No. 706,738. Patented Aug. 12, 1902.

R. A. FESSENDEN.

WIRELESS TELEGRAPHY.

(Application filed May 29, 1901.)

(No Model.)

FIG. 1.

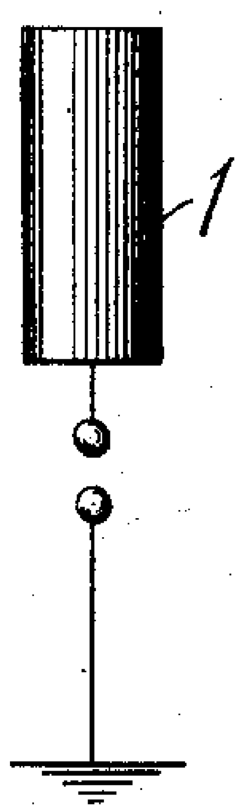


FIG. 2.

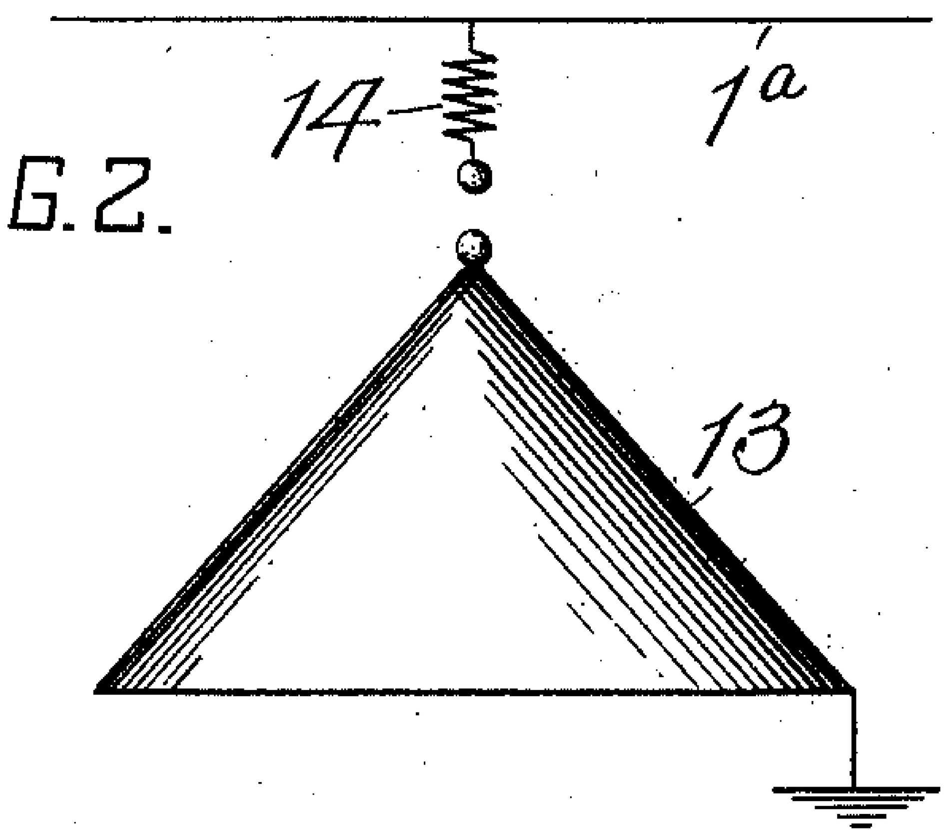


FIG. 3.

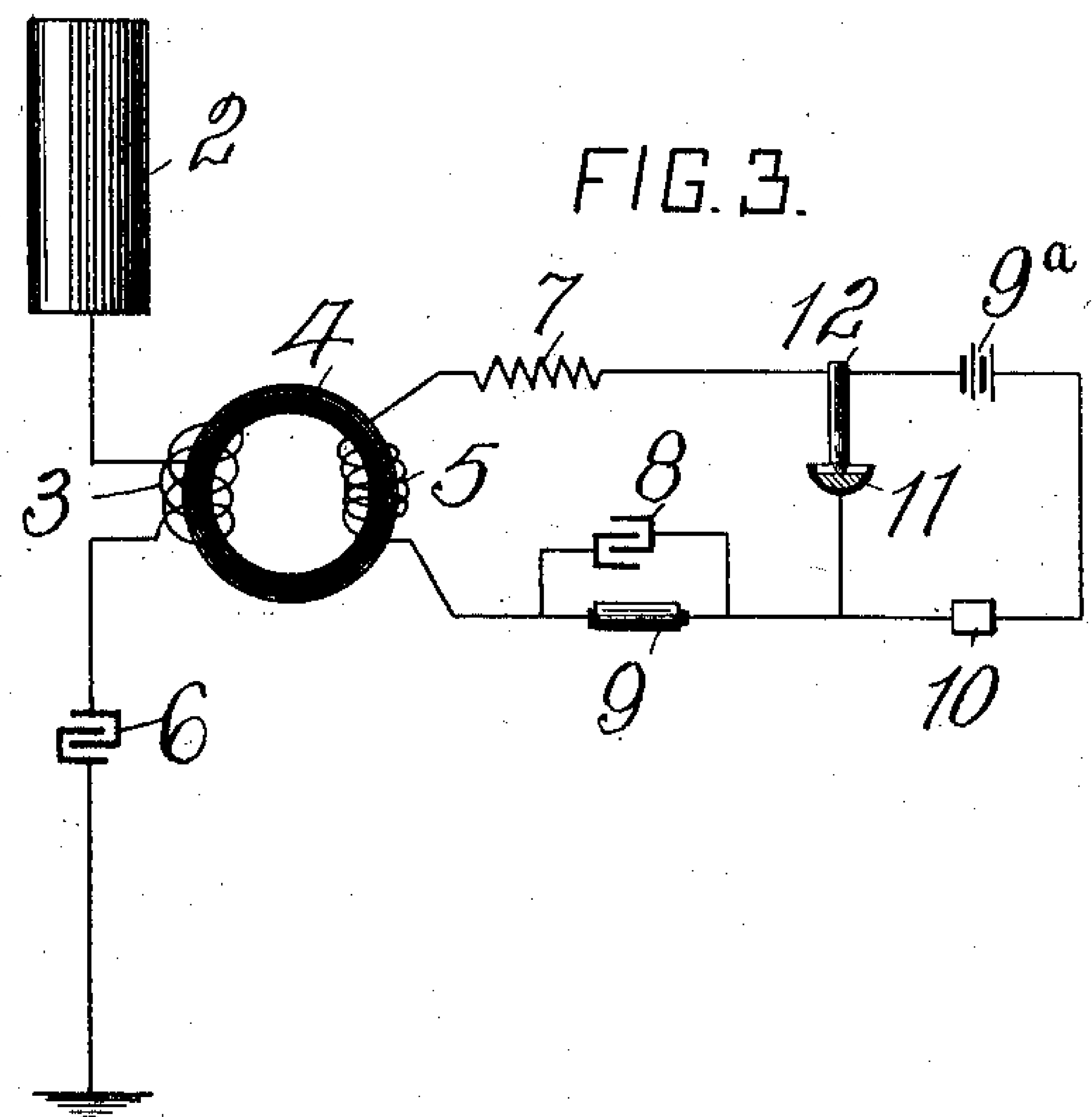


FIG. 4.

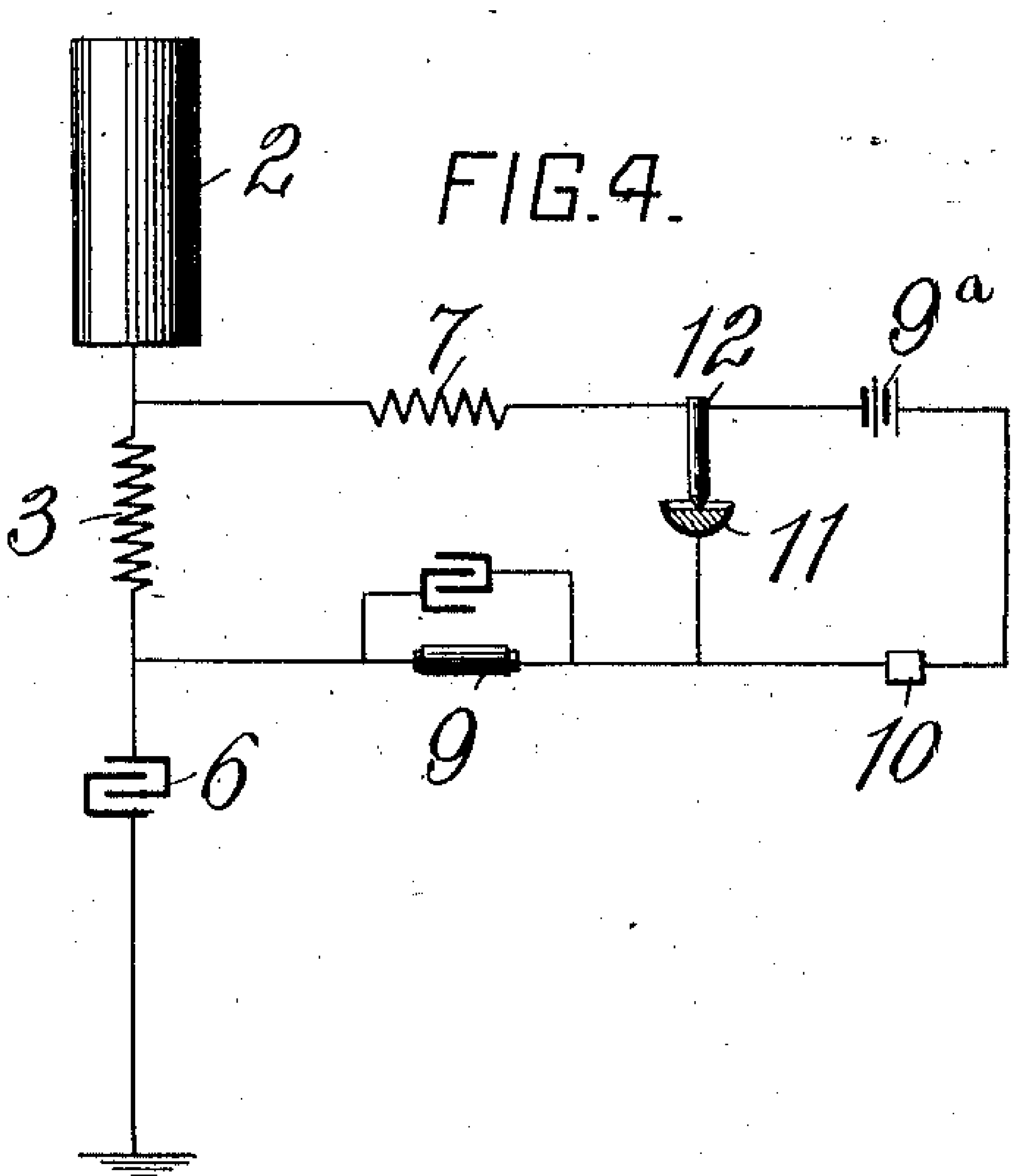
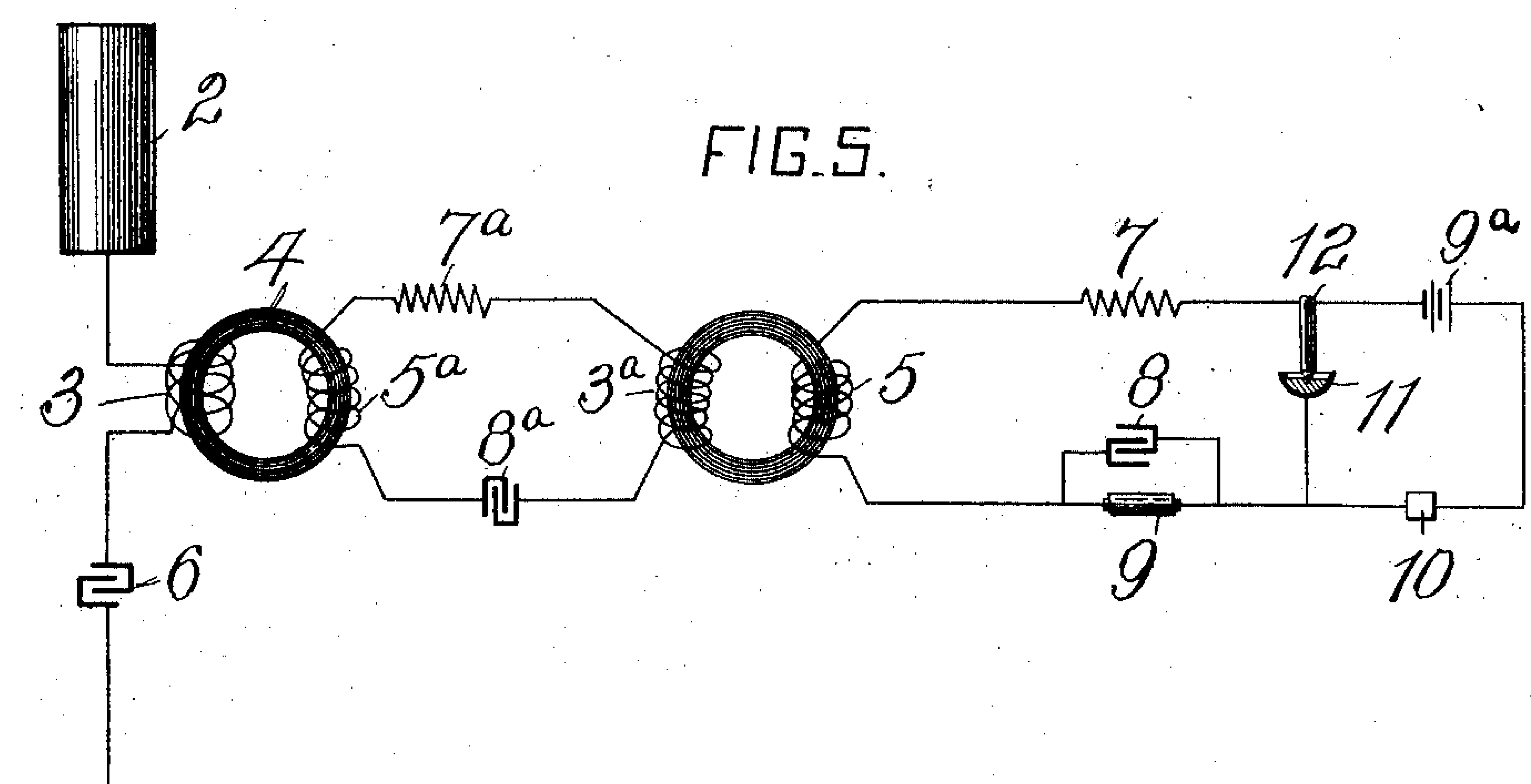


FIG. 5.



WITNESSES:

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UNITED STATES PATENT OFFICE.

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WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 706,738, dated August 12, 1902.

Application filed May 29, 1901. Serial No. 62,302. (No model.)

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Allegheny, in the county of Allegheny and State of Pennsylvania, have invented or discovered certain new and useful Improvements in Wireless Telegraphy, of which improvements the following is a specification.

The invention described herein relates to certain improvements in apparatus for wireless telegraphy, and has as its object the provision of suitable means whereby a transformer or other inductive means may be employed for raising the voltage at the receiving-station.

It is also an object of the invention to increase the number of oscillations in the conductor during its discharging period, so that only a small fraction of the energy will be discharged or radiated at each oscillation.

It is a further object of the invention to provide for selective signaling by so tuning the receiving apparatus that it will respond solely to waves of one periodicity.

The invention is hereinafter more fully described and claimed.

In the accompanying drawings, forming a part of this specification, Figures 1 and 2 illustrate diagrammatically forms of conductors for sending-stations. Fig. 3 illustrates diagrammatically the apparatus for the receiving-station, and Figs. 4 and 5 are similar views of modifications of the receiving apparatus.

The addition of capacity to sending-conductors where signals are to be sent long distances has heretofore been considered useless. While this is true when a coherer or other closer for a secondary circuit is used alone, I have found that by the employment at the receiving-station of inductive means as a transformer for raising the voltage in the secondary circuit the addition of capacity to the sending-conductor has a decidedly beneficial effect. At the sending-station I employ a sending-conductor 1—such, for example, as that shown and described in application No. 62,301, filed July 2, 1901—having a large capacity relative to that of a wire of the same height and of low self-inductance and resistance. At the receiving-station the receiving-conductor 2 may be similar to that at the sending-station or of any other suitable form or construction. By the terms "sending-conductor" and "receiving-conductor" as herein used I include all of the circuit from the top to ground, if grounded, or, if not grounded, from one extreme end to the other extreme end of the circuit, including all apparatus in series with the circuits, while under the term "radiating portion" is included all of sending-conductor from top or extreme end of same to point of junction with apparatus for effecting the oscillatory charging and discharging thereof, such as sparking terminals, transformer-coils, armature-windings, &c. The terms "tuned" and "resonant" are used herein one to include the other. This receiving-conductor, which is connected to ground, includes as a part thereof a transformer, as the inductance or coil 3, forming the primary of an induction-coil, the core 4 of which is preferably formed of fine wire. The secondary coil 5 of the transformer forms a part of another or secondary circuit, which circuit, as well as the prime receiving-circuit, consisting of the conductor 2, inductance 3, and capacity 6, (when used,) is so proportioned that its natural period of electric oscillation is identical with that of the sending system. The tuning of the secondary circuit is effected by means of an inductance 7 and a capacity 8, included in said circuit, as shown in Fig. 3. The inductance 7 employed in tuning the secondary circuit may be combined with and form a part of the secondary coil 5. When a coherer 9 or similar instrument is used as a receiver, the capacity 8 should be placed (if used) in shunt to the coherer, because thus advantage is taken of the resonant rise of potential in a shunt-path between the lump inductance and capacity of a resonant circuit. The secondary circuit also includes a battery 9^a and a relay 10 or other translating device. In order to prevent the local battery from operating the relay except when the coherer has been rendered conductive, an opposing source of voltage, preferably an electrolytic cell, is bridged across the secondary circuit. This cell preferably consists of a cup 11, formed of zinc and containing caustic potash, and a copper wire or rod 12, having a fine point and capable of being moved up and down in the solution, so as to vary the back electromotive force of the cell, because if the surface exposed to the liquid is large the quantity of electricity passing through the cell would not be sufficient to polarize to so great an extent as if the surface were smaller. It is of course recognized that where the quantity is not limited the back voltage of polarization always reaches a fixed limit; but in the present case the quantity passing each way is limited and the effect is reversed each half-period and is not cumulative. This cell is so connected as to present a counter electromotive force to the local battery when the coherer is inoperative, but to permit the alternating current flowing through it, and so render the coherer operative.

As shown in Fig. 4, the secondary circuit may form a shunt around the inductance 3, and, as shown in Fig. 5, three or more tuned circuits may be used at the receiving-station, with the result of affording an additional safeguard as against any accidental operation of the receiving apparatus. When using three or more tuned circuits, the prime circuit and the last circuit of the series are arranged as before described, and the intermediate circuit or circuits includes the secondary coil whose primary forms the inductance 3 of the conductor and the primary coil 3^a of an induction-coil whose secondary is included in the next circuit of the series. Each circuit includes a capacity and an inductance, whereby it may be properly tuned.

It will be noticed that the current 7^a 3^a 8^a 5^a in Fig. 5 forms a closed tuned secondary circuit.

The employment of simple wires having small capacity as the radiating portions of sending-conductors is objectionable, for the reason that the radiation is so rapid that there are very few oscillations in each discharge, and hence the inductive rise in voltage at the receiving-station cannot attain sufficient value to permit of the use of inductive devices for raising the potential at such station. By the employment of sending-conductors having radiating portions of large capacity at the sending-station and by properly proportioning the self-inductance and resistance the radiation from the sending-conductor can be so controlled that there will be a large number of oscillations—*e. g.*, fifty or more for each total discharge. In other words, the total discharge is so controlled that only a small fraction of the total energy is radiated at each oscillation. By thus extending the period of radiation opportunity is afforded for the inductive voltage at the receiving end to rise to its full value. By increasing the number of oscillations for each total discharge from the sending-conductor and by adjusting the receiving system so that its natural period corresponds, or approximately so, to the period of the electromagnetic waves the distance of travel of the waves is not dependent upon the heights of the sending and receiving conductors, as has heretofore been held. When low frequency is obtained by increasing the capacity alone or by increasing both capacity and self-induction, the curve of resonance is broader than is obtained by increasing the self-induction alone, though in the former cases the amount of energy radiated for a given voltage and length of conductor is more than is obtainable with a sharp resonance-curve. On account of this fact—*i. e.*, that it is preferable to use sending-conductors having large capacity or large capacity and self-induction and that in these cases the curve of resonance is broadened—it has heretofore been impossible to make the receivers respond solely to waves of one periodicity, as other periodicities, if above a certain power, will affect the receivers. By constructing the sending-conductor so the oscillations for each total discharge are increased and by employing at the receiving-station two or more tuned circuits a very perfect resonance or tuning between the stations can be attained. With one tuned circuit at the receiving-station and with sending-conductors permitting a rapid radiation at the sending-station electrostatic and hysteresis effects become very prominent, and the great self-inductance desirable for sharp resonance cannot be attained. By employing at the receiving end two tuned circuits, the first consisting of the receiving-conductor and the other secondary to the first, the relative inductance may be greater in the secondary than in the primary circuit of the receiving-conductor or the sending-conductor, in which latter, as before explained, the capacity is preferably a dominant factor of tuning, and the electrical effect in the secondary will occur only when the periods are very closely the same.

In view of the fact that the terms "tuning," "syntony," and "resonance" may be used synonymously in some cases and in others to cover a more or less perfect sympathetic response between fundamentals and their harmonics it is particularly pointed out that all circuits intended to be "tuned" or responsive to a particular frequency should be tuned to that frequency as a fundamental, the quantity $\sqrt{LC}$ being equal in the two circuits said to be tuned, and, as was early pointed out, a receiver-circuit is preferably always identical with any corresponding transmitting-circuit—that is to say, not only is the quantity $\sqrt{LC}$ of the one equal to the quantity $\sqrt{LC}$ of the other, but the quantity L of the one equals L of the other, as the quantity C of the one equals the quantity C of the other. This latter is not true of the secondary circuits shown in Figs. 3 and 5 of the present application, wherein the inductance preponderates in the secondary, while capacity preponderates in the primary. It is true, however, that these circuits are preferably tuned to the same fundamental, the quantity $\sqrt{LC}$ being the same in both cases. An additional advantage peculiar to this construction is that it permits high ratios of transformation to be obtained, for since the length of the secondary should not be greater than the length of the receiving-conductor and a considerable length of wire—say twenty (20) or thirty (30) feet—should preferably be used in the primary in order to obtain sufficient magnetizing effect, as is well known in the art, a ratio of transformation approximately greater than one to five cannot be obtained with a single tuned secondary; but by employing several transformers in series it is evident the stepping-up process will be repeated a number of times, and the ratio between the final and primary voltages may be made large.

In lieu of the cylindrical form of conductor, as shown in Fig 1, a horizontal conductor 1^a, as shown in Fig. 2, having a large radiating area—*i. e.*, a large capacity—may be employed. This horizontal conductor may be formed by a group or network of wires or a sheet of metal. It is preferred to employ in connection with the horizontal conductor a metal cone 13, which serves to deflect the radiated waves and direct them along the surface of the earth. If desired, a self-inductance 14 may be placed in the circuit of the conductor 1^a. This conductor is preferably so constructed that its capacity is relatively much larger than that of a wire of equal length and extending vertically from a point in the plane of the conductor to the ground.

I claim herein as my invention—

1. In a system of signaling by electromagnetic waves, a receiving-conductor having a transforming device in series in the circuit, in combination with a circuit including a translating device and having a local source of voltage and controlled by the transforming device and a source of voltage so arranged that its voltage will oppose the voltage from the local source operating the translating device, substantially as set forth.

2. In a system of signaling by electromagnetic waves, a receiving-conductor having a transforming device in series in the circuit, in combination with a circuit including a translating device and having a local source of voltage and controlled by the transforming device and an electrolytic cell so arranged that its voltage will oppose the voltage from the local source operating the translating device, substantially as set forth.

3. In a system of signaling by electromagnetic waves, a sending-conductor adapted to maintain and to radiate persistent oscillations, in combination with a receiving-conductor and one or more secondary circuits controlled by the receiving-conductor, a wave-responsive device included in a secondary circuit of the series, the several circuits being each tuned to correspond to the period of the sending-conductor, substantially as set forth.

4. In a system of signaling by electromagnetic waves, a sending-conductor adapted to radiate electromagnetic waves having its electrical constants so proportioned that only a relatively small fraction of the energy of the charged conductor is radiated during a single oscillation, in combination with a prime conductor including the receiving-conductor, one or more secondary circuits controlled by the prime conductor and a wave-responsive device included in the last circuit of the series, the several circuits being each tuned to correspond to the period of the sending-conductor, substantially as set forth.

5. In a system of signaling by electromagnetic waves, a sending-conductor adapted to maintain and to radiate persistent oscillations, in combination with a receiving-conductor and one or more secondary circuits controlled by the receiving-conductor, the ratio of inductance to capacity being larger in a secondary circuit than in the sending-conductor, a wave-responsive device included in a secondary circuit of a series, the several circuits being each tuned to correspond to the period of the sending-conductor, substantially as set forth.

6. In a system of signaling by electromagnetic waves, a sending-conductor adapted to maintain and to radiate persistent oscillations in combination with receiving-conductor and one or more secondary circuits controlled by the receiving-conductor, the inductance of the secondary circuit being greater than that of the primary circuit, a wave-responsive device included in the secondary circuit of the series, the several circuits being each tuned to correspond to the period of the sending-conductor, substantially as set forth.

In testimony whereof I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:
W. B. FEARING,
S. C. GRAY.