No. 763,772. PATENTED JUNE 28, 1904.

G. MARCONI.
APPARATUS FOR WIRELESS TELEGRAPHY.

APPLICATION FILED NOV. 10, 1900.

NO MODEL.

Fig. 1.

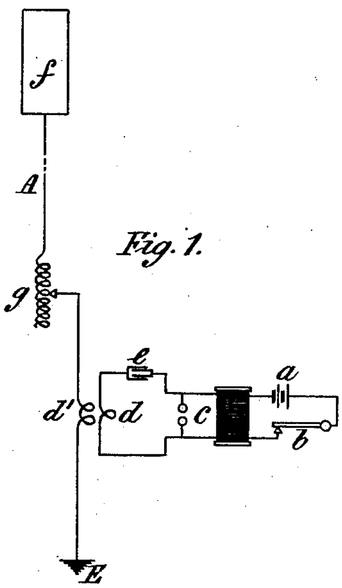


Fig. 2.

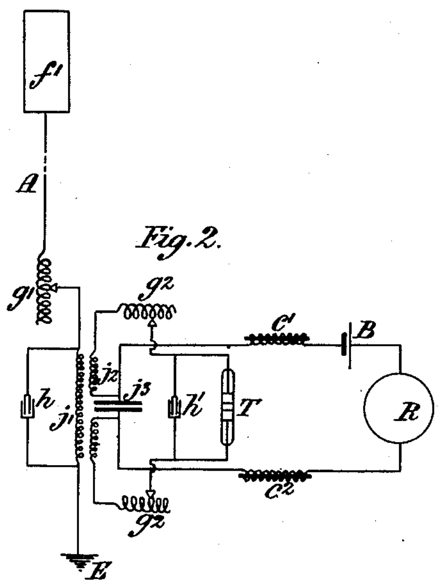


Fig. 3.

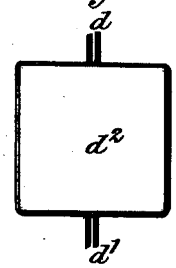


Fig. 4.

Fig. 5.

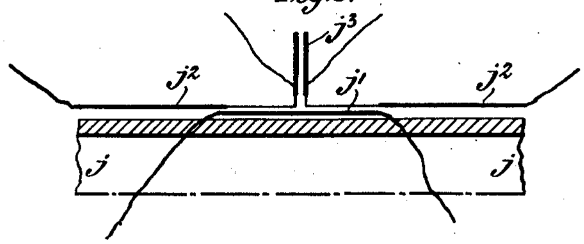


Fig. 6.

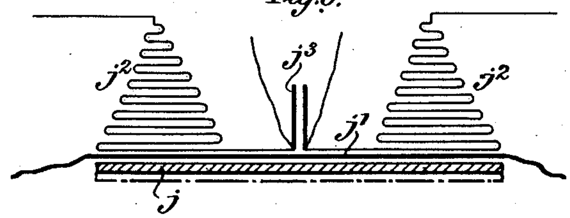


Fig. 7.

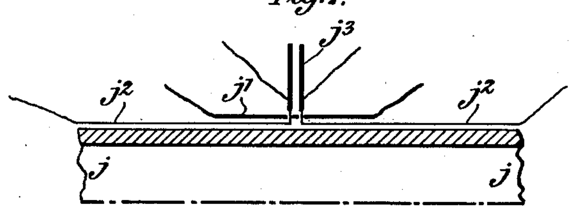
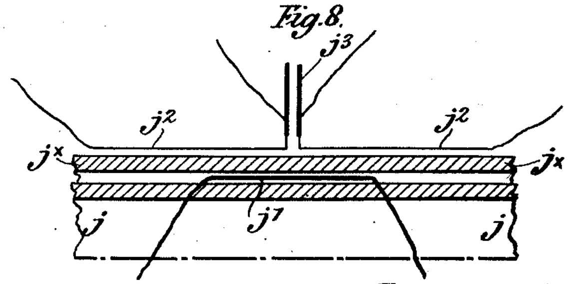


Fig. 8.



Witnesses.

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UNITED STATES PATENT OFFICE.

GUGLIELMO MARCONI, OF LONDON, ENGLAND, ASSIGNOR TO MARCONI'S WIRELESS TELEGRAPH COMPANY, LIMITED, OF LONDON, ENGLAND.

APPARATUS FOR WIRELESS TELEGRAPHY.

SPECIFICATION forming part of Letters Patent No. 763,772, dated June 28, 1904.

Application filed November 10, 1900. Serial No. 36,010. (No model.)

To all whom it may concern:

Be it known that I, GUGLIELMO MARCONI, electrician, a subject of the King of Italy, residing and having a post-office address at 18 Finch Lane, Threadneedle street, in the city of London, England, have invented certain new and useful Improvements in Apparatus for Wireless Telegraphy, of which the following is a specification.

My invention relates to apparatus for communicating electrical signals without wires and by means of Hertz oscillations or electric waves; and the object of the invention is to increase the efficiency of the system and to provide new and simple means whereby oscillations or electric waves from a transmitting-station may be localized when desired at any one selected receiving station or stations out of a group of several receiving-stations.

In my prior United States patent No. 586,193 (Reissue No. 11,913, dated June 4, 1901) I have shown and described the combination at a transmitting-station of an oscillation-producer, such as an induction-coil, having one end of its secondary coil connected to one contact of a spark-producer and to the earth and having the other end of the said secondary connected to the opposite contact of the spark-producer and to a vertical wire or elevated plate, and I have further shown at a receiving-station an imperfect contact connected in circuit with a vertical receiving-wire and with the earth. According to the present invention the system includes at the transmitting-station the combination, with an oscillation-transformer of a kind suitable for the transformation of very rapidly alternating currents, of a persistent oscillator, and a good radiator, one coil of said transformer being connected between the aerial wire or plate and the connection thereof to earth, while the other coil of the transformer is connected in circuit with a condenser, a producer of Hertzian oscillations or electric waves shown in the form of a spark-producer, and an induction-coil (constituting the persistent oscillator) controlled by a signaling instrument. The complete system also includes at a receiving-station an oscillation-transformer one coil whereof is included between the aerial receiving-wire and earth, constituting a good absorber of electrical oscillations, while a device responsive to electric waves, such as an imperfect contact or a device for operating the same, is included in a circuit with the other coil of said transformer. The system also requires as essential elements thereof the inclusion in the lines (at both stations) from the aerial conductor to the earth of variable inductances and the use at both stations of means for varying or adjusting the inductance of the two circuits at each station to accord with each other. By this arrangement of apparatus I am able to secure a perfect "tuning" of the apparatus at a transmitting-station and at one or more of a number of receiving-stations.

Referring to the accompanying drawings, Figure 1 indicates diagrammatically the arrangement of apparatus at a transmitting-station. Fig. 2 indicates diagrammatically the arrangement of apparatus at a receiving-station. Figs. 3 and 4 are views, plan and side, of the preferred form of transformer at the transmitting-station. Figs. 5, 6, 7, and 8 are diagrammatic views of forms of transformers at the receiving-station.

The transmitting-station is provided under my present invention with a source a of current electrically connected in circuit with the primary of an induction-coil c and with a circuit-closing key b or otherwise controlled by a signaling instrument. In the secondary circuit of said induction-coil the spherical terminals or other contacts of a spark-producer or other electric-wave or oscillation producer are included with a shunt therefrom, in which shunt is included the primary coil d of an oscillation-transformer, such as d^*. A condenser e, preferably one provided with two telescoping metallic tubes separated by a dielectric and arranged to readily vary the capacity by being slid upon each other, is included in one connection from the induction-coil to the transformer-winding d. The secondary coil d' of the transformer is connected (at one end) to the earth E and at its other end to a vertical wire A or an elevated plate f.

It is obvious that instead of the induction-coil and associated parts for producing the electric waves or oscillations I may use any other proper means for producing such waves or oscillations—such, for instance, as a generator of alternating electric currents.

The illustrated arrangement of parts at a transmitting-station enables much more energy to be imparted to the radiator *f*, the approximately closed circuit of the primary being a good conserver and the open circuit of the secondary being a good radiator of wave energy. My experiments have demonstrated that the best results are obtained at the transmitting-station when I use a persistent oscillator—an electrical circuit of such a character that if electromotive force is suddenly applied to it and the current then cut off electrical oscillations are set up in the circuit which persist or are maintained for a long time—in the primary circuit and use a good radiator—*i. e.*, an electrical circuit which very quickly imparts the energy of electrical oscillations to the surrounding ether in the form of waves—in the secondary circuit.

In operation the signaling-key *b* is pressed, and this closes the primary of the induction-coil. Current then rushes through the transformer-circuit and the condenser *e* is charged and subsequently discharges through the spark-gap. If the capacity, the inductance, and the resistance of the circuit are of suitable values, the discharge is oscillatory, with the result that alternating currents of high frequency pass through the primary of the transformer and induce similar oscillations in the secondary, these oscillations being rapidly radiated in the form of electric waves by the elevated conductor.

For the best results and in order to effect the selection of the station or stations whereat the transmitted oscillations are to be localized I include in the open secondary circuit of the transformer, and preferably between the radiator *f* and the secondary coil *d'*, an inductance-coil *g*, Fig. 1, having numerous coils, and the connection is such that a greater or less number of turns of the coil can be put in use, the proper number being ascertained by experiment.

At the receiving-stations employing my present invention I prefer to use a receiver such as those described in my several United States Patents, Nos. 586,193, 627,650, 647,007, 647,008, 647,009, and 668,315, capable of being affected by electrical waves or oscillations of high frequency.

As a responder to electric waves I may use at the receiving-station any of the now well-known forms of such devices, such as those which depend for their action on the reduction of the resistance of a metallic microphone by the action of electric waves or "coherers," one form of which is disclosed in my Patent No. 586,193, or I may employ one which depends for its action on the increase of the resistance of the device under the influence of the electric waves or "anticoherers," such as described by Branly in *La Lumiere Electrique* of June 13, 1891, or I may use those which depend upon the action of an electric wave as a magnetizing or demagnetizing agency, such as I have disclosed in my application Serial No. 132,974, filed November 28, 1902, or I may use various other well-known devices, such as the electrolytic, electrothermal, electromagnetic, or electrodynamic responders.

Referring to Fig. 2, *f'* indicates a plate or cylinder (not essential at either transmitter or receiver) at the upper end of an elevated conductor A, which is connected to the primary coil *j'* of a transformer or induction-coil and thence to earth E. In a shunt around said primary *j'* I usually place a condenser *h*, preferably similar in construction and operation to the condenser *e*. An inductance-coil *g'* of variable inductance is interposed in the primary circuit of the transformer, being preferably located between the cylinder *f'* and the coil *j'*, and the inductance of said coil may be adjusted in accordance with the method described by me in my Letters Patent of the United States No. 676,332 to harmonize with the inductance of coil *g* at the transmitting-station, Fig. 1 of the accompanying drawings, or with that of the coil or coils at one or more of the transmitting-stations included in the communicating system.

The secondary coil j^2 of the transformer is wound in two parts, preferably as described in my United States Letters Patent No. 668,315, dated February 19, 1901, and the outer ends of said coil are connected in certain cases through one or more interposed inductance-coils g^2, preferably of variable inductance, with the terminals of a coherer T or other detector of electrical oscillations. The inner ends of the split secondary coil are connected to the plates of a condenser j^3. A condenser *h'* is sometimes included in a shunt around the detector T. B is a battery, and R a relay connected to the condenser j^3 and controlling a telegraphing instrument or a printing device. *c'* and c^2 are choking-coils preventing oscillations from the secondary j^2 running into the battery-circuit, and thereby confining them to the wave-responsive device.

The capacity and self-induction of the four circuits—*i. e.*, the primary and secondary circuits at the transmitting-station and the primary and secondary circuits at any one of the receiving-stations in a communicating system—are each and all to be so independently adjusted as to make the product of the self-induction multiplied by the capacity the same in each case or multiples of each other—that is to say, the electrical time periods of the four circuits are to be the same or octaves of each other.

In employing this invention to localize the transmission of intelligence at one of several receiving-stations the time period of the circuits at each of the receiving-stations is so arranged as to be different from those of the other stations. If the time periods of the circuits of the transmitting-station are varied until they are in resonance with those of one of the receiving-stations, that one alone of all of the receiving-stations will respond, provided that the distance between the transmitting and receiving stations is not too small.

The adjustment of the self-induction and capacity of any or all of the four circuits can be made in any convenient manner and employing various arrangements of apparatus, those shown and described herein being preferred. In practice I have found the following preferred details of arrangements of apparatus to work well: The aerial conductors A at all stations and the conductor for the transformer-windings at the receiving-stations are composed of seven strands of copper wire .889 millimeters in diameter. The transformer at the transmitting-station may be of any of the following forms:

1. Around a block or core d^2, preferably a square block—say .17 meters wide—of insulating material is wound a primary coil d in length .946 meters, while the secondary d' consists of two turns or squares, one lying on each side of the primary. (See Figs. 3 and 4.) The insulation of both primary and secondary consists of 1.25 millimeters of rubber and one millimeter of jute, making a total thickness of 2.25 millimeters.

2. A transformer in all essential respects similar to 1, but with a primary of 1.93 meters and the core or block on which both primary and secondary are wound, is .3048 meters wide.

3. A transformer having a cylindrical core 10.16 centimeters in diameter and with a primary having ten turns wound thereon; over this, but separated by two millimeters of paper or other insulant, the secondary, also of ten turns.

Various forms of transformers, &c., which may be employed by me are described in my British Patent No. 7,777 of 1900.

The inductance-coils g and g' are preferably of copper wire 6.25 millimeters in diameter, wound on a cylinder 10.64 centimeters in diameter, with an interval of 2.28 millimeters between adjacent turns. The inductance-coils g^2 at the receiving-station are preferably of silk-covered copper wire .19 millimeter diameter wound upon cylinders 3.7 centimeters in diameter.

Various forms of induction-coils j' j^2 may be used. Figs. 5, 6, 7, and 8 show details of different forms. The figures show diagrammatically greatly-enlarged longitudinal sections not strictly to scale. Instead of showing the section of each coil or layer of wire as a longitudinal row of dots or small circles, as it would actually appear, it is for simplicity shown as a continuous longitudinal straight line.

Referring to Fig. 5, the primary j' preferably consists of 3.046 meters of silk-covered copper wire, say, and seventy-one millimeters in diameter wound in one layer on a core of ebonite or other insulating material 2.9 centimeters in diameter. Insulating material is wound over and on each side of this, so as to make a cylindrical core, say, 3.13 centimeters in diameter, on which is wound the secondary, each half of which consists of 6.4 meters of silk-covered copper wire .19 millimeter in diameter joined to 13.41 meters of silk-covered copper wire .37 millimeter in diameters wound in the same sense as the primary, the thinner wire being over the primary and the thicker being beyond the ends thereof.

The form of induction-coil shown in Fig. 6 has a primary of one hundred turns of copper wire .037 centimeters in diameter wound on a core j (2.9 centimeters in diameter) with a single silk covering and coated with paraffin-wax. The secondary j^2 is of copper wire .019 in diameter, insulated with a single silk covering, and is wound over the primary, commencing in the middle and in the same way as the primary. Each half of the secondary is in layers of the following number of turns: first layer, seventy-seven turns; second layer, forty-nine turns; third layer, forty-six turns; fourth layer, forty-three turns; fifth layer, forty turns; sixth layer, thirty-seven turns; seventh layer, thirty-four turns; eighth layer, thirty-one turns; ninth layer, twenty-eight turns; tenth layer, twenty-five turns; eleventh layer, twenty-two turns; twelfth layer, nineteen turns; thirteeth layer, sixteen turns; fourteenth layer, thirteen turns; fifteenth layer, ten turns; sixteenth layer, seven turns; and seventeenth layer, three turns, making five-hundred turns in all.

A third form of induction-coil (shown in Fig. 7) has a primary of 3.048 meters of silk-covered copper wire .19 millimeter in diameter and a secondary of 30.48 meters of silk-covered copper wire .1 millimeter in diameter wound in one layer on a core four centimeters in diameter, the primary being in one layer outside of the secondary.

The fourth form of induction-coil is shown in Fig. 8. Its primary consists of 3.048 meters of silk-covered copper wire .37 millimeter in diameter wound on a core 2.9 centimeters in diameter and inserted in a tube $j^{\times}$ of four centimeters external diameter, on which is wound the secondary of 27.432 meters of silk-covered copper wire .12 millimeter in diameter, the break at the middle of the secondary being over the middle of the primary.

Other forms of transformers which may be employed by me are described and claimed in my British Patent No. 7,777 of 1900.

The following tables give preferred adjustments, those details opposite any tune in the transmitting-station table being of course used in connection with those opposite the same tune in the receiving-station table:

Transmitting-Station.

Tune.	Aerial conductor.	Transformer *d d'*.	Inductance number of turns of *g* included.	Capacity microfarads *e*.	Length of spark in millimeters.
No. 1.	36.576 meters of cable.	No. 1.	None.	.006984	3
No. 2.	do.	No. 1.	45	.016895	4
No. 3.	do.	No. 2.	None.	.004112	3
No. 4.	do.	No. 2.	100	.016849	4
No. 5.	Zinc cylinder 9.144 meters long, 1.524 meters in diameter, and hoisted 3.048 meters above ground.	No. 2.	None.	.001600	12.5
No. 6.	30.48 meters of cable.	No. 3.	None.	.000573	4

Receiving-Station.

Tune.	Induction-coil.	Capacity in microfarads of—		Inductance introduced in—	
		h.	*h'*.	*g'*. Number of turns.	*g²*.
No. 1.	No. 1.	Omitted.	Omitted.	None.	None.
No. 2.	No. 1.	Omitted.	.00004	45	None.
No. 3.	No. 2.	.0046	Omitted.	Up to 21 may be inserted.	None.
No. 4.	No. 2	.0046	Omitted.	100	2 coils of 15.24 meters at each end of secondary.
No. 5.	No. 3.	Omitted.	Omitted.	None.	None.
No. 6.	No. 4.	Omitted.	Omitted.	None.	None.

It will be observed that both the transmitter and the receiver are the same for tunes 1 and 2 and that when the capacity of the condenser *e* is varied the two stations can be brought into tune by including forty-five turns of each of the coils *g g'* and by introducing a condenser *h'* of small capacity in parallel with the coherer T. Similarly the transmitter and receiver are the same for tunes 3 and 4, and when the capacity of *e* is varied the stations are tuned by including one hundred turns of each of the coils *g* and *g'* and by also including the coils g^2.

While I have herein shown and described details of construction and of arrangement found by me to be useful, yet I do not wish to be understood as confining my claims thereto. Obviously modifications which are within my invention will readily suggest themselves to skilled persons.

What I claim is—

1. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency; an open circuit electrically connected with the oscillation-producer aforesaid and a variable inductance included in the open circuit, substantially as and for the purpose described.

2. At a station employed in a wireless-telegraph system, an oscillation-receiving conductor, a variable inductance connected with said conductor; a wave-responsive device electrically connected with said conductor and in circuit with a condenser, substantially as and for the purpose described.

3. At a station employed in a wireless-telegraph system, a signaling instrument comprising an induction-coil, the secondary circuit of which includes a condenser discharging through a means which automatically causes oscillations of the desired frequency, and the

primary circuit of which includes a generator; means for varying the primary circuit; an open circuit electrically connected with the oscillation-producer aforesaid, and a variable inductance included in the open circuit, substantially as and for the purpose described.

4. In a system of syntonic wireless telegraphy, a circuit so arranged as to form a persistent oscillator, a circuit so formed as to constitute a good radiator in inductive relation thereto, means for inducing in the oscillator-circuit electric undulations of a predetermined period, and means for attuning the natural period of vibration of each of said circuits to the period of the undulations so induced.

5. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising a conductor elevated at one end and connected to capacity at the other end, said conductor including a variable inductance and an element having appreciable capacity.

6. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, and means for adjusting the oscillation period of each of the two circuits connected with the transformer to bring them into accord with each other, substantially as described.

7. An element of an apparatus employed in a system of telegraphy by electric waves or oscillations of high frequency, comprising an open circuit so arranged as to constitute a radiator of such waves or oscillations, and means for varying at will the natural period of vibration of the said circuit.

8. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected to a condenser-circuit discharging through a means which automatically causes oscillations of the desired frequency, substantially as described.

9. At a transmitting-station employed in a wireless-telegraph system, the combination of a transformer whose secondary is connected to an open circuit including a radiating-conductor at one end and capacity at the other end, a variable inductance being included in said circuit, and whose primary is connected in series with an adjustable condenser and with a means which automatically causes oscillations of the desired frequency, substantially as described.

10. A system of wireless telegraphy, in which the transmitting-station and the receiving-station each contains an oscillation transformer, one circuit of which is an open circuit and the other a closed circuit, the two circuits at each station being in electrical resonance with each other and in electrical resonance with the circuits at the other station, substantially as described.

11. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency electrically connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end to capacity and, at the other end, to an inductance, and an aerial conductor connected to the inductance, substantially as and for the purpose described.

12. In apparatus for communicating electrical signals, the combination, with an oscillation-transformer, at a transmitting-station, of an induction-coil; an electric circuit containing the secondary of the said coil, a condenser and the primary coil of the oscillation-transformer; a producer of electric waves of high frequency connected with the secondary of the induction-coil; a signaling instrument in circuit with the primary of the induction-coil; the secondary coil of the oscillation-transformer electrically connected, at one end, to capacity and, at the other end, to a variable inductance, and an aerial conductor connected to the variable inductance, substantially as and for the purpose described.

13. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a variable inductance being included in said circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a condenser in circuit with the wave-responsive device, substantially as described.

14. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

15. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a condenser located in said circuit between the coil and the capacity, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

16. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, an adjustable condenser in a shunt connected with the open circuit and around said transformer-coil, a wave-responsive device electrically connected with the other coil of the oscillation-transformer, and means for adjusting the two transformer-circuits in electrical resonance with each other, substantially as described.

17. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end and capacity at the other end, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and means included in each of said transformer-circuits, for adjusting said circuits in electrical resonance with each other, substantially as described.

18. At a receiving-station employed in a wireless-telegraph system, the combination of an oscillation-transformer, an open circuit connected with one coil of said transformer, said circuit including an oscillation-receiving conductor at one end, and capacity at the other end, a variable inductance being included in said open circuit, a wave-responsive device electrically connected with the other winding of the oscillation-transformer, and a variable inductance included in circuit with the wave-responsive device, substantially as described.

19. In a system of wireless telegraphy, the combination at a receiving-station, of an oscillation-transformer; an open circuit comprising, in part, an aerial conductor connected with one end of the primary coil of the oscillation-transformer; a connection from the other end of said coil to capacity; a variable inductance in said open circuit; and electrical connections from the secondary coil of the oscillation-transformer to a receiving instrument, battery, condenser, wave-responsive device and a variable inductance, substantially as and for the purpose described.

20. In a system of wireless telegraphy, a transmitting-station containing an oscillation-transformer, the primary of which is connected to a condenser-circuit discharging through a spark-gap which automatically causes electric waves of the desired frequency, the secondary of said transformer connected to an open circuit including a radiating-conductor, and with a capacity and a coil for charging the condenser aforesaid; a receiving-station containing an oscillation-transformer, the primary of which is connected with an oscillation-receiving conductor and with a capacity, a wave-responsive device connected with the secondary of said transformer, and a receiving instrument connected with the wave-responsive device, all in combination with means for bringing the four transformer-circuits, two at each station, into electrical resonance with each other, substantially as described.

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Witnesses:

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