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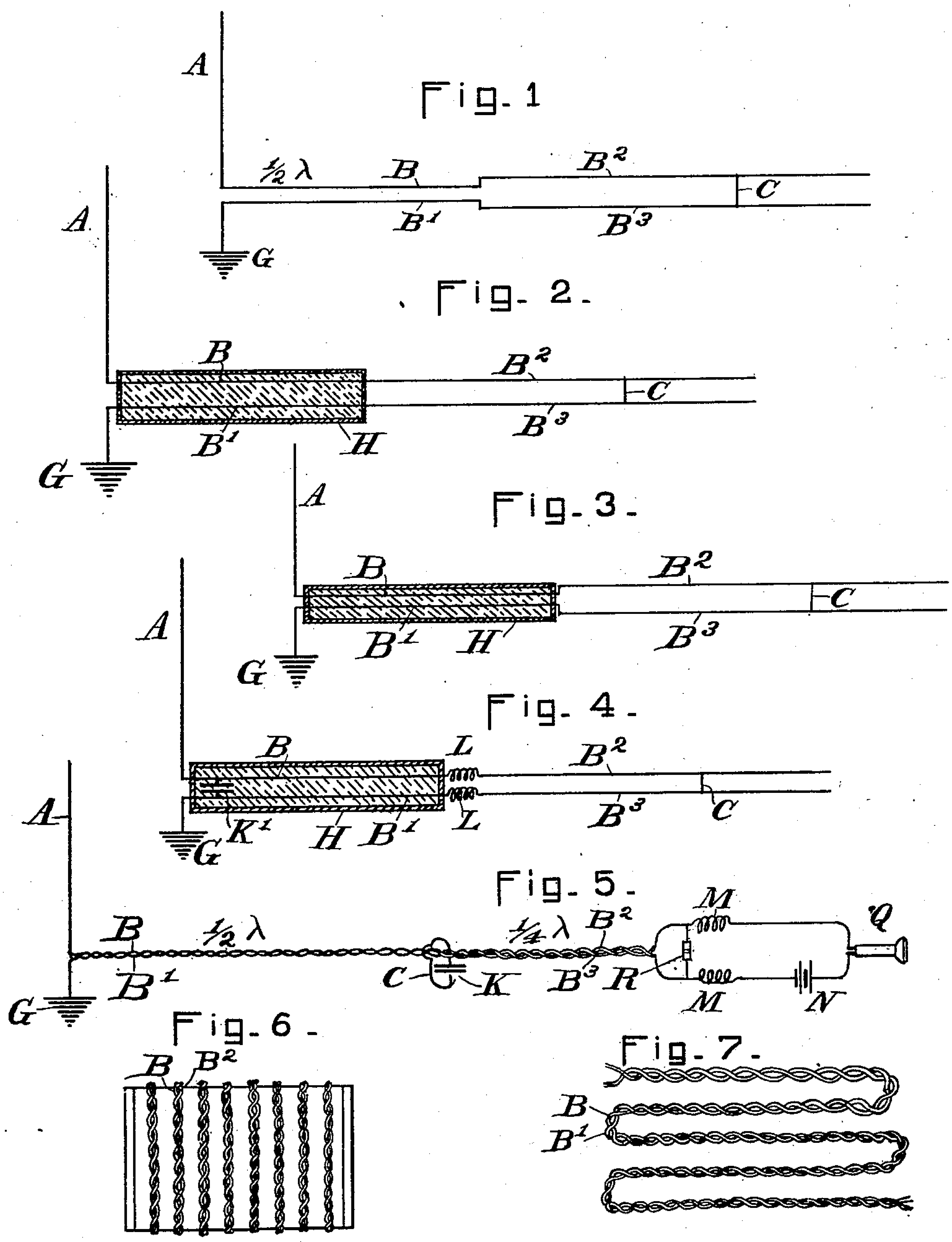
L. DE FOREST.

WIRELESS SIGNALING.

APPLICATION FILED NOV. 20, 1902.

NO MODEL.



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No. 730,819. Patented June 9, 1903.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW HAVEN, CONNECTICUT, ASSIGNOR TO THE GREATER NEW YORK SECURITY COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

WIRELESS SIGNALING.

SPECIFICATION forming part of Letters Patent No. 730,819, dated June 9, 1903.

Original application filed March 8, 1902, Serial No. 97,239. Divided and this application filed November 20, 1902. Serial No. 132,138. (No model.)

To all whom it may concern:

Be it known that I, LEE DE FOREST, a citizen of the United States, and a resident of the city and county of New Haven and State of Connecticut, have invented certain new and useful Improvements in Wireless Signaling, of which the following is a specification.

My invention relates to improvements in those systems in electric signaling commonly referred to as "wireless" telegraphs, and comprises the novel features and parts and the combinations thereof, which will be hereinafter described, and particularly pointed out in the claims.

This application is a division of an application, Serial No. 97,239, filed by me March 8, 1902, for an improvement in space telegraphy.

In the drawings accompanying herewith I have shown and in the specification will describe various forms of apparatus embodying my invention without, however, showing all of the numerous modifications now known to me or possible to be made, yet sufficient in number to make clear the principles of my invention and of what it consists. I am not, therefore, to be understood as limiting myself to those forms and modifications herein shown, but to be understood as claiming my invention broadly, the modifications shown being given merely in illustration of the principle and as showing the form and arrangement of parts now preferred by me.

Figure 1 shows one of the simpler forms of apparatus embodying my invention designed for use either with a sending or a receiving apparatus, such apparatus not, however, being shown. Figs. 2, 3, and 4 show amplifications of the same form of apparatus, likewise designed for connection with either a receiving or sending apparatus. Fig. 5 shows a modification illustrating how the conductors may be practically made so as to adapt them to disposal within feasible and convenient limits. Figs. 6 and 7 show the same form of conductors as in Fig. 5 and methods of disposing the same in practical use.

In my application above referred to I have shown and described the use of parallel wires forming what is known in the art as a "Lecher" system as a resonant conducting system between the antenna and the wave-radiating or wave-receiving device, as the case may be—that is, in either a receiving or a sending apparatus. As therein pointed out, conductors disposed so as to form a Lecher system—that is, parallel, so as to act inductively upon each other to thereby set up stationary electrical waves—form a resonant system the period of which may be determined and adjusted with great accuracy and facility, and the oscillations set up therein are persistent or slightly damped. In consequence of these characteristics such a system is excellently adapted to use in a wireless-telegraph apparatus. In my present invention a simple method is shown by which the Lecher system may be made to act as a transformer to step the potential either up or down, as desired, and whereby the lengths of wire required may be compactly disposed, so as to reduce them to practicable dimensions.

The general theory of the Lecher system shows that the mutual induction of the Lecher wires decreases as the two wires are brought together, becoming zero for the wires in actual contact, and, conversely, the capacity of the system is thus increased. Consequently if one system of such parallel wires, as B B′, Fig. 1, of length equivalent to one-half wave length of the vibration transmitted be added to another system, as B^2 B^3, of the same period of electrical vibration, but having its two parallel wires farther apart, then this second system B^2 B^3 may take up the impulse transmitted from the first system unaffected as to its period of vibration, yet transformed to a wave of higher potential, but of correspondingly-diminished magnetic energy or current. On the same principle if the first-mentioned system—say of one-half wave length—have for the dielectric between its two parallel wires a substance of higher specific inductive capacity than that between the two parallel wires of the second system then the capacity of the first system per unit length is greater than that of the second system. The electrical energy will therefore be transferred from the first to the second system altered in its relative proportions of electrostatic and electromagnetic energies. So in the arrangement last described the transformation will be as before to step up the potential and to diminish the currents flowing in the second system. Such a system is illustrated in Fig. 2, in which the wires B B′ are parallel throughout their length, but the first half-wave length from the upright is inclosed in a casing H, containing oil. Thus I employ one pair of parallel wires—*e. g.*, of length equivalent to a half-wave length of the vibration transmitted—immersed in and separated by an oil and connected to one end of this system another system of parallel wires of a length also equivalent to one-half wave length, but equally separated by air or by a dielectric of small specific induction capacity, and thus obtain between the two wires of this second system a higher difference of potential than existed between the wires of the first system. Such immersion in a fluid may result in a change in the wave length required for a given period. In Fig. 3 a combination of both plans is shown, the first half-wave length B B′ being immersed in oil and also having its wires closer together than the second half-wave length B^2 B^3, which are separated only by air. When desirable to still further increase the self-induction of one of such systems of parallel wires as I have described, I may insert at corresponding points in each of the two wires inductive or momentum coils of suitable impedance and construction—such, for instance, as are shown at L in Fig. 4. Similarly to increase the capacity of the other system I may attach to each of the parallel wires thereof an armature of a condenser of suitable area—such, for instance, as the condenser K of Fig. 4. Any of the usual period adjusting or tuning devices may be employed in connection with my invention in the usual manner. Such combination of systems as I have here described thus affords a step-up or step-down device entirely differing from "transformer-coils," ordinarily so called, a device novel and useful in its application to the art of space telegraphy.

Each section of the Lecher wires should be of a length corresponding with one-half of the length of the wave of the period for which the system is attuned. As this means a very considerable length of wire, some means for reducing the wires to a compact and reasonable bulk is desired. Such a means is shown in Figs. 5, 6, and 7. Here the two wires, which are insulated, are twisted together, forming a twisted pair, the distance between them being regulated by the thickness of the insulation. It is desirable that the pitch of the twist be not too steep. The twisted pair is well adapted to use upon a spool or coiled in any other manner which may be desirable to economize space or to secure portability. If the two simple parallel wires untwisted were coiled upon a spool with convolutions parallel and near together, interference by induction between adjacent convolutions would arise; but when closely twisted such adjacent convolutions of the coil, if not too close together, will not interfere with one another. In any considerable length of the convolution one wire will first lie adjacent to another carrying current of like sine and then to one carrying current of opposite sine, so that for any considerable length of wire the inductive effects from the two wires in the convolutions adjoining will be neutralized. In practice I have successfully used such wires twisted with a pitch equal to three turns to the inch, wound upon a spool about three inches in diameter, with successive turns separated about an eighth of an inch. Their use is not, however, limited to even a near approximation to the above proportions, which are given only to show what has been found successful without any intention of limiting myself thereto. To obtain the transformer or step up or down effect before mentioned, it is only necessary to vary the thickness or character of the insulation as between the sections of the wires lying on opposite sides of a nodal point. The same result may also be obtained by changing the dielectric between the wires, as by immersing them in oil in the manner shown in Figs. 3 and 4.

Condensers, inductance-coils, or any other lag-producing or period-adjusting devices may be employed, as is shown by the condenser K′ and inductance-coils L L in Fig. 4, to influence or modify the period of the system. Bridges, as C in Figs. 4 and 5, may be employed to connect the wires at nodal points without interfering with the passage of the stationary waves from one side thereof to the other and without materially cutting out or shunting waves of the particular period for which the device is adjusted. It will, however, act to more or less cut out or shunt waves of other periods, thus protecting a receiving device from waves other than the desired frequency or preventing the radiation of waves of other than the desired frequency, in accordance as the system is used with a receiving or sending apparatus. The bridge C of Fig. 5 has a condenser K therein, which forms, in effect, a non-resistance path for waves of a high frequency, such as are used for conveying the signals, while serving to stop waves of a low frequency or potential—such, for instance, as would be used in the local circuit for operating the receiving apparatus.

In connection with Fig. 5 I have shown a wave-sensitive member R, such as a coherer or other responder, choke-coils M M, local battery N, and a signal-indicating device, as a telephone-receiver Q. In the other figures I have not shown either a wave-producing or wave-receiving device, although either may be used. The connection for either should be made at a point corresponding with a loop of the electrostatic wave. In Figs. 1, 2, 3, and 4 this would naturally be at the ends of the wires, as shown. It might, however, be placed between any of the nodal points.

The twisted wires, as shown in Figs. 5, 6, and 7, is a convenient and practical way of reducing the Lecher system to a compact and easily-portable form and may be advantageously employed irrespective of whether or not the transformer feature is employed. They act essentially like true parallel wires, and their use is governed by the same rules, and the results obtained are the same as with the parallel wires. They may therefore be substituted for the parallel wires in any combination.

I have herein spoken of one of the conductors as being connected with the antenna. The connection contemplated is either a direct connection or an inductive one, as by induction or transformer coils, the effect being substantially the same in transferring the waves from the antenna to the resonant system.

Having thus described my invention, what I claim, and desire to secure by Letters Patent, is—

1. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series and adapted to produce a change in the relative proportions of the electrostatic and electromagnetic energies by the transmission from one set to the other.

2. In space telegraphy, the combination with an antenna of two sets of parallel conductors connected in series and having substantially equal periods of vibration, said sets of conductors being adapted to produce a change in the relative proportions of the electrostatic and electromagnetic energies by the transmission from one set to the other.

3. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series, the conductors of one set having a greater capacity per unit length than those of the other set.

4. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series, the conductors of one set having a greater self-induction per unit length than those of the other set.

5. In space telegraphy, the combination with an antenna, of a plurality of sets of parallel conductors, connected in series, one of said conductors being connected with the antenna, the conductors of one set being separated farther than the conductors of the other set.

6. In space telegraphy, the combination with an antenna, of a plurality of sets of parallel conductors connected in series, one of said conductors being connected with the antenna, the conductors of the two sets being separated by dielectrics of different specific inductive capacity.

7. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series and adapted to produce a change in the relative proportions of the electrostatic and the electromagnetic energies by the transmission from the one set to the other, and a wave-indicating device connected between said conductors.

8. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series and having substantially equal periods of vibration, said sets of conductors being adapted to produce a change in the relative proportions of the electrostatic and electromagnetic energies by the transmission from one set to the other, and a wave-indicating device connecting the wires of one set substantially at a loop of the electrostatic waves therein.

9. In space telegraphy, the combination with an antenna, of two sets of parallel conductors connected in series, the conductors of one set having a greater capacity per unit length than those of the other set, and a wave-indicating device connecting the conductors of one set at a point corresponding substantially with the loop of the electrostatic waves therein.

10. In space telegraphy, the combination with an antenna, of a plurality of sets of parallel conductors connected in series, one of said conductors being connected with the antenna, the conductors of one set being separated farther than the conductors of the other set, and a wave-indicating device connecting the conductors of one set substantially at a loop of the electromagnetic waves therein.

11. In space telegraphy, the combination with an antenna, of a plurality of sets of parallel conductors connected in series, one of said conductors being connected with the antenna, the conductors of the two sets being separated by dielectrics of different specific inductive capacity, and a wave-indicating device connecting the conductors of one set.

12. In wireless signaling, the combination with an antenna, of a plurality of sets of parallel conductors one of said conductors being connected with the antenna, the corresponding conductors of different sets being connected in series, said conductors being adapted to produce a change in the relative proportions of the electrostatic and electromagnetic energies by the transmission from one set to another.

13. In wireless signaling, the combination with an antenna, of a plurality of sets of parallel conductors one of which is connected with the antenna, the corresponding conductors of different sets being connected in series, said conductors in different sets varying in capacity per unit length.

14. In wireless signaling, the combination

with an antenna, of a plurality of sets of parallel conductors one of which is connected with the antenna, the corresponding conductors of different sets being connected in series, the conductors in different sets varying in separation.

15. In wireless signaling, the combination with an antenna, of a plurality of sets of parallel conductors one of which is connected with the antenna, the corresponding conductors of different sets being connected in series, the conductors in different sets being separated by dielectrics of different specific inductive capacity.

16. In wireless signaling, the combination with an antenna, of parallel conductors one of which is connected with the antenna, each of said conductors containing a plurality of sections which are each equivalent to half a wave length, said conductors being adapted to produce a change in the relative proportions of the electrostatic and the electromagnetic energies by the transmission from one set to the other.

17. In wireless signaling, the combination with an antenna, of parallel conductors, one of which is connected with the antenna, each of said conductors containing a plurality of sections, which sections are each equivalent to half a wave length, the corresponding sections of said conductors forming sets which vary in capacity per unit length.

18. In wireless signaling, the combination with an antenna, of parallel conductors, one of which is connected with the antenna, each of said conductors containing a plurality of sections, which sections are each equivalent to half a wave length, the corresponding sections of said conductors forming sets which vary in capacity per unit length.

19. In wireless signaling, the combination with an antenna, of parallel conductors, one of which is connected with the antenna each of said conductors containing a plurality of sections, which sections are each equivalent to a half-wave length, the conductors of different sets varying in separation.

20. In wireless signaling, the combination with an antenna, of parallel conductors, one of which is connected with the antenna, each of said conductors containing a plurality of sections, which sections are each equivalent to half a wave length, the conductors of different sets being separated by dielectrics of different specific inductive capacity.

21. In wireless signaling, the combination with an antenna, of two conductors one of which is connected with the antenna, said conductors each containing a plurality of sections, the different conductors within each section maintaining a substantially uniform separation, but varying in separation in different sections.

22. In wireless signaling, the combination with an antenna, of two conductors one of which is connected with the antenna, said conductors each containing a plurality of sections, the different conductors within each section maintaining a substantially uniform separation, and being adapted to produce a change in the relative proportions of the electrostatic and electromagnetic energies by the transmission from one set to another.

23. In wireless signaling, the combination with an antenna, of two conductors one of which is connected with the antenna, said conductors each containing a plurality of sections, all having substantially equal periods of vibration, the corresponding sections of different conductors maintaining a substantially uniform separation, said conductors being adapted to produce a change in the relative proportions of electrostatic and electromagnetic energies by transmission from one section to another.

24. In wireless signaling, the combination with an antenna, of two conductors, one of which is connected with the antenna, said conductors each containing a plurality of sections, the corresponding sections of different conductors maintaining a substantially constant separation, the pairs of conductors in different sections varying in capacity per unit length.

25. In wireless signaling, the combination with an antenna, of two conductors, one of which is connected with the antenna, said conductors each containing a plurality of sections, the corresponding sections of different conductors maintaining a substantially uniform separation within the section, the conductors of different sections being separated by dielectrics of different specific inductive capacity.

26. In wireless signaling, the combination with an antenna, of two conductors, one of which is connected with the antenna, said conductors each containing a plurality of sections, the conductors within any such section maintaining a substantially constant inductive relationship with each other but varying such relationship between the different sections.

27. In wireless signaling, the combination with an antenna, of two conductors, one of which is connected with the antenna, said conductors each containing a plurality of sections, all having equal periods of vibration, the conductors within any section maintaining substantially uniform inductive relationship with each other throughout said section but varying such relationship between the different sections.

28. In wireless signaling, a resonant electrical system comprising a plurality of conductors divided into sections having equal periods of vibration, said conductors within any section maintaining a substantially uniform inductive relationship with each other but varying such relationship between different sections.

29. In wireless signaling a resonant elec-

trical system comprising a plurality of parallel conductors divided into sections having equal periods of vibration, the wires within any section being parallel but the wires of different sections varying in separation.

30. In wireless signaling, a resonant electrical system comprising a plurality of conductors divided into sections, said conductors within any section maintaining a substantially uniform separation but varying in separation in different sections.

In testimony whereof I have hereunto affixed my signature, this 17th day of November, 1902, in the presence of two witnesses.

LEE DE FOREST.

Witnesses:

FRANCIS X. BUTLER,

RICHARD D. KNABE.