L. DE FOREST.

SPACE TELEGRAPHY.

APPLICATION FILED JAN. 29, 1907.

979,276.

Patented Dec. 20, 1910.

3 SHEETS—SHEET 1.

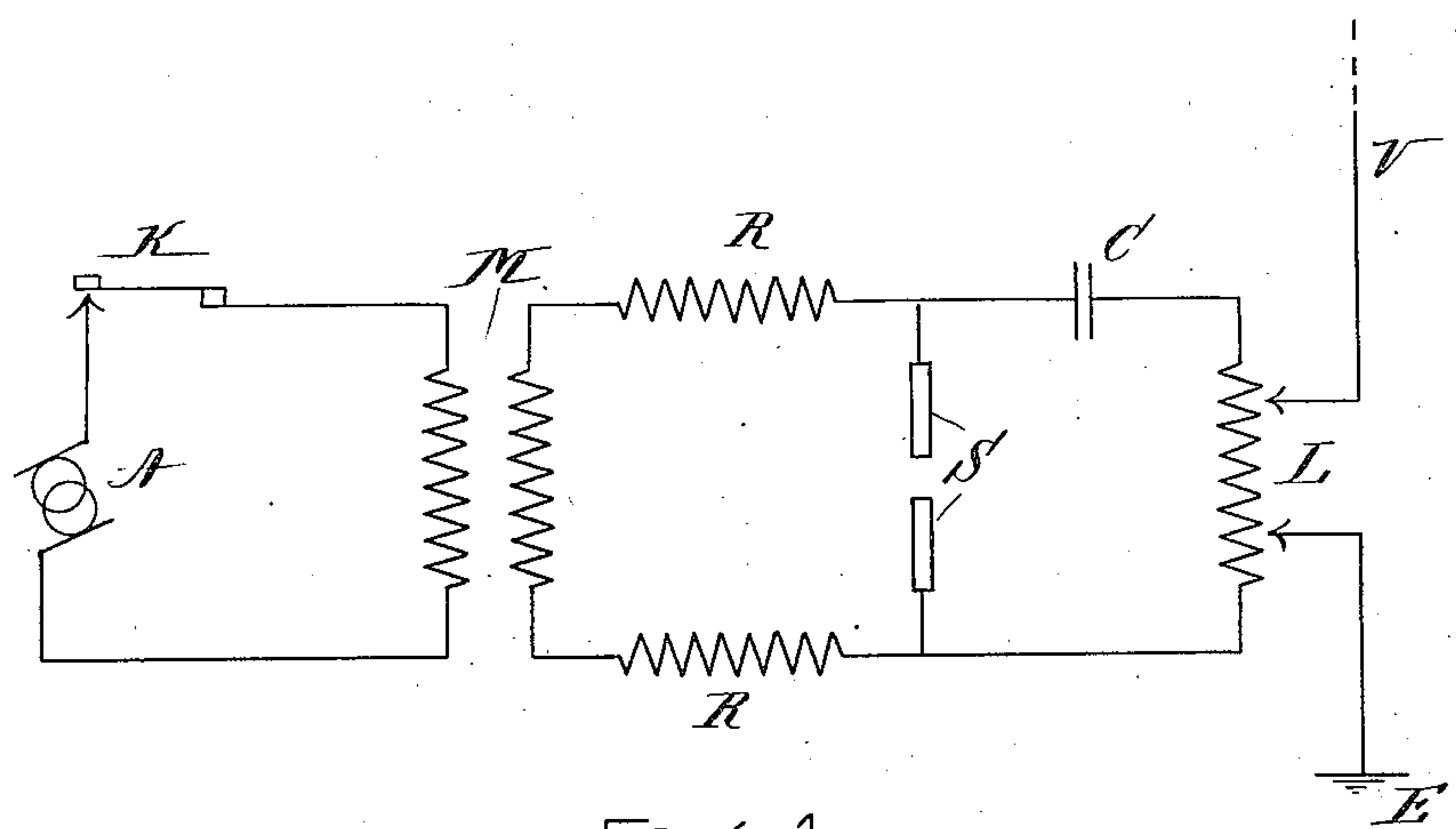

Fig. 1.

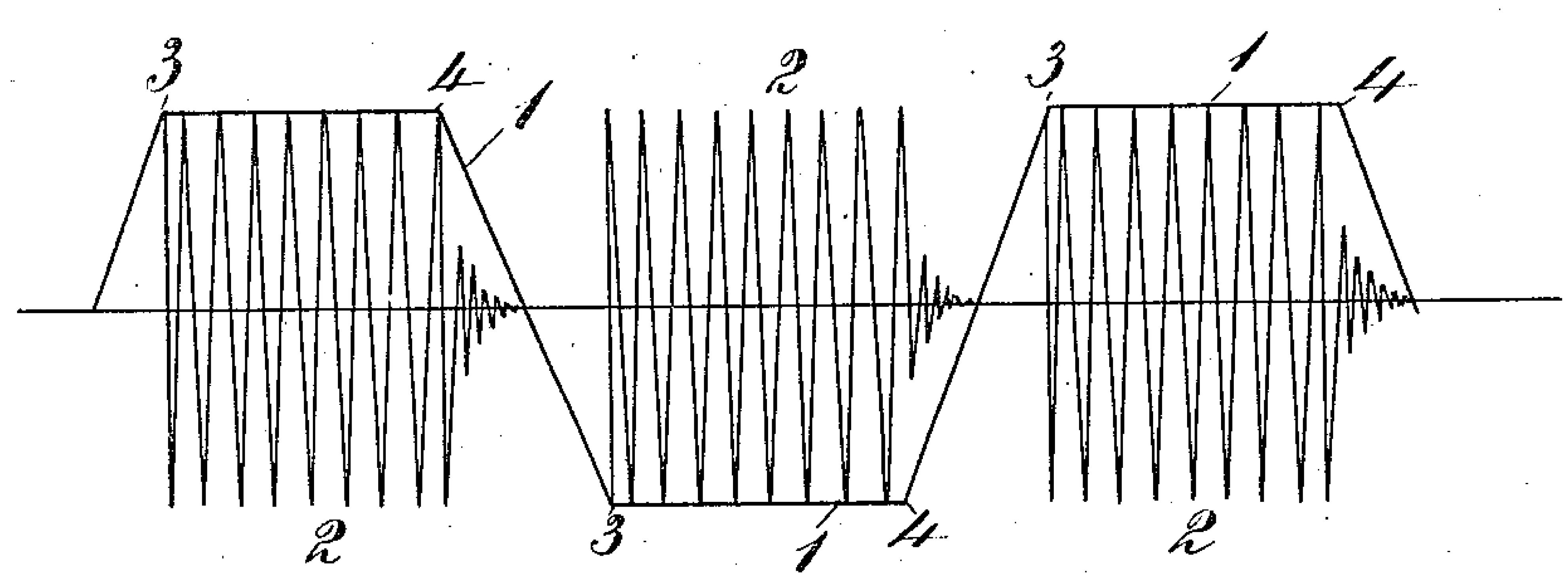

Fig. 1a

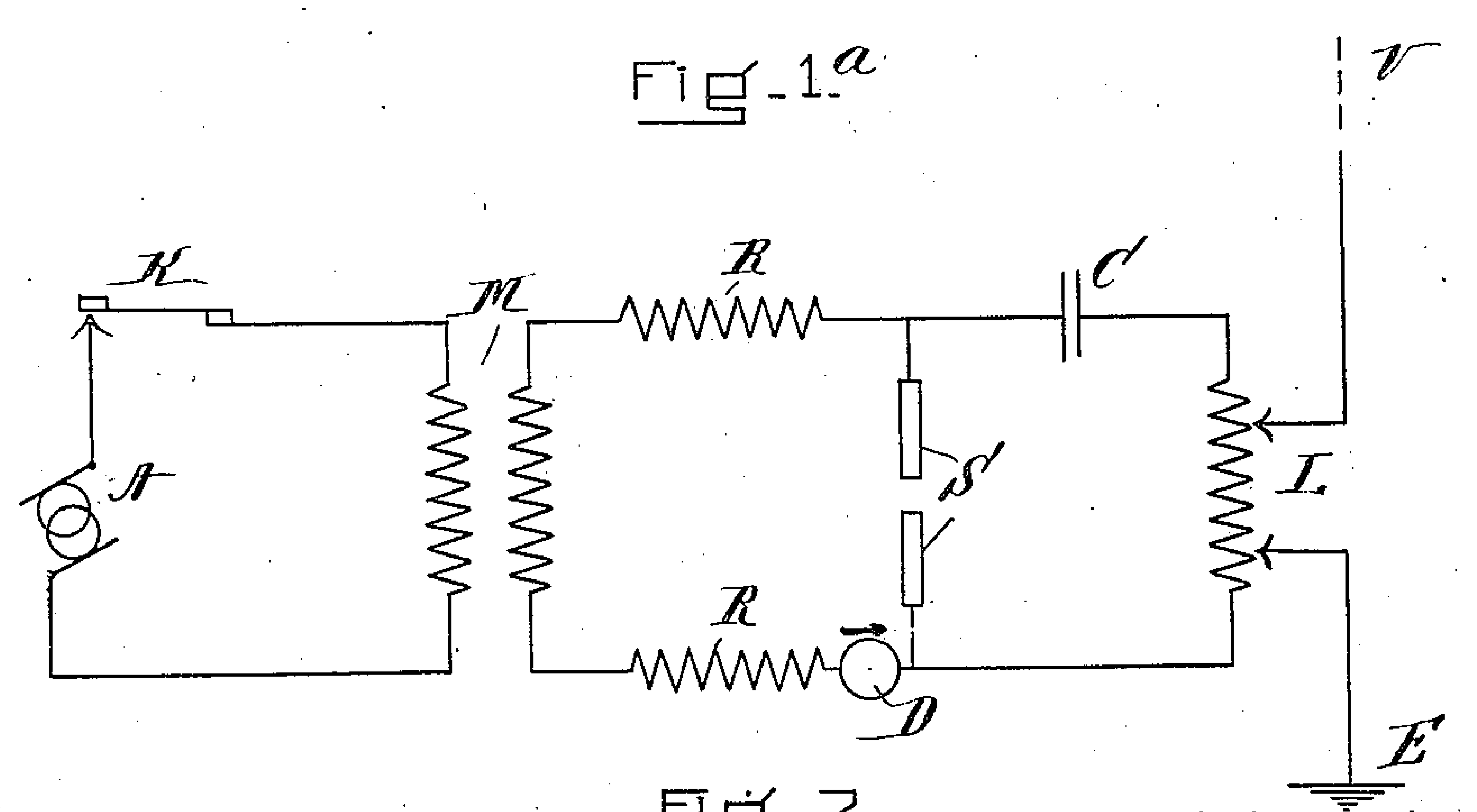

Fig. 2.

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3 SHEETS—SHEET 2.

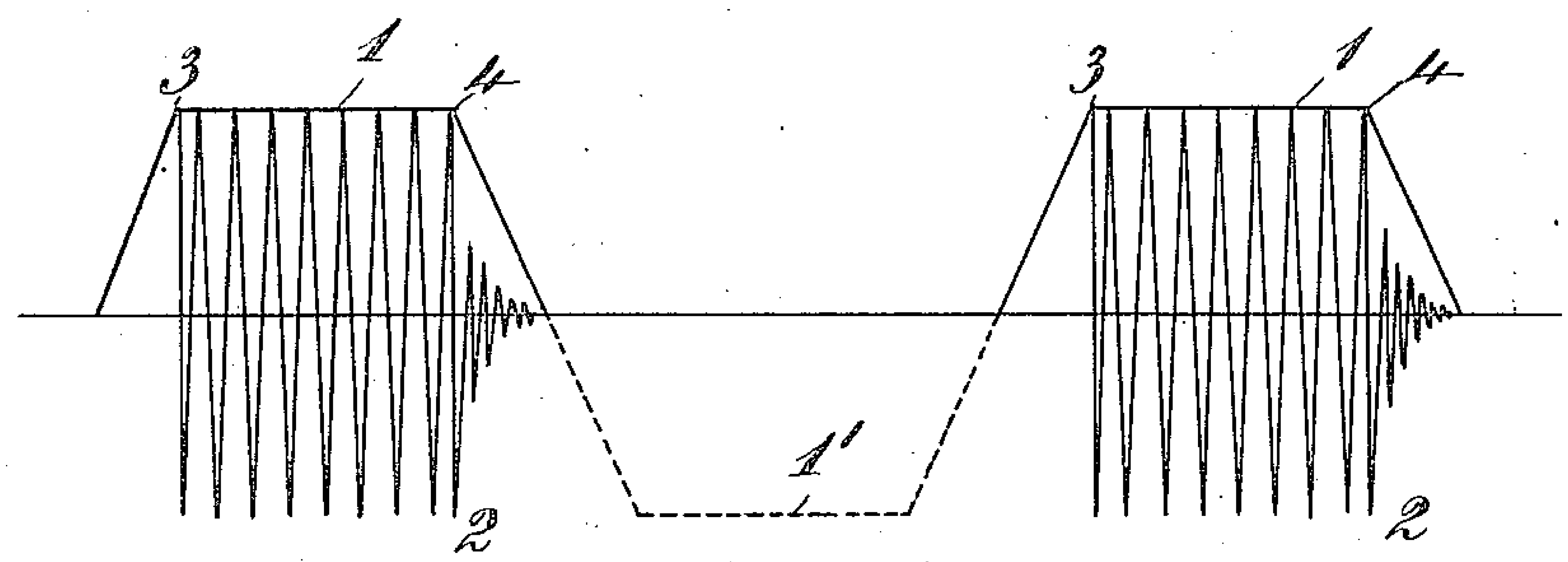

Fig. 2a.

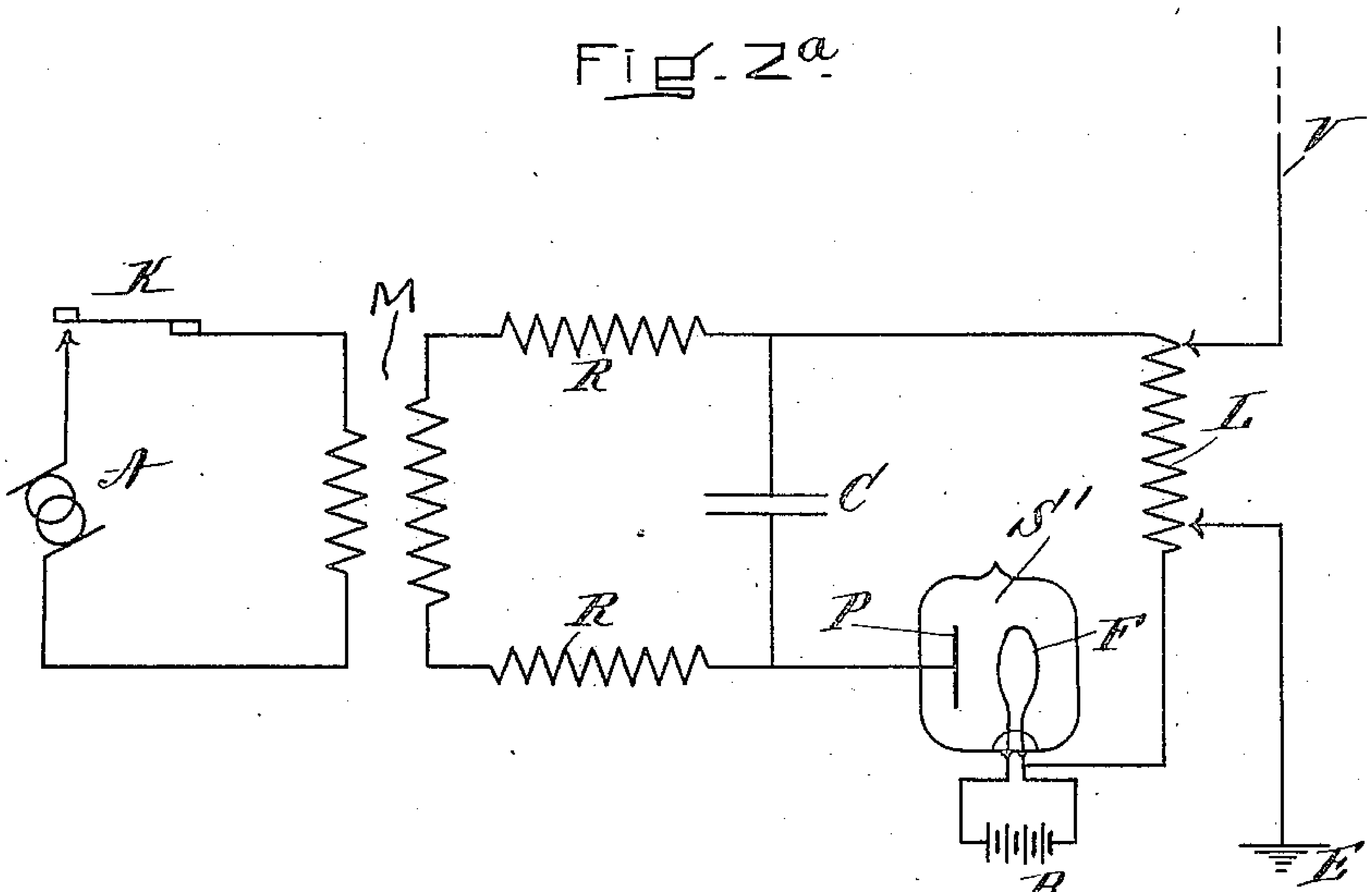

Fig. 3.

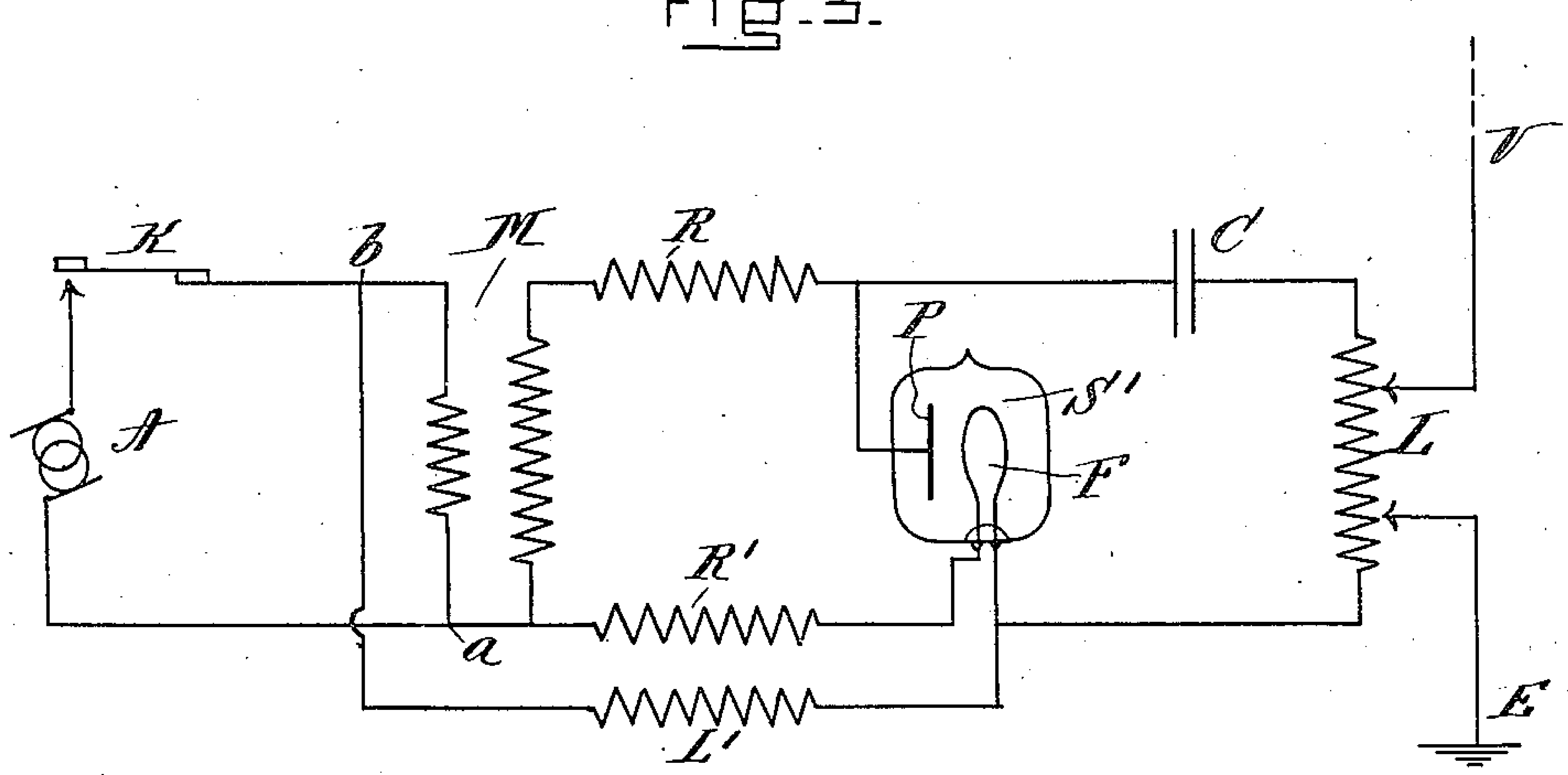

Fig. 4.

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3 SHEETS—SHEET 3.

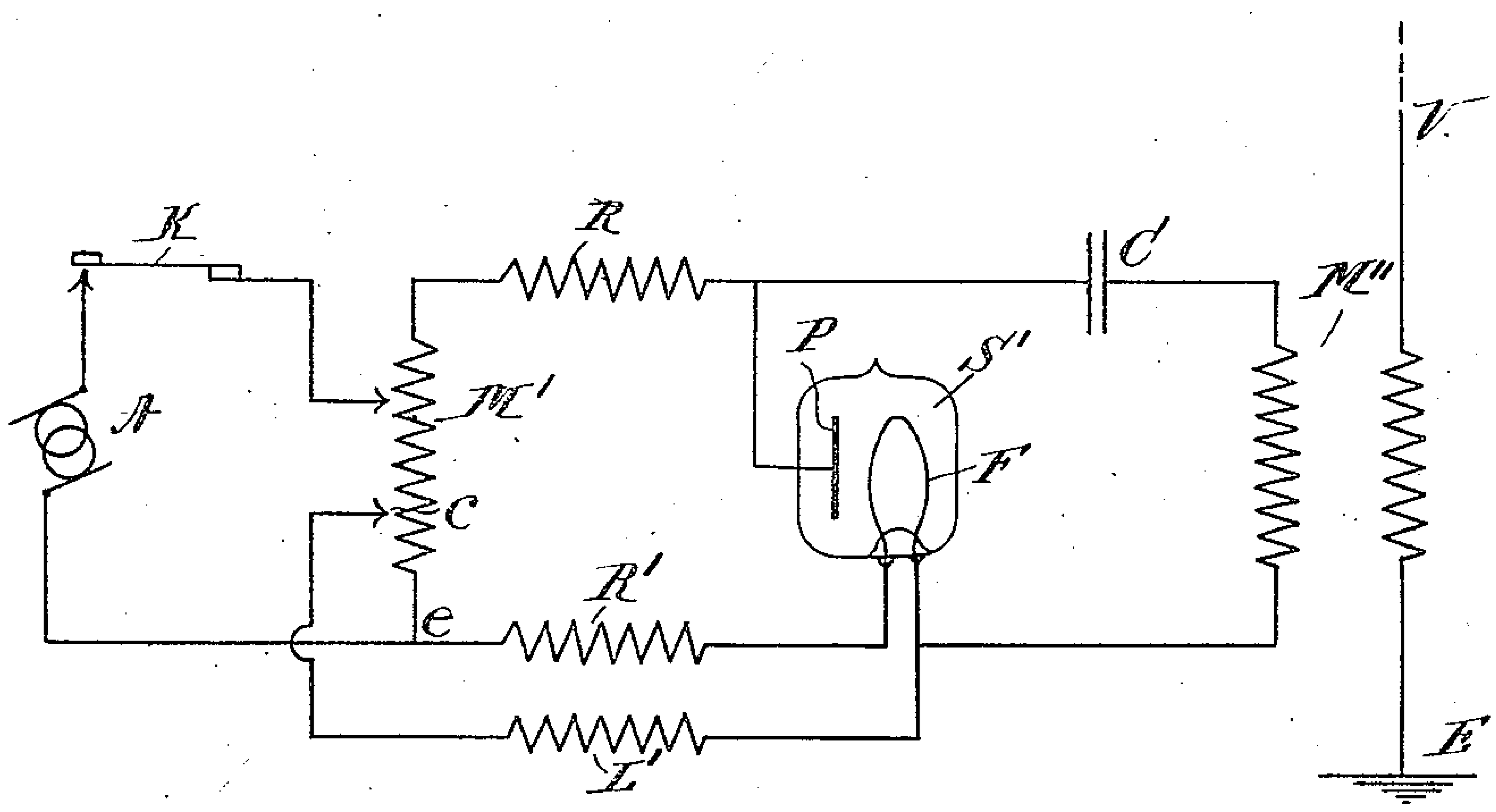

Fig. 5.

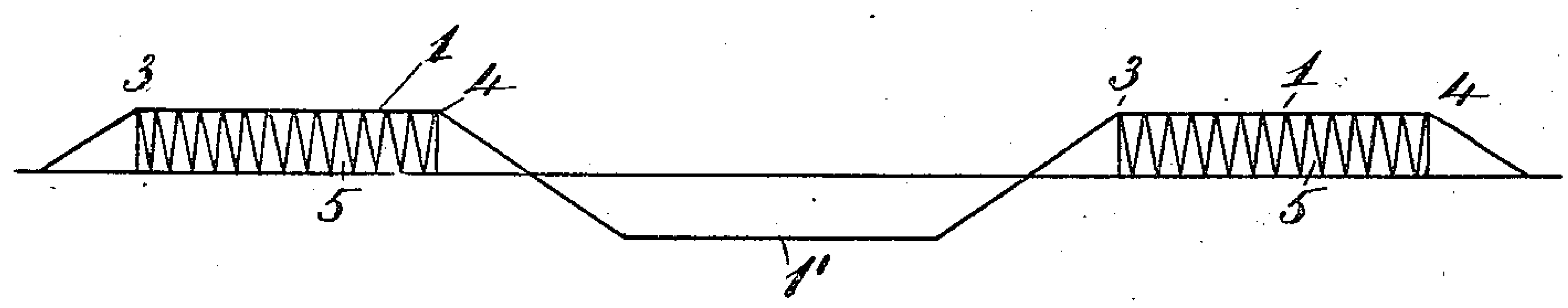

Fig. 5a

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UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW YORK, N. Y., ASSIGNOR, BY MESNE ASSIGNMENTS, TO DE FOREST RADIO TELEPHONE CO., A CORPORATION OF NEW YORK.

SPACE TELEGRAPHY.

979,276. Specification of Letters Patent. Patented Dec. 20, 1910.

Application filed January 29, 1907. Serial No. 354,664.

To all whom it may concern:

Be it known that I, Lee de Forest, a citizen of the United States, and a resident of New York, in the county of New York and State of New York, have invented a new and useful Improvement in Space Telegraphy, of which the following is a specification.

My invention relates to electromagnetic wave radiating systems,—space telegraph or telephone systems,—and its object is to provide a system by means of which electromagnetic waves which are of great persistency, although not continuous, may be radiated.

In the employment of the usual sonorous or oscillating circuit consisting of a condenser and an inductance, the latter being usually the primary of an oscillation transformer, together with a spark-gap for suddenly disturbing the electrical equilibrium of such circuit by discharging said condenser, there is a limit to which the persistence may be increased with a given frequency and a given amount of energy absorbed, for the energy absorbed by such sonorous circuit, on the one hand, and the persistence function and frequency, on the other hand, are respectively direct and reciprocal functions of the capacity thereof. It has been proposed therefore to employ continuously oscillating circuits consisting, *inter alia*, of the so called singing-arc circuit, or a circuit in the nature of a singing-arc circuit and consisting of an inductance and a capacity connected in series with a spark-gap and having a source of direct current connected through large ohmic resistance to the terminals of said gap. In a wireless telegraph system employing either of such continuously oscillating circuits to energize the transmitting antenna it is necessary to supply a device at the receiving station to commutate the energy in the local receiving circuit if a variable zero indicating device, such as a telephone receiver, is to be employed, such device being commonly known as a "ticker."

By means of the present invention I am able to obtain as great a persistency as is desirable while at the same time reducing the energy output required for the radiation of continuous electromagnetic waves and obviating the necessity for commutating or interrupting the current in the receiving circuit.

My invention may best be understood by having reference to the drawings which accompany and form a part of this specification and which represent in diagram several embodiments thereof.

In the drawings Figures 1, 2, 3, 4 and 5 represent space telegraph transmitting systems, and Figs. 1^a, 2^a, and 5^a show curves drawn to rectangular coördinates, in which the abscissæ represent time and the ordinates represent current amplitudes.

In the figures, C is a condenser, L L′ are inductances, R R′ are resistances which may or may not be inductive resistances, R′ is a resistance which preferably is inductive, M is a transformer, A is a source of vibratory electromotive force, K is a key, V is an elevated conductor and E is an earth connection.

In Figs. 1 and 2, S represent arc electrodes which may both be metal or both carbon, or one of which may be metal and the other carbon. The electromotive force impressed upon the arc electrodes preferably is such that the time rate of change of its amplitude is first abrupt, then slow or practically constant throughout the greater portion of the continuation of a half-cycle, and finally abrupt, as shown graphically in Fig. 1^a in which the curve (1) represents the variation with time of the amplitude of said electromotive force. Such electromotive force may be obtained by means of an alternating current generator giving what is commonly known as a flat-top electromotive force wave. I do not, however limit myself to an electromotive force having this particular time-amplitude variation. The resistances or, more generally, the impedances, R R need not be employed and if the electromotive force of the source A is of the order 1000 volts I may eliminate the transformer M, which otherwise preferably is of the step-up type.

The separation of the electrodes S preferably is such that the voltage across the gap will rise abruptly to its full value as indicated on curve (1) at 3, before the condenser C begins to discharge, and from this time until the time at which the voltage begins to fall as indicated on curve (1) at 4, an undamped train of oscillations, graphically shown at 2, will be developed in the circuit L C S. The energy of these oscillations may be translated to the antenna V in any suitable manner, such for example as indicated in Fig. 1, in which the antenna is adjustably connected to the inductance L.

The system shown in Fig. 2 is essentially the same as that above described in connection with Fig. 1 with the exception that a rectifier D may be connected in the system in any suitable manner so that the polarity of the potentials applied to the electrodes by the source A is never reversed, in which case, as indicated in Fig. 2^a, the second half cycle, graphically shown by curve (1′), is suppressed. In either case the time interval elapsing between points 3 and 4 will be a considerable fraction of a second, for example, one two-hundredth of a second, so that a very large number of practically undamped oscillations will take place in the circuit L C S between the time the applied pressure rises sufficiently to effect the first discharge and the time said pressure begins to fall. By way of example, if the time-period of the circuit L C S is one two-hundred-thousandth of a second, one thousand complete undamped oscillations will take place in said circuit during each half-cycle in the case above assumed. In such case, it will suffice to so proportion the tuned receiving circuit that its electromagnetic time-constant is one two-hundredth of a second to enable the currents developed therein to reach the steady state so that in said circuit the current amplitude will be equal to the ratio of the applied pressure by the ohmic resistance. Thus it will be seen that I gain by means of the present invention all the advantages of absolute continuity of oscillation while at the same time greatly reducing the output of energy required therefor. Furthermore vibratory currents of the required potential are easier to generate and control than the direct currents heretofore used for obtaining continuous electrical oscillations. It will be understood of course that as soon as that persistency is obtained which will permit the currents in the receiving circuit to reach their steady state, so that for oscillations of the frequency to which said circuit is attuned the current amplitude is equal to the electromotive force divided by the ohmic resistance of said circuit, any further increase in persistency represents a waste of energy without resulting advantages.

Another advantage of the present invention is that the telephone receiver in the receiving system which is associated in the usual way with an oscillation detector, will give forth sounds having a rate of variation equal to that of the current delivered by the source A, to the end that no local circuit interrupter will be required.

In the systems shown in Figs. 3, 4 and 5, the device indicated at S′ consists in an evacuated vessel inclosing a plate P and a filament F which may be heated to incandescence by the battery B, as in Fig. 3, or by current conducted thereto by leads from the points *a b* of the primary of the transformer M, as in Fig. 4, or by currents conducted thereto by leads from the points *c c* of the autotransformer M′, as in Fig. 5. It will be understood of course that the member F may be any heated or glowing body as, for example, a Nernst-lamp glower. The conductivity of the device S′ is unilateral, being from the nonheated member P to the heated member F, and the rectifying effect of S′ will be practically perfect within a certain high-voltage limit, beyond which limit a relatively small amount of current will flow from F to P. Although this limit may be reached and exceeded on account of the resonant rise of potential in the circuit L C S′, the efficiency of rectification will nevertheless be high.

In virtue of the rectifying effect of the device S′, the discharges of the condenser C in Figs. 3, 4 and 5, within the above mentioned high voltage limit, will be unidirectional and not oscillatory, and only during the half-cycles in which that armature of the condenser which is connected to the plate P is charged positively will there be any high frequency pulsations in the circuit L C S′, as indicated in Fig. 5^a. Thus if the generator A deliver an alternating current of 60 cycles per second, there will be sixty periods per second during which high frequency pulsations are being created in circuit L C S′ (or M″ C S′, Fig. 5) alternating with sixty periods of rest. In Fig. 5^a, curve (1), 3 and 4 have the same significance as in Figs. 1^a and 2^a, and 5 represents graphically the variation with time of the high frequency unidirectional pulsations above referred to, while curve (1′) represents one of the half cycles during which no pulsations are created.

Any suitable connection or coupling between the circuit of the condenser C and the antenna V may be employed. In Figs. 3 and 4 an autotransformer, and in Fig. 5 a transformer having two separated windings, are shown by way of example.

It will be apparent from the foregoing, that my invention includes the use of a vibratory electromotive force with either of the two types of continuously-oscillating circuits above referred to.

I claim:

1. In an electromagnetic wave radiating system, a circuit including in series an inductance, a condenser and two separated arc-electrodes, an antenna associated with said circuit, and a generator of vibratory electromotive force operatively connected with said arc-electrodes, the separation of said arc-electrodes being such that the voltage across the gap will rise abruptly to its

maximum before the condenser begins to discharge thereacross.

2. In an electromagnetic wave radiating system, a circuit including in series an inductance, a condenser and two separated arc-electrodes, an antenna associated with said circuit and a generator of vibratory electromotive force, operatively connected with said arc electrodes, and so arranged that the variation of current amplitude with time is practically zero throughout the greater portion of the continuance of a half-cycle.

3. In an electromagnetic wave radiating system, a circuit including in series an inductance, a condenser and two separated arc-electrodes, an antenna associated with said circuit, a source of vibratory electromotive force and connections having large impedance between said source of electromotive force and said arc-electrodes, the separation of said arc-electrodes being such that the voltage across the gap will rise abruptly to its maximum before the condenser begins to discharge thereacross, at each half cycle of operation.

4. A circuit including in series an inductance, a condenser and two separated arc-electrodes, in combination with a generator of vibratory electromotive force operatively connected with said arc-electrodes, the separation of said arc-electrodes being such that the current amplitude across the gap rises abruptly to its full maximum before the condenser begins its discharge.

5. A circuit including in series an inductance, a condenser and two separated arc-electrodes in combination with a generator of vibratory electromotive force, whereof the variation of amplitude with time is practically zero throughout the greater portion of the continuance of a half cycle, operatively connected with said arc-electrodes.

6. A circuit including in series an inductance, a condenser and two separated arc-electrodes in combination with a source of vibratory electromotive force and connections having large impedance between said source of electromotive force and said arc-electrodes, the separation of said arc-electrodes being so related to the amplitude of said electromotive force as to cause an electrical arc to be developed therebetween.

In testimony whereof, I have hereunto subscribed my name this 27th day of Dec. 1906.

LEE DE FOREST.

Witnesses:
THOMAS I. GALLAGHER,
GEO. K. WOODWORTH.