June 4, 1929. C. LE G. FORTESCUE 1,715,701

COMBINED WIRELESS SENDING AND RECEIVING SYSTEM

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Fig. 1

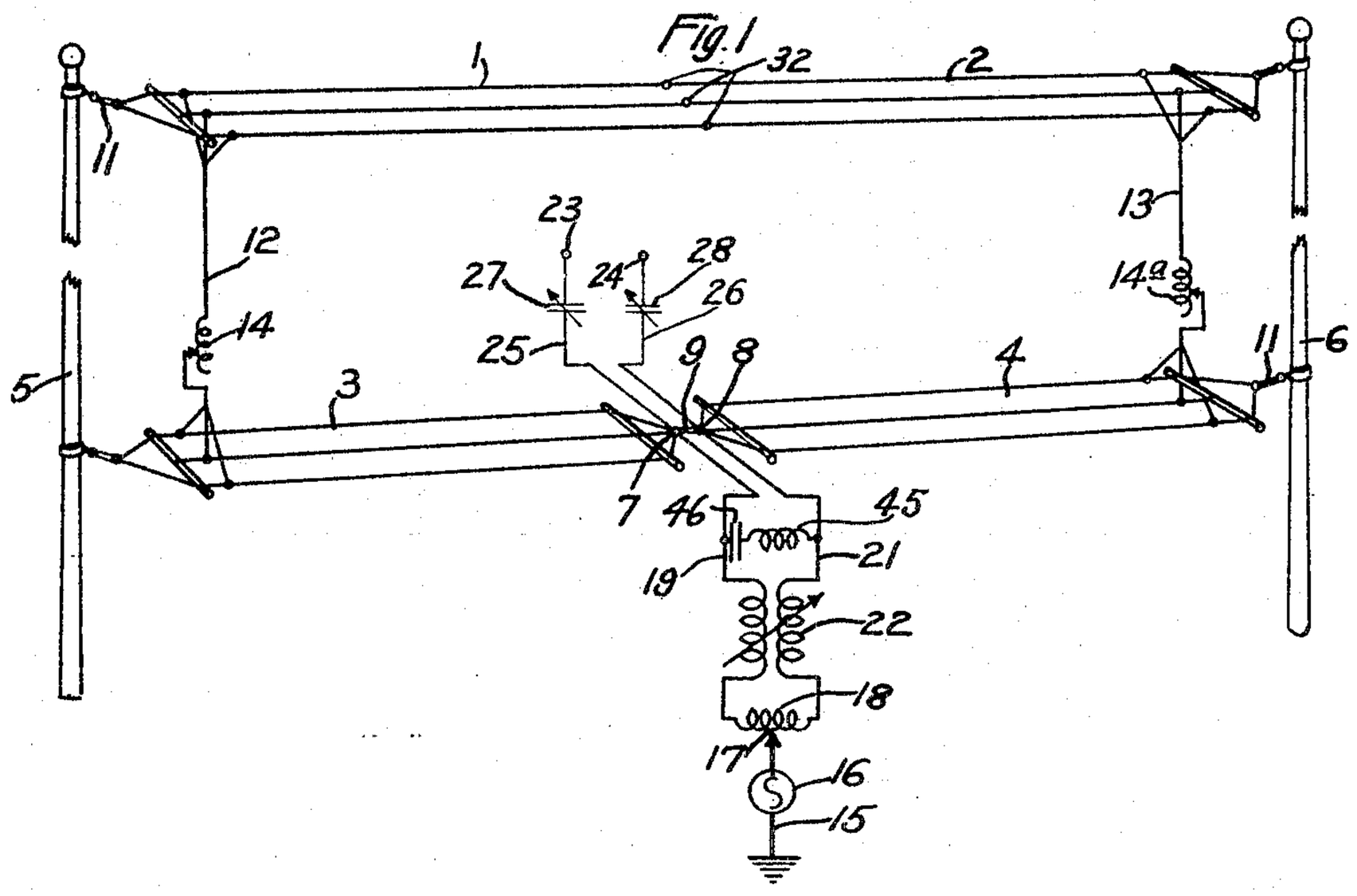

Fig. 2.

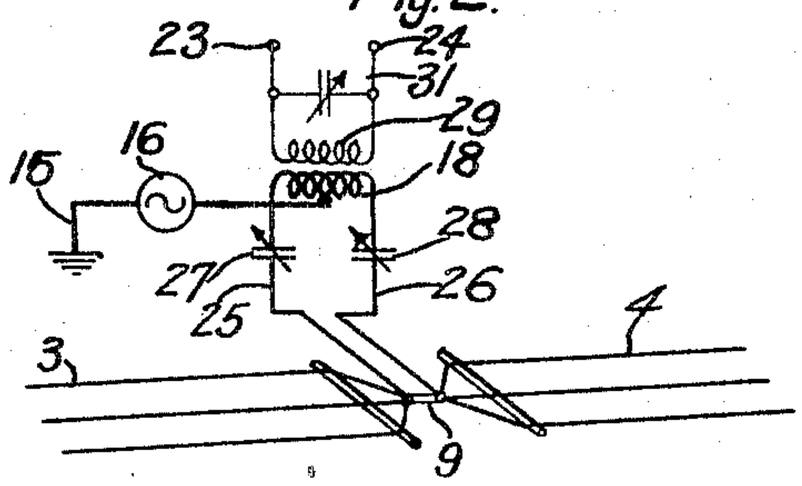

Fig. 4.

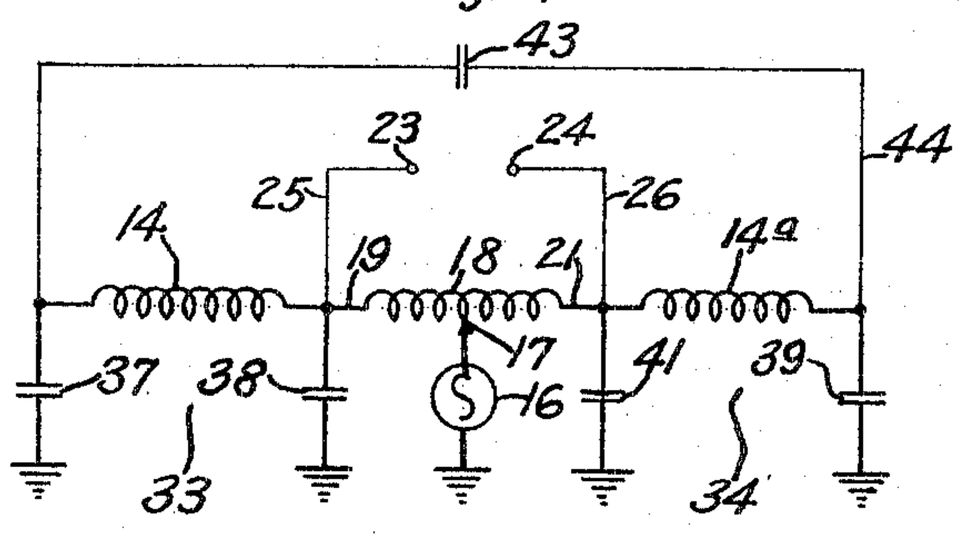

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Fig. 3.

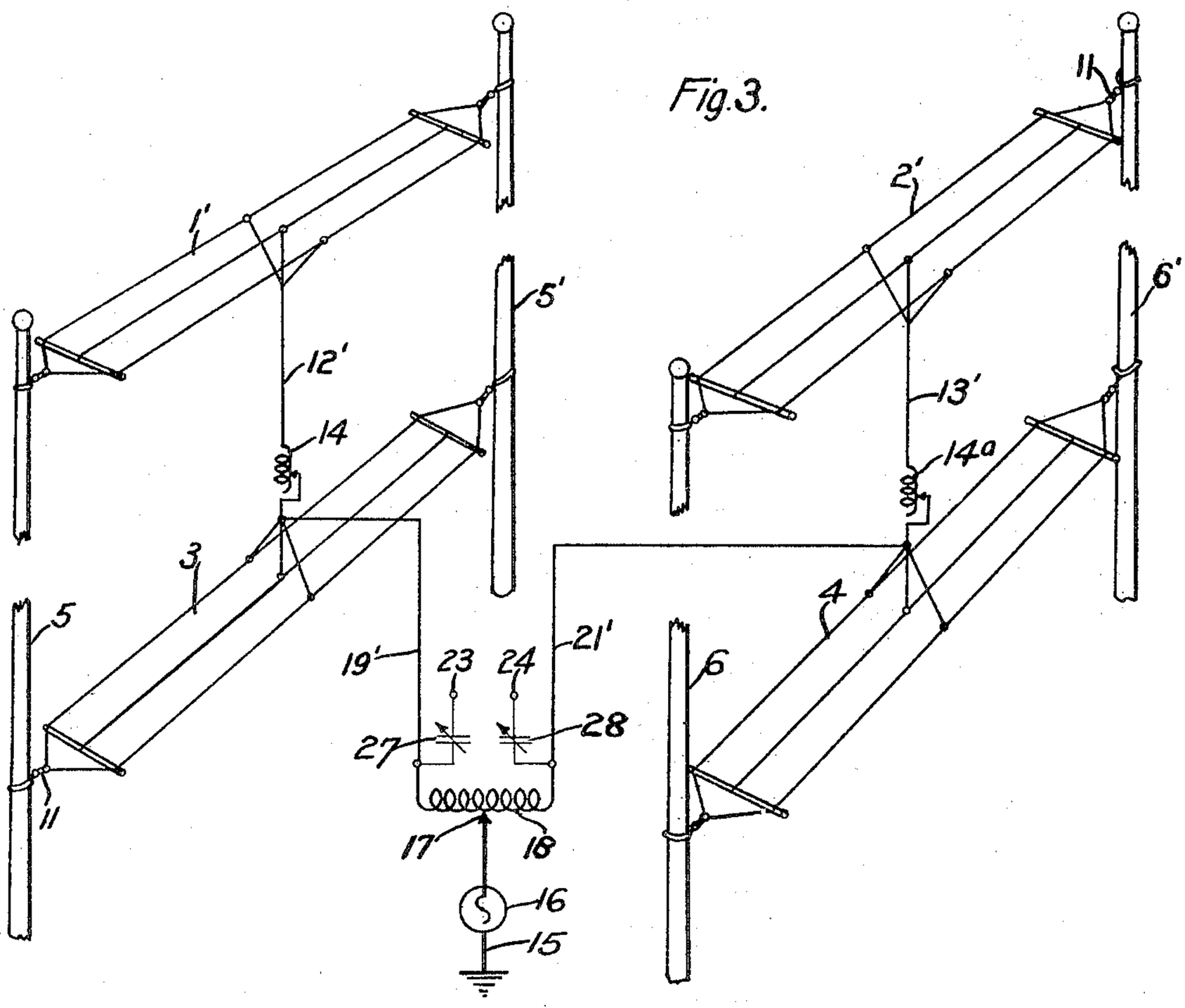

Fig. 5.

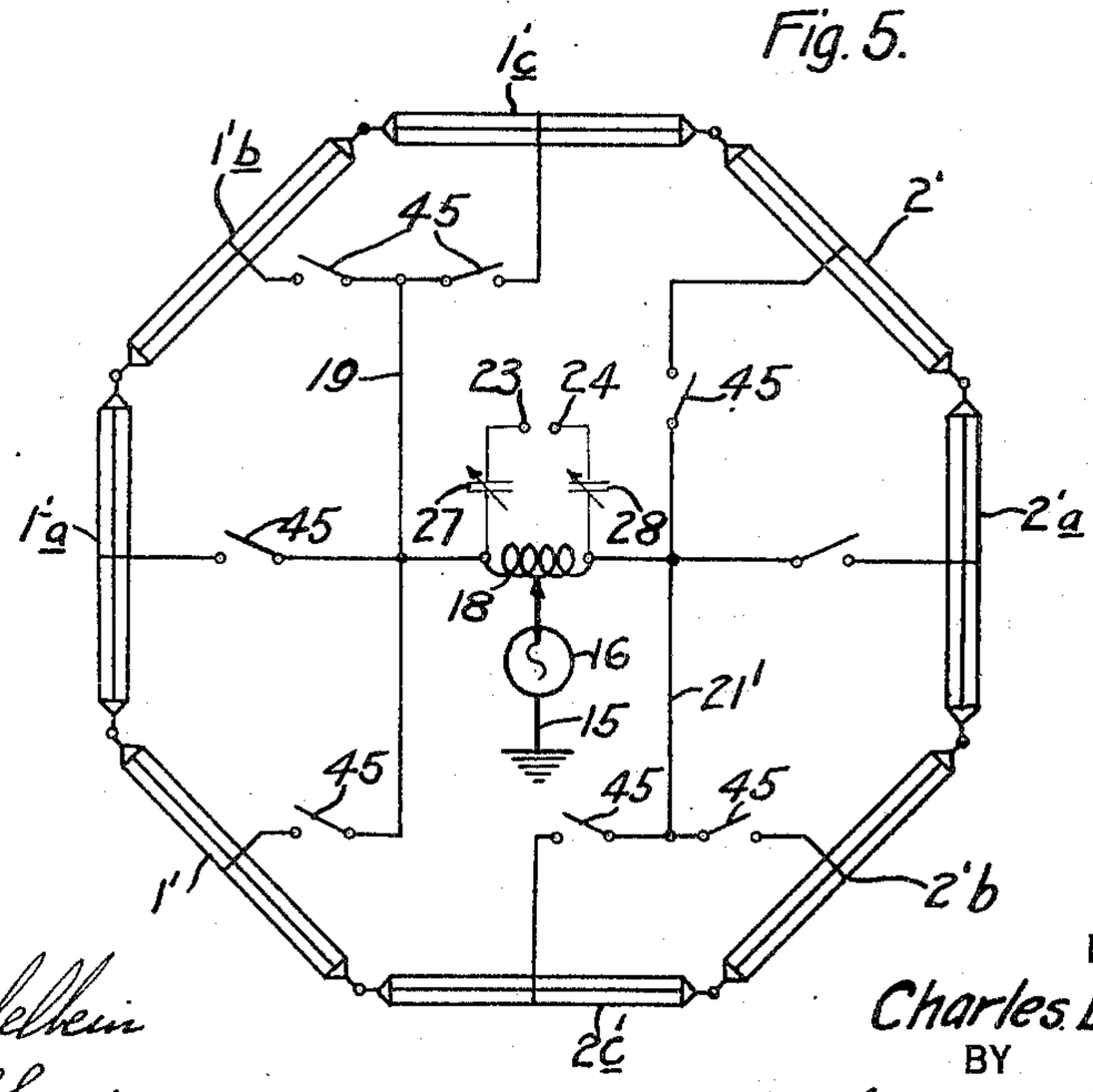

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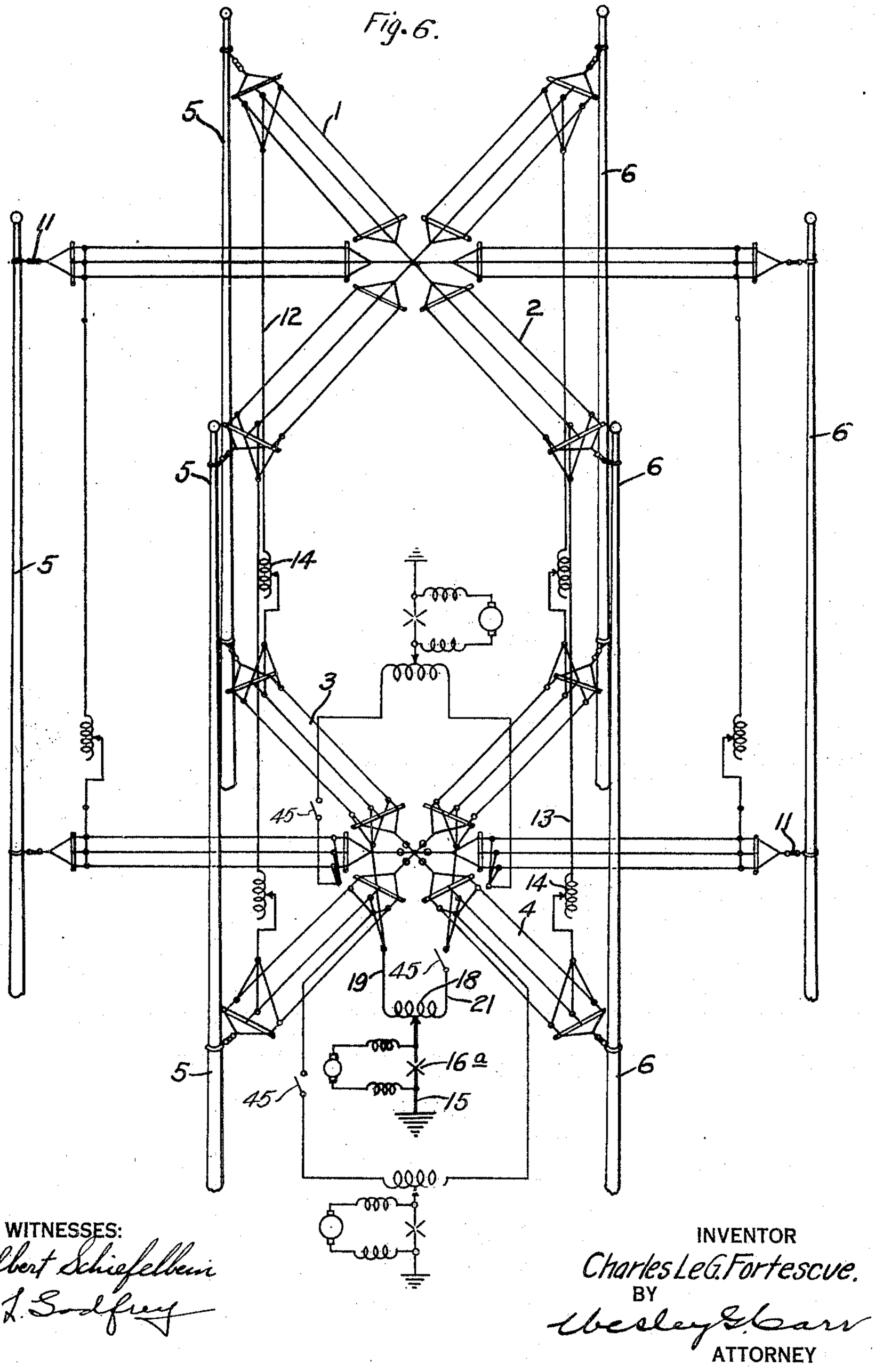
Fig. 6.



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UNITED STATES PATENT OFFICE.

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COMBINED WIRELESS SENDING AND RECEIVING SYSTEM.

Application filed December 31, 1921. Serial No. 526,228.

My invention relates to wireless telegraph systems and more especially to duplex wireless telegraph systems.

In its broad aspect, the object of my invention is to provide an improved wireless telegraph system wherein transmission and reception of wireless signals may be simultaneously effected.

More specifically, one object of my invention is to provide a wireless system of the above indicated character wherein transmission and reception of wireless signals may be effected upon a common wave length.

Another object of my invention is to provide a duplex wireless transmission system wherein simultaneous transmission and reception of signals may be effected without necessitating switching operations.

A further object of my invention is to provide an antenna system wherein the effects of certain forms of static impulses causing interference in wireless receiving systems may be eliminated.

A still further object of my invention is to provide an arrangement of radiating systems whereby several messages may be simultaneously transmitted and received over the same system.

Other objects of my invention will be apparent from the following description of the nature, the mode of operation, and the particular advantages of my invention.

My invention consists in the details of construction and operation and circuit arrangement hereinafter set forth and claimed and shown in the accompanying drawing, wherein—

Fig. 1 is a diagrammatic elevational view of a combined sending and receiving system embodying my invention;

Fig. 2 is a detail view showing a modification in the coupling of the antenna and the receiving circuits;

Fig. 3 is a diagrammatic perspective view showing a modification in the arrangement of the antennæ;

Fig. 4 is a view showing an equivalent-circuit diagram of the system embodying my invention;

Fig. 5 is a diagrammatic plan view showing one type of radiating system wherein the antennæ are symmetrically disposed with respect to a common center; and

Fig. 6 is a diagrammatic perspective view showing another arrangement of antennæ systems which are symmetrically disposed with respect to a common center.

In Fig. 1, I have shown a pair of antenna parts 1 and 2, which, for purposes of illustration, have been combined to form a single antenna, and a pair of additional antennæ 3 and 4 therefor. The antenna parts and additional antennæ are supported by towers 5 and 6. Adjacent terminals 7 and 8 of the additional antennæ 3 and 4, respectively, are connected by an insulator 9. The antenna parts and the additional antennæ may be insulated from the towers by means of insulators 11. Conductors 12 and 13 connect corresponding ends of the antenna parts 1 and 2 and the additional antennæ 3 and 4, respectively, to form a loop circuit. Inductance coils 14 and 14*a* are included in the respective conductors 12 and 13 for tuning purposes.

A grounded conductor 15, which may include a source of radio-frequency energy 16 is operatively connected to a midpoint 17 of a balance coil 18, opposite terminals thereof being connected to the terminals 7 and 8, of the additional antennæ by means of conductors 19 and 21, respectively. The balance coil 18 may be either of the iron-core or of the air-core type. In order to adjust any imperfections in the balance coil 18, an adjustable mutual-inductance device 22 may be so included in the conductors 19 and 21 as to equalize the currents flowing therein.

In some cases, where transmission and reception are effected at different frequencies, such small potential differences as may exist between the terminals of the coil 18, by reason of slight unbalancing in the radiating circuits, may be compensated for by shunting the terminals 7 and 8 with a circuit resonant to the transmitting frequency. Such circuit is shown in Fig. 1 and comprises an inductance coil 45 and condenser 46.

A receiving system of any well known type may be connected to terminals 23 and 24, the latter being electrically connected to terminals 7 and 8 by means of conductors 25 and 26, whereby a loop circuit is formed. In order to provide for the proper tuning

of the loop circuit, variable condensers 27, 28 are connected in the leads just mentioned. The tuning condensers 27, 28 may be adjusted either singly or together in such manner as to have equal capacities.

An alternative arrangement for operatively connecting the receiving circuit to the antenna circuit is shown in Fig. 2. Here it will be noted that the balance coil 18 is included in the leads 25 and 26 and that the receiving circuit is inductively coupled thereto through a coil 29. A condenser 31 may be shunted across the terminals of the latter coil, as is common in receiver circuits.

The system shown in Fig. 3 differs from that of Fig. 1 in the arrangement of antennæ. In this modification, the antennæ 1^1 and 2^1 have additional antennæ 3 and 4, and are separately supported by pairs of towers 5, 5′ and 6, 6′, the antennæ 1′ and 2′ being electrostatically coupled, whereas in Fig. 1 they are electrically connected at a point 32. Conductors 12′ and 13′ connect substantially midpoints of their respective antennæ and supplemental antennæ and, similarly, conductors 19′ and 21′ connect substantially midpoints of the supplemental antennæ 3 and 4 to the balance coil 18.

A better understanding of the operation of my invention may be had by referring to the equivalent circuit shown in Fig. 4. In this figure, a pair of parallel-resonant circuits 33, 34 are connected in parallel by the ground and by conductors 19 and 21, the balance coil 18 being serially included in said conductors. The parallel-resonant circuits may be energized from the common source of energy 16 which is included in a circuit extending from the ground to a midpoint 17 of the balance coil 18.

The parallel-resonant circuit 33 comprises a condenser 38, corresponding to the ground-capacity effect of the additional antenna 3, shunted by the tuning coil 14 in series with a condenser 37 which corresponds to the ground-capacity effect of the antenna 1. Similarly, the parallel-resonant circuit 34 comprises a condenser 41, corresponding to the ground-capacity effect of the additional antenna 4, shunted by the tuning coil 14*a* in series with a condenser 39 which corresponds to the ground-capacity effect of the antenna 2.

A connection between the right-hand terminals of the coil 14*a* in Figure 4 and the left hand terminal of the coil 14 is provided. In the equivalent circuit for the form shown in Figure 1, this is an all-metallic connection. In the equivalent circuit for the form shown in Figure 3, this connection is through a capacity. Figure 4, as drawn, therefore, is the equivalent circuit for Figure 3 but it may be used without difficulty in explaining the action of Figure 1 since the connection 43—44 acts merely as a connection in each case. The capacity 43 represents the capacity between the antennæ 1′ and 2′ of Figure 3. The connection when all-metallic instead of through a capacity corresponds to the connection at 32 in Figure 1.

Terminals 23 and 24 of a receiving system (not shown) may be connected, through leads 25, 26, to opposite terminals of coil 18 in a loop-receiving circuit comprising the coils 14, 18 and 14*a* and the condenser 43.

In operation, during transmission, energy is supplied to the radiating systems or so-called "parallel-resonant circuits" 33 and 34, as shown in Fig. 4, and is radiated from both circuits in accordance with well known principles. Since the currents supplied to the two transmitting systems are equal, and the point 17 is intermediate the ends of the coil 18, the net electromotive force impressed upon the terminals 23, 24 is zero.

Upon the receipt of signal impulses in the loop comprising the antennæ and conductors 12′ and 13′, variable potentials of signal frequency are impressed upon the terminals 23, 24 which may be detected by any of the well known receiving systems.

In view of the foregoing description, it may readily be seen that transmission and reception of signal impulses may be simultaneously effected and, if necessary, upon the same wave length.

In sending, my antenna system is particularly advantageous by reason of the fact that the radiating element may be supplied with power, at 100% power-factor, from a low-voltage, high-frequency generator, since no wattless or changing currents circulate through the generator.

In some cases, where transmission and reception are effected at different frequencies, such small potential differences as may exist between the terminals of the coil 18 by reason of slight unbalancing in the radiating circuits, may be compensated for by shunting the terminals 7, 8 with a circuit resonant to the transmitting frequency. Such circuit is shown in Fig. 1 and comprises an inductance coil 45 and a condenser 46.

In receiving, the foregoing arrangement of antennæ is particularly adapted to eliminate the disturbing effects of certain forms of static impulses. As may readily be seen, currents, which are induced in the antennæ by reason of potential differences between the space immediately surrounding the antennæ and the ground, and for other causes well known in the art, are balanced in their effects upon the receiving system. If necessary, the balancing of the static effects may be perfected by adjusting the relative heights of the upper antennæ or of the lower antennæ, or by adjusting one of the tuning coils 14, 14*a*.

In large high-power wireless stations, the

arrangement of antennæ shown in Fig. 3 lends itself to a form of construction shown in Fig. 5.

In the system there shown, pairs of antennæ 1′ and 2′, 1′*a* and 2′*a*, etc., and corresponding auxiliary antennæ (not shown) are so disposed as to form the sides of a polygon. Each pair of antennæ and their corresponding auxiliary antennae are connected to the common source of energy 16 through the balance coil 18, as shown in the previous figures. The several conductors which connect the auxiliary antennæ to the source of energy have no detrimental effects, serving merely to increase the capacity of the system.

The antenna system of Fig. 1 lends itself readily to a multiple-antenna system, as shown in Fig. 6, wherein the pairs of antenna parts 1, 2 and their corresponding additional antenna 3, 4 extend radially outwardly, in opposite directions, from a common central point. This system, has, for purposes of illustration been shown as comprising three distinct antennæ systems, each similar to that of Fig. 1.

When a number of messages are to be simultaneously transmitted each antenna system should employ a different frequency. In Fig. 5 I have shown provision for this by introducing switches 45 by which the several antennæ may be connected to the source at will. To simplify the drawing, I have shown but a single source. If a plurality of sources are used, of course, they would be of different frequencies. Any of the means known to the art for changing the frequency as the switches 45 are changed may if desired, be associated with the single source illustrated.

In Fig. 6 I have shown a plurality of sources, one for each set of antenna parts, with switches for connecting each source to its radiating system when desired. The several sources are illustrated as each supplied with an arc 16*a* so that the different frequencies may be obtained by differently tuning the associated circuits. Of course, any means of obtaining the different frequencies may be used instead, if desired.

The messages are superposed upon the frequencies by any usual modulating means. As the invention is in no way dependent upon the system of modulation used, these means have not been illustrated. Each of the several radiating systems should be supplied with its own modulating means in order that each may carry its own message.

While I have shown several embodiments of my invention it is capable of various changes and modifications without departing from the spirit thereof. I desire, therefore, that only such limitations shall be imposed thereon as are indicated by the prior art or specifically set forth in the appended claims.

I claim as my invention:—

1. In a wireless system, a pair of elevated antenna parts, said parts being operatively associated, a pair of additional antennæ therefor, a conductor connecting said additional antennæ, said conductor including an inductance coil, conductors for connecting said antenna parts to corresponding additional antennæ, said last-mentioned conductors including inductance coils for tuning purposes, a ground conductor and a source of radio-frequency energy included in said ground conductor, the ungrounded terminal thereof being connected to the mid-point of said first-named inductance coil.

2. In a wireless system, a source of energy, a plurality of tuned radiating circuits connected in parallel to said source of energy, each of said radiating circuits including antennæ of different heights and a tuning means between them.

3. In a wireless system, a plurality of tuned radiating circuits symmetrically connected in parallel to a common source of energy, each of said radiating circuits including an antenna and an additional antenna and a tuning means between them.

4. In a wireless system, a source of radio-frequency currents, a pair of radiating circuits connected in parallel to said source, each of said radiating circuits including antennæ of different heights and a tuning means between them, and means for so associating said antennæ as to form a loop circuit adapted for receiving purposes.

5. In an electrical system, a pair of parallel-resonant circuits, a source of energy, a pair of connecting means for connecting said circuits in parallel relation to said source, one of said means including an inductance coil, a circuit including said source of energy extending from the other of said connecting means to an intermediate point on said inductance coil, whereby substantially equal currents are supplied to said parallel-resonant circuits, and a circuit symmetrically associated with said inductance coil, whereby the currents supplied to said parallel-resonant circuits balance in their effect upon said associated circuit.

6. In an electrical system, a pair of parallel-resonant circuits, a source of radio-frequency currents, a pair of connecting means for connecting said circuits in parallel to said source, an inductance coil serially included in circuit with one of said connecting means, a circuit including said source and extending from the other of said connecting means to an intermediate point on said inductance coil, whereby substantially equal energy is supplied to said parallel-resonant circuits, and a receiving circuit operatively associated with said inductance coil, whereby the amounts of energy supplied to said parallel-resonant circuits bal-

ance in their effect upon said receiving circuit.

7. In a duplex wireless system, a pair of parallel-resonant circuits, each of said circuits comprising condensive and inductive elements, said condensive elements consisting of condenser effects between ground and each of two antennæ, a source of ultra-audio-frequency currents, a pair of connecting means for connecting said circuits in parallel to said source, one of said connecting means having an inductance coil serially included in circuit therewith, a circuit including said source and extending from the other of said connecting means to a midpoint of said inductance coil, whereby equal energy is supplied to said parallel-resonant circuits, and a receiving system associated in balanced relation with said inductance coil.

8. In a wireless system, a plurality of tuned radiating circuits connected in parallel to a common source of energy, each circuit comprising a pair of antennæ of different relative exposure to incoming signal impulses and a tuning means between them, said pairs of antennæ extending radially outwardly from a common center, and receiving means differentially responsive to the energy received on said antennæ.

9. A combined sending and receiving system for the electrical transmission of signals, including a balancing impedance element, sending and receiving devices differentially associated with said balancing impedance element, one of said devices including terminal conductors connected to the ends of said balancing impedance element, and a separate mutual-reactance element for equalizing the currents in said terminal conductors.

10. A combined sending and receiving system for the electrical transmission of signals, including a balancing impedance element, sending and receiving devices differentially associated with said balancing impedance element, said devices being adapted to respectively different frequencies, one of said devices including terminal conductors connected to the ends of said balancing impedance element, and a series-resonant circuit shunting said device and tuned to the frequency of the other device.

11. A radio transmitting system comprising a plurality of pairs of radiating circuits each including an elevated inductance and a capacity between an elevated conductor connected to said inductance and the earth, a source of energy for each pair of radiating circuits, the circuits of each pair being connected in parallel to the source common to said pair, and the circuits in different pairs being tuned to different frequencies.

In testimony whereof, I have hereunto subscribed my name this 19th day of December, 1921.

CHARLES LE G. FORTESCUE.