No. 730,247. PATENTED JUNE 9, 1903.

L. DE FOREST.

WIRELESS TELEGRAPHY.

APPLICATION FILED NOV. 4, 1902.

NO MODEL.

Fig. 1.

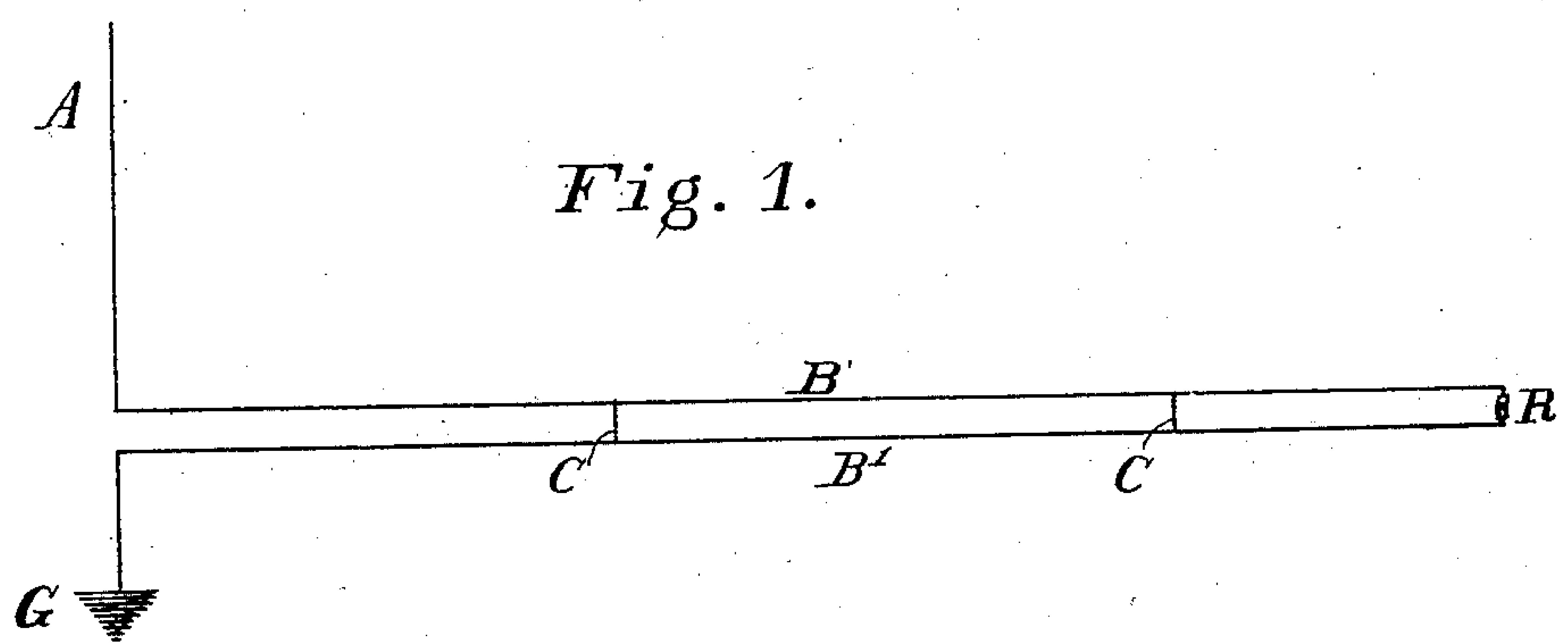


Fig. 2.

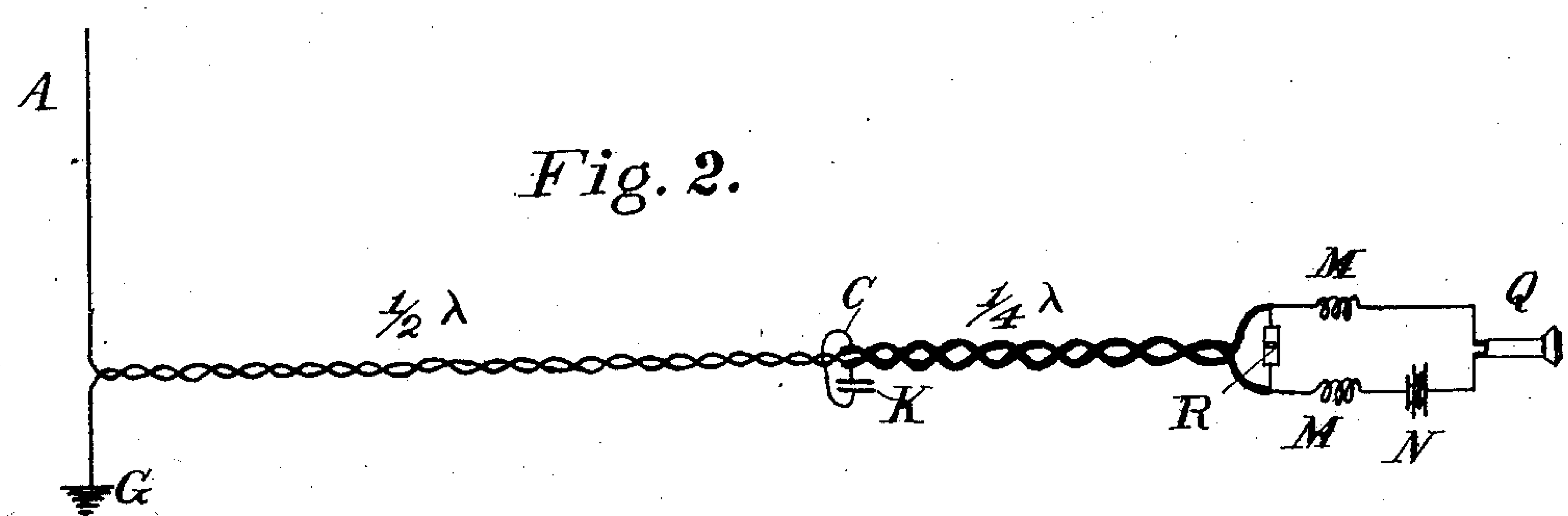


Fig. 3.

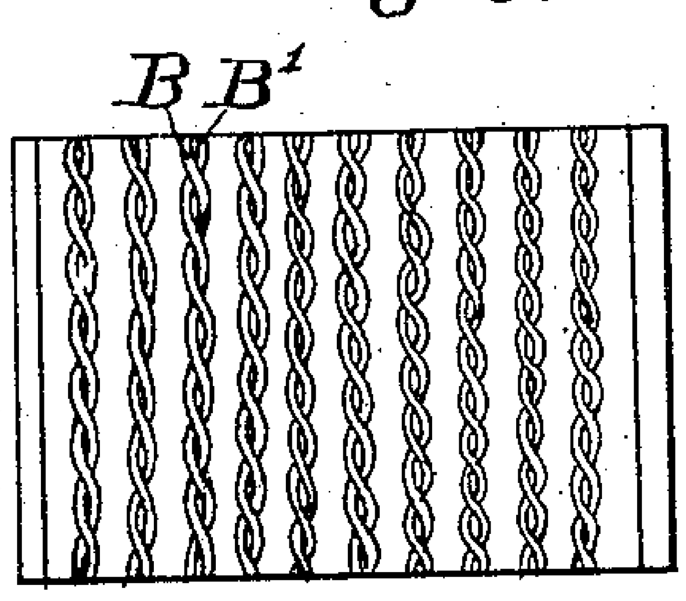
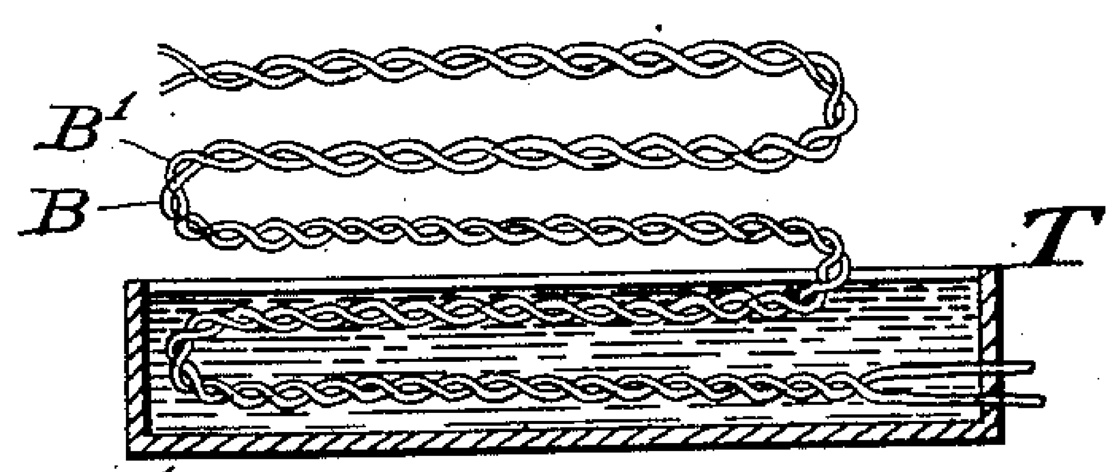


Fig. 4.



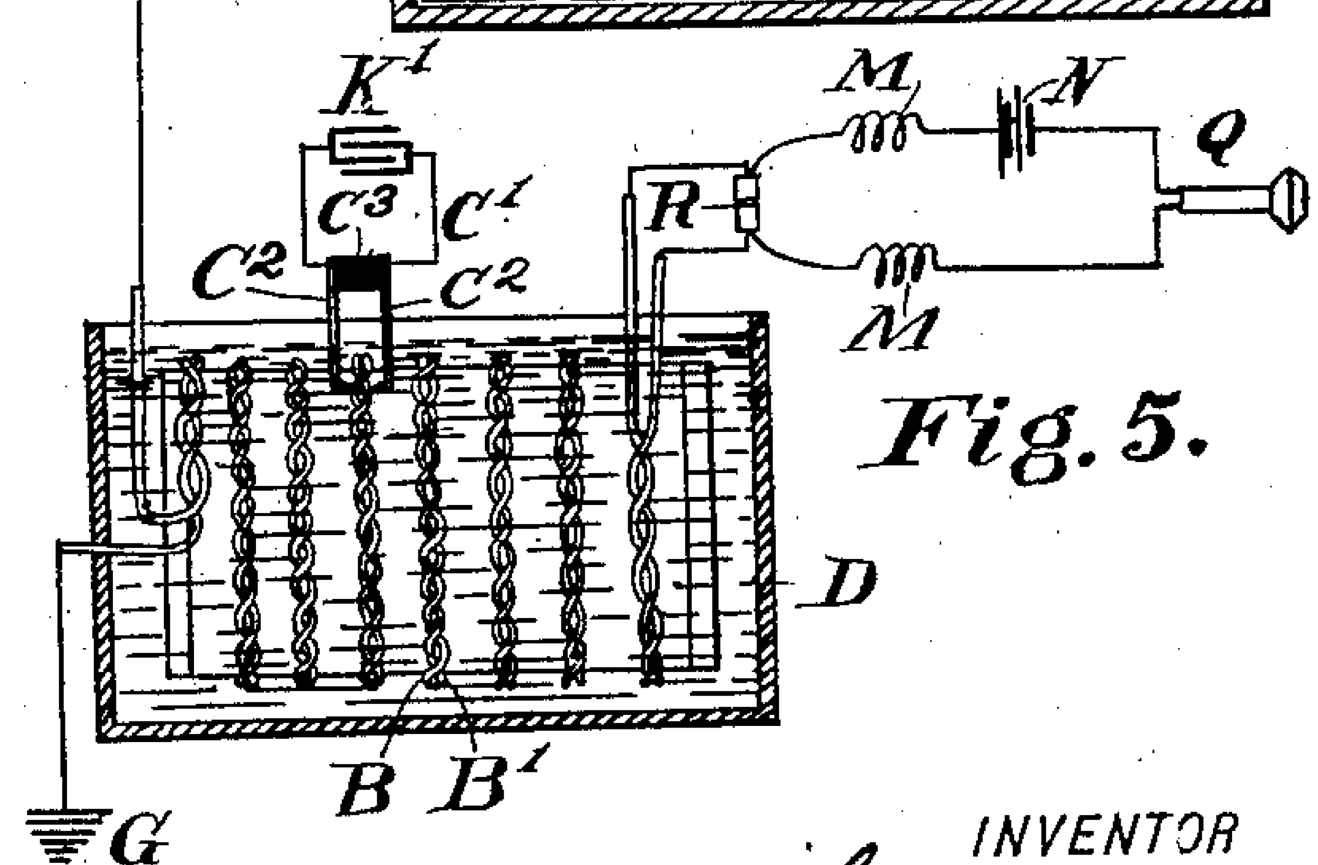


Fig. 5.

WITNESSES:

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No. 730,247. Patented June 9, 1903.

UNITED STATES PATENT OFFICE.

LEE DE FOREST, OF NEW HAVEN, CONNECTICUT.

WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 730,247, dated June 9, 1903.

Application filed November 4, 1902. Serial No. 130,062. (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 New Haven, in the county of New Haven and State of Connecticut, have invented certain new and useful Improvements in Wireless Telegraphy, of which the following is a specification.

My invention relates to an improvement in wireless telegraphy, and comprises the features and parts and combinations thereof hereinafter described, and particularly pointed out in the claims.

Figure 1 is a diagram by the use of which certain features of my invention may be more readily explained. Fig. 2 shows the modification of the device shown in Fig. 1 which is the subject of my invention. Figs. 3, 4, and 5 show practical forms of disposing of the wires in a compact manner.

In application Serial No. 97,239, filed March 8, 1902, I have shown and fully explained a resonant system for use either with a sending or a receiving apparatus of a wireless signaling system the chief feature of which is the use of parallel wires, one of which is connected with the antenna, said wires comprising what is known in the electrical art as a "Lecher" system. Such a system is illustrated in Fig. 1. The two wires B and B′ are parallel and of a multiple of quarter of the length of the wave for which the system is designed. In Fig. 1 each conductor is shown as being of a length equal to one and a quarter wave lengths. Such conductors, as was fully set forth by me in the application before mentioned, form a highly-resonant and slowly-damped system, electric oscillations communicated thereto causing the formation in the system of stationary electric waves which persist for some time. Therefore when such a system is employed for wireless signaling by connecting one conductor to the antenna and the other to the earth or other capacity and placing between the conductors a wave-producing or a wave-receiving device, as the case may be, the result is to produce in the system an extended series of stationary waves which by their cumulative effect have a greater effect upon the sensitive member designed to be affected thereby, whether that sensitive member is a distant one affected by the radiated waves or an adjacent one in circuit with the Lecher system. The characteristics of the Lecher system and the adaptation thereof to use in wireless signaling have been fully pointed out in the application referred to and need not be repeated here. In Fig. 1 a very simple form thereof is shown, consisting of two wires B B′, one of which is connected with the antenna A and the other with the ground G, said conductors being optionally connected at nodal points of the electrostatic waves by bridges C, which assist to accurately locate the nodes and having a coherer or other responder R between the wires at a loop of the electrostatic waves therein. While such a system is highly resonant and its use leads to valuable results, a compact manner of embodying the same for practical use is desired. To use straight parallel wires of the length required would in many if not most cases be wholly impracticable and would forbid their use in a device designed to be portable or to be installed in a small space.

I have discovered that if two insulated wires be twisted together they possess the characteristic features of the Lecher system and also by reason of such twisting the wires may be wound upon a spool or otherwise be disposed in a compact manner, so that the required length of wire may be embodied in an apparatus which is yet portable. In Fig. 2 the twisted wires are shown as extending in a straight line, a bridge C, with condenser K, being shown at a node, and a coherer, responder, or other sensitive member R, operated by potential, is shown at an electrostatic loop. In Fig. 1 neither wave-producing nor wave-receiving devices are shown, the system being capable of use with either and the point of connection being determined by whether the attached device is designed for operation with electrostatic or electromagnetic waves. The point of connection should be at a loop of the kind of waves for which it is designed. A local receiving-circuit is shown connected with the responder R of Fig. 2, said circuit containing choke-coils M M, battery N, and a telephone or other indicating device Q. While the twisted wires may be used in extended position, as shown in Fig. 2, it is desirable that they be disposed in some more convenient and compact form, as by winding them upon a spool, as is shown in Fig. 3. It is desirable that the pitch of the twist be not too steep and also that the coils be not too close together. 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 sign and then to one carrying current of opposite sign, 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. So far as I am aware such a method of embodying the Lecher wires and of utilizing their advantages has never before been used. It retains practically all the theoretical advantages of the straight parallel wires embodied in a compact form, which makes the apparatus portable and practical. The twisted wires may be otherwise coiled or disposed in any suitable way—such, for instance, as is shown in Fig. 4, in which they are disposed in successive layers.

In Fig 5 I have shown a spool, such as is shown in Fig. 3, immersed in an oil-bath D to increase the period of the wires. Any other medium which is of greater specific inductive capacity than air may be used instead of oil. In this case the length of wires required for a given period is less than would be required where the wires are separated by air. When immersed in oil, the wires should be wrapped in an oil-absorbing insulant, such as paper, to prevent their contact. Another advantage of oil immersion for the wires is the increased insulation strength of the system.

As a further lag or period controlling or adjusting device I have shown a bridge C′ and condenser K′. This bridge is designed to be adjustable in position along the wires, the two arms C^2 terminating in points designed to penetrate the insulation on the wires at any point and contacting each with its respective wire. Any suitable construction to secure this result may be employed. I have shown two arms C^2, mounted on an insulating-block C^3 and designed to have sufficient spring to enable them to be separated and to hold in place when released. A separate clip may be employed for each wire. A movable bridge such as this makes adjustment of the period or attunement of any coil very easy and accurate.

Bridges, sliding, removable, or stationary, condensers, inductance-coils, and any of the usual lag-producing or period-adjusting devices may be employed in connection with the twisted wires as with the plain parallel wires. Their application to and effect with the twisted wires are controlled by the same laws as with the parallel wires. While the twisted wires may not be technically parallel, they are uniformly separated, which seems to be the more essential feature to secure the resonant action of the Lecher system. Bends in the wire so long as the uniform separation is maintained do not seem to affect their proper action.

The twisted wires forming the resonant system may have the sections thereof on opposite sides of nodes separated by different distances, as by varying the thickness of the insulation, as is shown by the terminal section in Fig. 2 or that section between C and the wave-responsive device in which the insulation has been thickened or be surrounded by dielectrics of different specific inductive capacity, as by air and oil, respectively, so as to get the transformer action which was pointed out in my application Serial No. 97,239, as is shown in Fig. 4, in which a portion of the wire is immersed in oil within the receptacle T. As therein pointed out, this difference in separation or of the surrounding dielectric or of both together produces a change in intensity of the waves in passing from one section to another, thus acting virtually as a transformer. This feature is of value both in the sending and the receiving apparatus, to both of which my invention is applicable.

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

1. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted wires insulated from each other and equivalent in length to a multiple of a quarter-wave length, one of said wires being connected with the antenna and the other with a capacity.

2. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted wires insulated from each other and disposed in adjacent layers and equivalent in length to a multiple of a quarter-wave length, one of said wires being connected with the antenna and the other with a capacity.

3. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted wires insulated from each other and equivalent in length to a multiple of a quarter-wave length, one of said wires being connected with the antenna.

4. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted conductors insulated from each other and equivalent in length to a multiple of a quarter-wave length, one of said conductors

being connected with the antenna and the other with a capacity, and a wave-indicating device connected between said conductors.

5. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted conductors insulated from each other, one of said conductors being connected with the antenna and the other with a capacity, and a wave-indicating device connected between said conductors at a point corresponding substantially with a loop of a stationary wave in said conductors.

6. In wireless signaling, in combination, an antenna and a conductor consistimg of two twisted wires insulated from each other and equivalent in length to a multiple of a quarter-wave length, one of said wires being connected with the antenna, and a wave-indicating device connected between said wires.

7. In wireless signaling, in combination, an antenna and a conductor consisting of two twisted wires insulated from each other, one of said wires being connected with the antenna and the other with a capacity, said wires being equivalent in length to a multiple of a quarter-wave length, and a wave-indicating device connecting said wires at a point substantially corresponding with a loop of said waves.

8. A resonant system including two wires insulated from each other and twisted together.

9. In wireless signaling, a resonant system consisting of two conductors insulated from each other and twisted together, said conductors being maintained with substantially uniform separation.

10. In wireless signaling, a resonant system including two conductors insulated from each other and twisted together, said conductors being uniformly separated and of an equivalent length equal to a multiple of a quarter-wave length of the waves for which it is designed.

11. In wireless signaling, the combination with an antenna, of two insulated conductors twisted together and one connected with the antenna, said conductors being divided into a plurality of sections of equal periods of vibration, the separation of said conductors varying in different sections.

12. In wireless signaling, the combination with an antenna, of two insulated conductors twisted together and disposed in adjacent layers, one of said conductors being connected with the antenna, said conductors being divided into sections of equal periods of vibration, and maintaining substantially uniform inductive relationships between the two wires within any given section, but varying such relationships between different sections.

13. In wireless signaling, the combination with an antenna, of two insulated and twisted conductors, one of said conductors being connected with the antenna, said conductors being divided into sections of equal periods of vibration, said conductors within any section maintaining a uniform separation but varying the separation between different sections.

14. In wireless signaling, the combination with an antenna, of two insulated and twisted conductors, one of which is connected with the antenna, said conductors being divided into sections of substantially equal periods of vibration, and adapted to change the relative proportions of electrostatic and electromagnetic energies by transmission from one section to another.

15. In wireless signaling, the combination with an antenna, of two insulated and twisted conductors, one of which is connected with the antenna, said conductors being divided into sections and varying in capacity per unit length in different sections.

16. In wireless signaling, the combination with an antenna, of two insulated and twisted conductors, one of which is connected with the antenna, said conductors being divided into sections in which the conductors are separated by dielectrics of different specific inductive capacity.

17. A resonant system for use in wireless signaling consisting of two insulated and twisted conductors adapted to be placed in series with an antenna and a capacity, said conductors being surrounded by a dielectric of greater specific inductive capacity than air.

18. A resonant system for use in wireless signaling consisting of two insulated and twisted conductors adapted to be placed in series with an antenna and a capacity and immersed in oil.

19. The combination with a pair of twisted and insulated conductors adapted to be placed in series with an antenna and a capacity, of a movable bridge adapted to be attached to connect said wires at any point desired.

20. The combination with a pair of twisted and insulated conductors adapted to be placed in series with an antenna and a capacity, of a bridge provided with points adapted to penetrate the insulation to connect the ends of the bridge each with its respective conductor at any point desired.

In witness whereof I have hereunto affixed my signature, this 24th day of October, 1902, in the presence of two witnesses.

LEE DE FOREST.

Witnesses:
M. W. NOLAN,
L. CUSHING.