finally in the amplitude of the forced simple harmonic oscillations developed in the elevated conductor system which is preferably attuned as to its fundamental to said predetermined, definite frequency.

A fourth embodiment of the broad invention hereinafter claimed, is shown in Fig. 4. In this figure the required variations are produced by speaking into the transmitter T, which is included in a circuit with a battery B and the primary of the transformer M″, which transforms the current in the primary to a very high potential current in the secondary circuit containing the condenser C″, which serves to partly neutralize the inductance of the secondary and to exclude therefrom the current of the battery D. Currents developed in this secondary circuit co-operate with the battery D in producing sparks at the gap S, and modify the amplitude but not the period of the resulting oscillations in the circuit G.

The frequency of the simple harmonic electrical oscillations developed in the radiating conductor by the continuously oscillating circuits G, is of course far above the limit of audibility, but by the means already described such oscillations have their amplitude modified in accordance with the sound waves which affect the transmitter T, and accordingly there results the radiation of a continuous train of electromagnetic waves having its amplitude correspondingly modified. Such continuous train of high frequency simple harmonic electromagnetic waves, whose amplitude is so modified by the slower periodic vibrations of the frequency corresponding to the pitch of an audible tone or combination of tones, develops oscillatory electric currents of corresponding frequency and modified amplitude by impinging upon an elevated receiving conductor at a distant station. Such currents so developed in the elevated receiving conductor system may be selectively absorbed by properly designed resonant receiving circuits, attuned to the frequency of such currents. Such receiving systems are by way of example shown in Figs. 5 and 6, although it is to be understood that many other forms of receiving systems disclosed in my prior patents are suitable for this purpose. The bolometer receiver K is quantitative in action, and accordingly the current intensities in the local circuit *n* K R of said receiver correspond to the intensities or amplitudes of the electrical oscillations absorbed by the resonant circuit 33 in which the bolometer is included and, inasmuch as the amplitudes of such oscillations correspond to the sonorous vibrations of the sounds produced at a transmitting station, it follows that the current intensities in said local circuit likewise correspond to said sonorous vibrations and that if the device *n* be a telephone receiver it will reproduce said sonorous vibrations.

It is not necessary however to employ such receiving system including an oscillation responsive device K and an associated translating device *n* because, as shown in Fig. 6, the functions of these two elements may be performed by a single apparatus, which is both an oscillation responsive device and a translating device. The circuit arrangements of Fig. 6 are identical with those of Fig. 5, except that in the resonant circuit 33′ is included an electric translating device n_1 constituting one of the tuning elements of said resonant circuit and adapted to utilize in its operation the energy of the oscillations developed in said resonant circuit. In that embodiment of the invention shown in Fig. 6, such translating device consists of a condenser telephone C_3', such for example as described in connection with Fig. 12 of my reissue Letters Patent No. 12,149, and such condenser telephone constitutes one of the tuning elements of the resonant circuit 33′ and is adapted to utilize in its operation the potential energy of the oscillations developed in said circuit.

When such telephone receiver is subjected to a continuous and uniform vibratory or oscillatory current, whose frequency of vibration is above the limit of audibility or is higher than the pitch of the highest tone to which the moving parts of the receiver are capable of responding, the telephone receiver remains silent. When, however, the intensity or amplitude of the high frequency currents to which such receiver is subjected is not uniform, but is subjected to slower periodic vibrations whose frequency corresponds to the pitch of an audible tone or combination of tones to which the moving parts of the receiver are capable of responding, the receiver reproduces such tones or combinations of tones. In the system shown in Fig. 6 high frequency oscillatory currents of practically continuous duration are developed in the resonant circuit 33′ by the practically continuous trains of electromagnetic waves radiated by the systems shown in Figs. 1, 2, 3 and 4, and the variations in the amplitude or intensity of such high frequency oscillatory currents correspond to the variations in the amplitude or intensity of the electromagnetic waves which create them. The rate of vibration of the oscillatory currents so developed in the resonant circuit 33′ is, of course, so great as not to produce an audible sound in the telephone receiver n_1, but the latter responds to the variations in the amplitude of these vibrations and therefore reproduces the spoken words which control or vary the particular transmitter T that effects the variations in the amplitude of that particular train of waves to the frequency of which the resonant circuit 33′ is attuned.

Although in what has hereinbefore been stated I have made mention of resonator circuits in general, it is not all such circuits which are available for use in the manner described. For the purposes of this invention it is desirable that these circuits have a very marked resonance for the high frequencies or rates of vibration necessary to effect the radiation of electromagnetic waves from vertical oscillators or radiating conductors and in order that they may be thus decisive in their selective action, it is necessary to have the resistance and capacity of such circuits relatively small and their inductance relatively large. Also for the proper operation of resonator and sonorous circuits for such frequencies, it is of the greatest importance that the inductance and electrostatic capacity of the circuits be of the elastic type and, for this purpose, dielectric and magnetic hysteresis, Foucault currents and closed secondary reactions generally, should be avoided or minimized by any means best adapted for the purpose. Specifications for the design of inductances and electrostatic capacities suitable for use in such circuits and the proper relations that must subsist between the various members of a complex of circuits so that each circuit is not materially affected by its association with the other circuit or circuits have been fully set forth in my Letters Patent Nos. 714,756, 714,832, 737,170 and in other Letters Patent issued on my application on Aug. 16, 1904, to which reference may therefore be had.

The impedance presented by a resonant circuit to the passage of simple harmonic alternating or oscillating currents depends upon the frequency of said currents, being lowest when said frequency is that to which the resonant circuit is attuned and increasing as the frequency is increased or decreased from that value, and the rate of such increase of impedance with variations in frequency depends upon the selectance of the resonant circuit.

The term "selectance" or "selectivity" has been defined by me as the ability of a resonant circuit to differentiate currents of the frequency to which it is attuned from currents of other frequencies. It depends upon the selectance function $\sqrt{\frac{L}{CR^2}}$ wherein L represents the inductance, C the capacity, and R the dissipative resistance of the resonant circuit. This function will be seen to consist of the ratio of the electromagnetic to the electrostatic time-constant of the circuit, namely, L/R and CR respectively. This selectance function, when the factors comprised in it are expressed in the proper units, is the measure of the number of oscillations the circuit will execute before the amplitude of such oscillations will fall to a definite fractional part of its initial value after its electrical equilibrium has been disturbed, and therefore it represents the persistance of the oscillating circuit. So far as I am aware I was the first to point out this function of a resonant receiving circuit which I have termed its selectance and persistance, although I am aware that as early as April 24, 1891, the ratio of the potential difference at the terminals of the condenser to the applied pressure in a circuit containing a condenser and an inductance coil was expressed as $\frac{\sqrt{L/C}}{R}$, or the ratio of the reactance of the circuit to the resistance of the circuit when $p^2CL = 1$ (The Electrician, vol. 26, p. 762), which expression, however, while algebraically equivalent to my selectance and persistance functions, gave no information as to the relations that must subsist between the electromagnetic constants of a resonant circuit in order to effect the maximum selectance and persistance.

In Figs. 5 and 6 the condensers C'_1 perform the functions set forth in my Letters Patent No. 767,994, and therefore need not be further described herein.

It is to be distinctly understood that the various transformers employed in the various systems described in this specification are illustrated merely conventionally and that in actual practice they may be step-up transformers or step-down transformers as occasion may require, and also that where, as in Figs. 1, 2 and 3, a plurality of circuits are connected inductively in series by means of such transformers, the transformers are all arranged to transform in the same direction and to impress the energy of the source upon the elevated conductor or the electric translating device, as the case may be, at increased potential, if increased potential be desired, or at increased current, if increased current be desired.

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. 267,482, filed June 29, 1905.

I do not wish to be limited to the exact details of apparatus and circuit arrangements herein described and conventionally illustrated, because many modifications may be made therein by those skilled in the art without departing from the spirit of my invention; but

I claim, broadly, as my invention—

1. In a system of selective electric signaling, a transmitting system comprising means for radiating a substantially continuous train of electromagnetic signal waves and means for varying the amplitude of said waves in accordance with the sonorous vibrations of articulate or other sounds, in combination with a receiving system comprising means for selectively absorbing the energy of said waves and means quantitatively responsive to the variations in the amplitude thereof.

2. In a system of selective electric signaling,

a transmitting system comprising means for radiating a practically continuous train of electromagnetic waves of substantially constant amplitude and means for varying the amplitude of said waves by and in accordance with the sonorous vibrations of articulate or other sounds, in combination with a receiving system comprising means for selectively absorbing the energy of said waves and means for reproducing said sounds.

3. In a system of selective electric signaling, a transmitting system comprising means for developing a practically continuous train of electrical oscillations of substantially constant amplitude, means for varying the amplitude of said electrical oscillations by and in accordance with the sonorous vibrations of articulate or other sounds, and means for impressing said electrical oscillations so varied in amplitude upon an elevated transmitting conductor, whereby a practically continuous train of electromagnetic waves varied in amplitude in accordance with said sonorous vibrations is developed, in combination with a receiving system comprising means for selectively absorbing the energy of said waves and means for reproducing said sounds.

4. In a system of selective electric signaling, a transmitting system comprising means for radiating a practically continuous train of electromagnetic waves of definite frequency and of substantially uniform amplitude, and a variable resistance transmitter for varying the amplitude of said waves by and in accordance with the vibrations of the air accompanying vocal or other sounds, in combination with a receiving system comprising a resonant receiving circuit attuned to the frequency of said electromagnetic waves and means included in said resonant circuit for reproducing said sounds.

5. In a system of selective electric signaling, a transmitting system comprising means for radiating a practically continuous train of electromagnetic waves of definite frequency and of substantially uniform amplitude, and means for varying the amplitude of said waves by and in accordance with the sonorous vibrations of articulate or other sounds, in combination with a receiving system comprising a resonant receiving circuit attuned to the frequency of said electromagnetic waves and means associated with said resonant circuit for reproducing said sounds.

6. In a system of selective electric signaling, a transmitting system comprising a sonorous circuit for developing a practically continuous train of electrical oscillations of substantially constant amplitude, a variable resistance transmitter associated with said sonorous circuit for varying the amplitude of said electrical oscillations by and in accordance with the sonorous vibrations of articulate or other sounds, and means for impressing said electrical oscillations so varied in amplitude upon an elevated transmitting conductor, whereby a practically continuous train of electromagnetic waves varied in amplitude in accordance with said sonorous vibrations is developed, in combination with a receiving system comprising a resonant circuit for selectively absorbing the energy of said waves, and a bolometer fine wire or strip included in said resonant circuit.

7. In a system for the transmission and reception of vocal or other sounds, including articulate speech, without the use of guiding wires, a transmitting system comprising a transmitting conductor, means for developing a substantially continuous train of electromagnetic waves and means for modifying the amplitude of such waves in accordance with the air vibrations accompanying the sounds to be transmitted, in combination with a receiving system comprising a receiving conductor adapted to receive the energy of such modified waves and means for converting the energy of the electrical oscillations thereby produced in said conductor into air waves corresponding to said sounds.

8. In a system of electric signaling, a transmitting conductor, a sonorous circuit, associated therewith and adapted to develop therein a substantially continuous train of electrical oscillations of substantially constant amplitude, and a circuit, containing a condenser and an inductance coil, associated with said sonorous circuit and containing means whereby its electromagnetic constants may be varied in accordance with the air vibrations accompanying vocal or other sounds, in combination with an elevated receiving conductor adapted to absorb the energy of said electromagnetic waves and means associated therewith for converting the energy of the resulting electrical oscillations into sound waves.

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.