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R. A. FESSENDEN.

SIGNALING BY ELECTROMAGNETIC WAVES.

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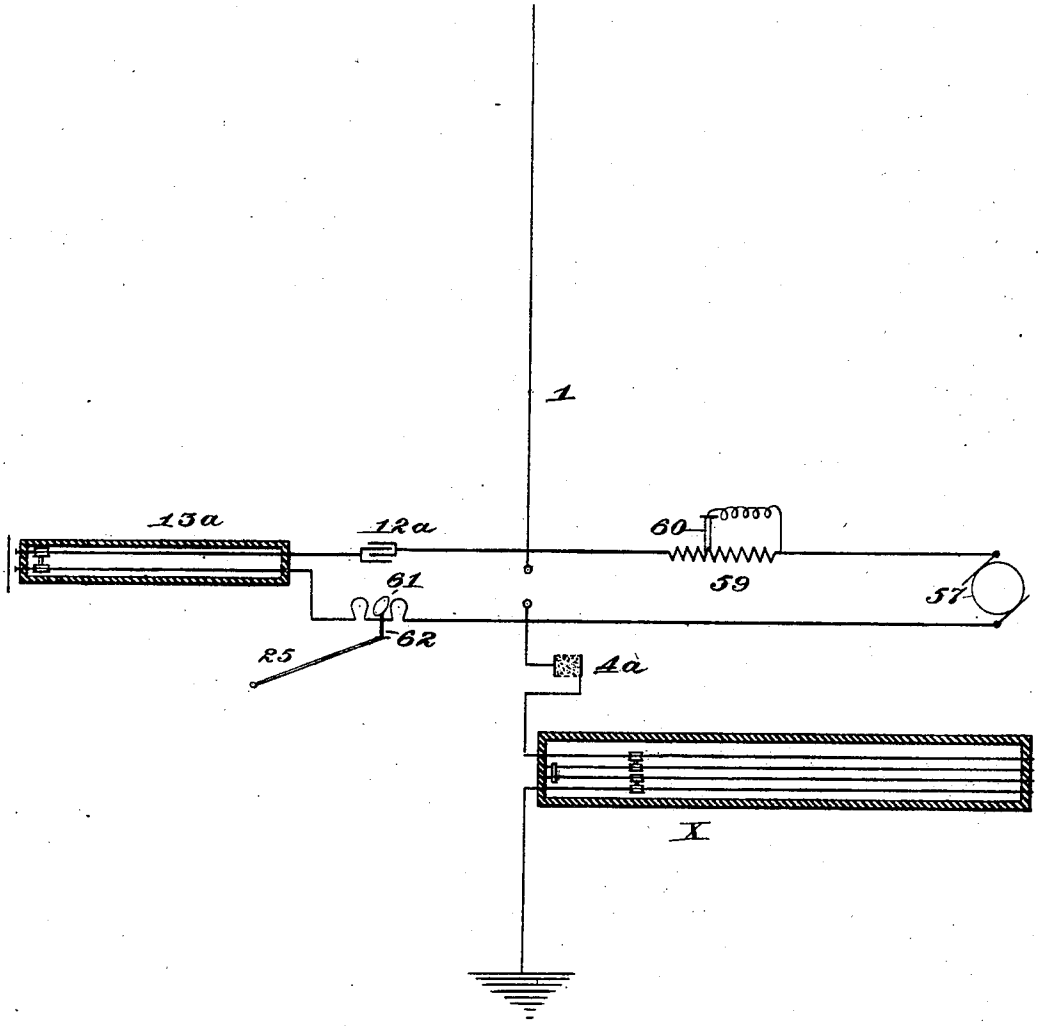
NO MODEL.



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UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF PITTSBURG, PENNSYLVANIA.

SIGNALING BY ELECTROMAGNETIC WAVES.

SPECIFICATION forming part of Letters Patent No. 730,753, dated June 9, 1903.

Application filed April 9, 1903. Serial No. 151,868. (No model.)

To all whom it may concern:

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

The invention herein described relates to certain improvements in the transmission of energy by electromagnetic waves.

It relates more particularly to the transmission of signals by electromagnetic waves, either telegraphic or telephonic.

It relates more particularly still to improvements in the methods and apparatus described in United States Patents Nos. 706,735, 706,736, 706,737, 706,747, and 727,325.

Heretofore in the practice of the art of wireless telegraphy when a continuous current has been employed as a means of producing electromagnetic radiation it has been used to excite an induction-coil and a mechanical break or its substantial equivalent, a Wenheldt interrupter, has been employed. This method is disadvantageous for the reason that any desired number of discharges per second cannot be obtained for mechanical and other reasons, and in addition in the case of the Wenheldt break the action is not uniform. For these reasons it has been difficult to obtain a substantially continuous stream of electromagnetic radiation, such as is adapted to be used with a cumulatively-acting receiver or with a telephonic transmitter—as, for example, those shown in Figure 10, United States Patent No. 706,742. In addition the lack of ability to produce any desired number of discharges per second has rendered it difficult to carry out the method of group tuning described in United States Patents Nos. 706,742 and 727,325—*i. e.*, sending out groups of waves of predetermined group frequency and operating thereby a receiver tuned mechanically or electrically to the group frequency.

By means of the apparatus herein described I am enabled to obtain from a continuous-current source any desired number of discharges per second across a discharge-gap used in the production of electromagnetic waves.

In the accompanying drawing, forming a part of this specification, the figure is a diagrammatic view illustrating the invention.

In the drawing, 1 is the sending-conductor, shown connected to ground.

2 is the discharge-gap.

12^a is a capacity.

13^a is a self-inductance, preferably variable.

57 is a continuous-current dynamo.

In the particular arrangement herein shown and described the continuous-current source should be one of constant voltage. When using such form of generator, a high resistance 59, preferably having a low inductance, is in series in the sending-circuit. Any suitable means, as a plug 60, for shunting a part of the resistance is preferably employed for cutting out more or less of the resistance. In operation the dynamo charges the condenser 12^a in the circuit 12^a 13^a, and when the potential has risen sufficiently a discharge across the spark-gap will occur, discharging the condenser and setting up oscillations in the sending-conductor. On account of the high resistance 59 some time is required to recharge the condenser to sparking potential. Hence the discharge is intermittent and may be made to occur as many times per second as desired by plugging out more or less of the resistance, and so to give any desired number of discharges per second.

Though I have herein described more particularly my invention in connection with a continuous-current source having constant voltage, I do not, however, limit myself to the use of a constant-voltage source of continuous current, because I believe myself to have been the first to use continuous currents directly for the production of electromagnetic radiation, and more particularly for electromagnetic wave-signaling, without the necessary use of an induction-coil or induction-coil break.

It is characteristic of my invention that on account of the fact that no break is used there is no necessary appreciable interval of time between the acts of charging and of discharging, as is the case when an induction coil or break is used.

Though a constant-voltage source of continuous current is herein more particularly described and shown, a constant-current

source of continuous current may be used if certain improvements and modifications are made to adapt it for purposes of wireless telegraphy. These necessary improvements and modifications are not, however, shown or claimed here.

I am aware that a source of continuous current has been used previously without a mechanical break to generate electromagnetic waves. I refer to the use of the Wenheldt break. This apparatus, however, was employed so as to perform exactly the same function as the ordinary mechanical break, was placed in the same position—*i. e.*, in the primary circuit of the induction-coil—and operated to break or open the primary circuit of the induction-coil in the same manner as the mechanical break. Its use therefore consisted in substituting one form of induction-coil break for another form without altering their functions, both forms of break interrupting the circuit of the source of voltage. This use therefore differs entirely in principle from the method contemplated by me, for though the Wenheldt break may be used by virtue of the fact that it is capable of functioning as a discharge-gap its use as a break for an induction-coil is not within the limits of my invention.

I am also aware that highly oscillatory currents have been obtained from a direct-current source by Elihu Thomson, United States Patent No. 500,630. The apparatus and method therein described differs, however, essentially from that shown herein by me, and it has not, so far as I am aware, been used for wireless-telegraphic purposes, nor could it be so used without certain important additions, improvements, and modifications. It differs in the fact that in the patent above referred to the high-frequency oscillations are obtained by using a circuit in which the current is maintained constant, the method in which this constant current is obtained not being essential so long as it is constant, and this constant current is swung from side to side, so that a portion of it passes alternately through the circuit in which the oscillations are produced and across a discharge-gap. In the method herein more particularly described, though I do not limit myself to this particular method, the source of voltage is maintained constant and the current is arranged so that it is not constant, but fluctuates. Again, in the Thomson method above referred to the amount of current which oscillates from side to side—*i. e.*, from the discharge-gap to the oscillating circuit and back again—is that required to charge the oscillating circuit. This amount will vary with the potential across the oscillating circuit, and this again will vary with the value of the mean resistance of the spark-gap. Consequently if this mean resistance varies—for example, on account of the terminals becoming heated—the periodicity of the oscillating discharge will vary. On the other hand, in my method herein described the periodicity is independent of the mean value of the resistance of the discharge-gap and depends upon the discharge voltage. Again, in the Thomson method described above, since the voltage which operates across the oscillating circuit is not the direct voltage of the direct-current generator, but the inductive voltage due to the large self-induction used, it is difficult to make and break the circuit after the manner commonly used in wireless telegraphy, and in the patent referred to the terminals are approached and then separated when it is desired to excite the oscillations. This method would be impracticable for ordinary telegraphic work without further modification. In the method herein claimed the terminals are always at the same distance apart. Again, in the Thomson patent referred to the oscillation frequency is necessarily identical with the discharge frequency, and this is not always advisable for wireless telegraphy, where it is sometimes advisable to have a group frequency in addition to a wave frequency. Lastly, in the device shown in the Thomson patent above referred to there is no means shown for effecting the radiation of electrical waves, and though systems of wireless telegraphy have been publicly experimented with for seven or eight years the device above referred to has not been applied to this purpose, from which it is believed that experimenters who may have tried this method have found that though admirably adapted for operating the devices in connection with which it is shown it was yet not obvious or true that it furnished a suitable means for generating electromagnetic waves or could be used for telegraphic purposes.

It is characteristic of the particular form herein shown that when the discharge-gap circuits—that is, the circuits of which the discharge-gap forms a portion—are discharged that the points between which the maximum difference of potential exists are shifted. For example, before the discharge the maximum potential is across the discharge-gap, while toward the close of the discharge the maximum difference of potential is across the resistance 59.

What I claim is—

1. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for charging the conductor without interrupting the source of voltage.

2. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for charging the conductor without interrupting the source of voltage.

3. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for charging and discharging the conductor without disconnecting the source of voltage.

4. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for charging and discharging the conductor without disconnecting the source of voltage.

5. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for charging and discharging the conductor without changing the electrical connection of the circuits.

6. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for charging and discharging the conductor without changing the electrical connection of the circuits.

7. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for charging the conductor after discharging without interrupting the source of voltage.

8. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for charging the conductor after discharging without interrupting the source of voltage.

9. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for charging the conductor after each discharge without interrupting the source of voltage.

10. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for charging the conductor after each discharge without interrupting the source of voltage.

11. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and electrical means for charging and discharging the conductor.

12. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and electrical means for charging and discharging the conductor.

13. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current, electrical means for charging and discharging the conductor at a rate determined by the electrical constants of the circuits.

14. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage, electrical means for charging and discharging the conductor at a rate determined by the electrical constants of the circuits.

15. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and electrical means for controlling the periodicity of charging of the radiating-conductor.

16. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage, and electrical means for controlling the periodicity of charging of the radiating-conductor.

17. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current, a discharge-gap, and means for electrically shifting the position of maximum difference of potential in the circuit.

18. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage, a discharge-gap, and means for electrically shifting the position of maximum difference of potential in the circuit.

19. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current and means for electrically shifting the position of maximum difference of potential in the circuit.

20. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage and means for electrically shifting the position of maximum difference of potential in the circuit.

21. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a source of continuous current, and means for charging and discharging the discharge-gap circuit without an appreciable time interval between charging and discharging.

22. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a source of practically-constant voltage, and means for charging and discharging the discharge-gap circuit without an appreciable time interval between charging and discharging.

23. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a constantly-responsive receiver a source of continuous current, and means for charging and discharging the discharge-gap circuit without an appreciable time interval between the charging and discharging.

24. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a constantly-responsive receiver a source of practically-constant voltage, and means for charging and discharging the discharge-gap circuit without an appreciable time interval between the charging and discharging.

25. In a system of signaling by electromag-

netic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a source of continuous current, a current-operated receiver and means for charging and discharging the discharge-gap circuit without an appreciable time interval between the charging and discharging.

26. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a source of practically-constant voltage, a current-operated receiver and means for charging and discharging the discharge-gap circuit without an appreciable time interval between the charging and discharging.

27. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a cumulative receiver, a source of continuous current and means for charging and discharging the discharge-gap circuit without an appreciable time interval between the charging and discharging.

28. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor operatively connected to a discharge-gap, a cumulative receiver, a source of practically-constant voltage and means for charging and discharging the discharge-gap circuit without appreciable time interval between the charging and discharging.

29. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of continuous current, a tuned circuit at the receiving end and means for charging and discharging the radiating-conductor without disconnecting the source of voltage.

30. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a source of practically-constant voltage, a tuned circuit at the receiving end and means for charging and discharging the radiating-conductor without disconnecting the source of voltage.

31. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a spark-gap, a capacity and a source of continuous current with a high resistance, whereby an intermittent discharge across the spark-gap having a practically-constant periodicity may be produced, substantially as set forth.

32. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a spark-gap, a capacity and a source of practically-constant voltage, with a high resistance, whereby an intermittent discharge across the spark-gap having a practically-definite periodicity may be produced, substantially as set forth.

33. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a spark-gap, one terminal of the spark-gap being connected to ground, a capacity and a source of practically-constant voltage with a high resistance, whereby an intermittent discharge across the spark-gap having a practically-constant periodicity may be produced, substantially as set forth.

34. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of continuous current connected thereto and means for causing the discharge across the discharge-gap to have a practically-constant periodicity, substantially as set forth.

35. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto and means for causing the discharge across the discharge-gap to have a practically-constant periodicity, substantially as set forth.

36. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor having one terminal connected to ground, a normally insulating discharge-gap, a source of continuous current connected thereto and means for causing the number of discharges across the discharge-gap to be practically constant, substantially as set forth.

37. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor having one terminal connected to ground, a normally insulating discharge-gap, a source of voltage connected thereto and means for causing the number of discharges across the discharge-gap to be practically constant, substantially as set forth.

38. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of continuous current connected thereto and means for causing any desired number of discharges per second across the discharge-gap, substantially as set forth.

39. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto and means for causing any desired number of discharges per second across the discharge-gap, substantially as set forth.

40. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of continuous current connected thereto, a local auxiliary circuit and means for causing the number of discharges per second across the discharge-gap to be practically constant, substantially as set forth.

41. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto, a local auxiliary circuit and means for causing the number of discharges per second across the discharge-gap

to be practically constant, substantially as set forth.

42. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap having one terminal connected to ground, a source of continuous current connected thereto and means for causing any desired number of discharges per second across the discharge-gap, substantially as set forth.

43. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap having one terminal connected to ground, a source of practically-constant voltage connected thereto and means for causing any desired number of discharges per second across the discharge-gap, substantially as set forth.

44. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of continuous current connected thereto, a capacity and means whereby any desired number of discharges per second across the discharge-gap may be produced, substantially as set forth.

45. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto, a capacity and means whereby any desired number of discharges per second across the discharge-gap may be produced, substantially as set forth.

46. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor having one terminal grounded, a normally insulating discharge-gap, a source of continuous current connected thereto, a capacity and means whereby any desired number of discharges per second across the discharge-gap may be produced, substantially as set forth.

47. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor having one terminal grounded, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto, a capacity and means whereby any desired number of discharges per second across the discharge-gap may be produced, substantially as set forth.

48. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto, a capacity and a high resistance, whereby intermittent discharges across the discharge-gap may be produced, the number of discharges per second across the discharge-gap being practically constant, substantially as set forth.

49. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating-gap, a capacity and a source of continuous current, and means for regulating the time of charging of the capacity whereby intermittent discharges across the gap may be produced, substantially as set forth.

50. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating-gap, a capacity and a source of practically-constant voltage, and means for regulating the time of charging of the capacity whereby intermittent discharges across the gap may be produced, substantially as set forth.

51. In a system of signaling by electromagnetic waves, the combination of a radiating-conductor, a normally insulating discharge-gap, a source of practically-constant voltage connected thereto, a capacity and a high resistance, whereby intermittent discharges across the discharge-gap may be produced, the number of discharges per second across the discharge-gap being practically constant, substantially as set forth.

In testimony whereof I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

T. L. SCLATER,

JESSIE E. BENT.