

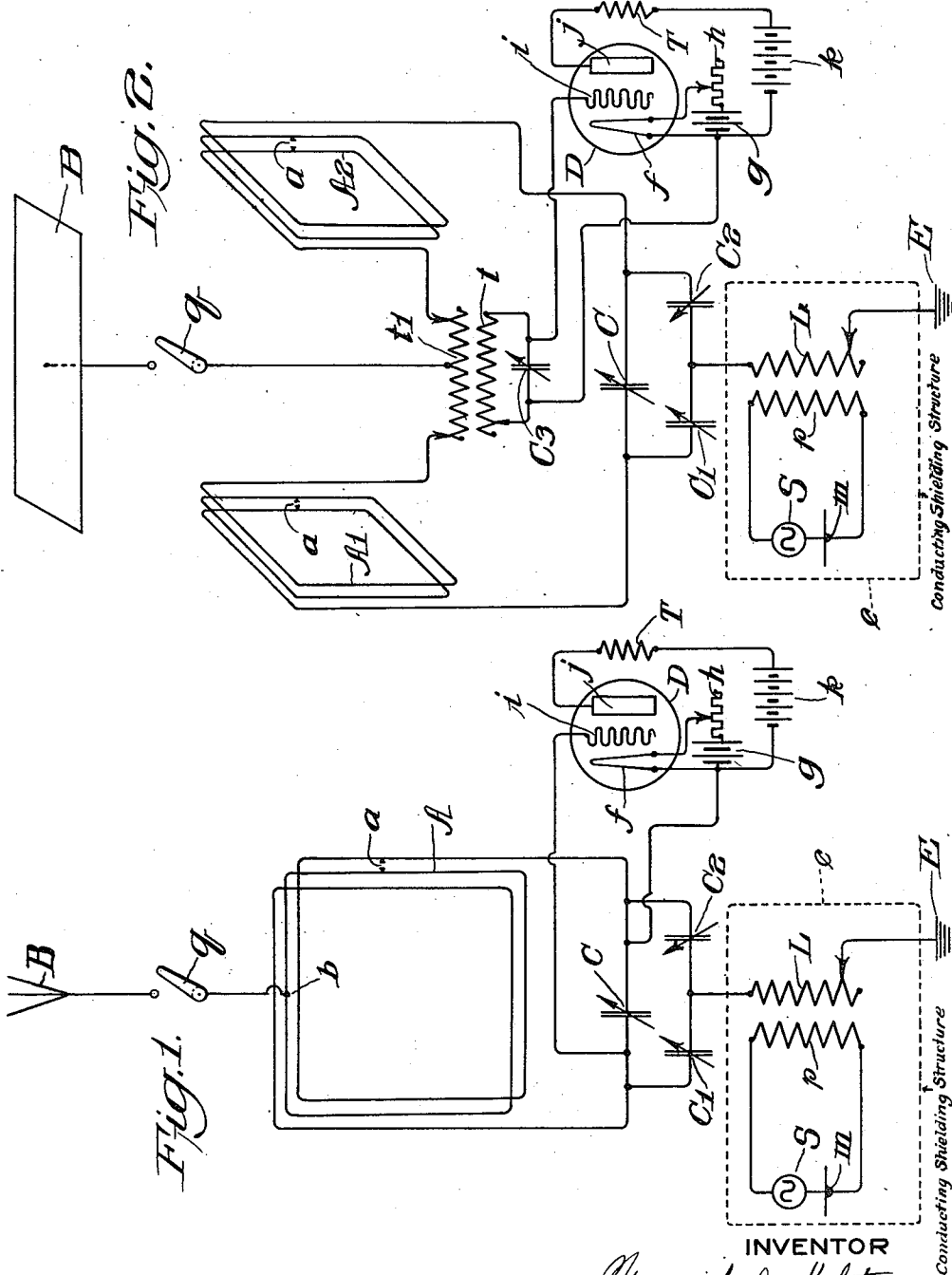
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RADIO METHOD AND APPARATUS

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UNITED STATES PATENT OFFICE.

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RADIO METHOD AND APPARATUS.

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My invention relates to apparatus for transmitting or receiving, or for transmitting and receiving electro-radiant energy or electro-magnetic waves for the transmission of intelligence, as for radio telegraphy or telephony, or for signaling in general, or for any other purpose.

My invention resides in apparatus for simultaneously transmitting and receiving telegraphic, telephonic or other messages without interference with each other and so enabling, particularly as regards radio telephony, the carrying on of conversation between widely separated stations in the usual manner practiced with wire telephony, without recourse to throwing of switches or change of connections.

My invention resides also in apparatus for simultaneously transmitting and receiving telegraphic, telephonic or other messages as above referred to by production of directional effects as regards reception.

My invention resides also in apparatus of the character above referred to, as well as to such apparatus when used for reception only, wherein reception is effected through an inductive coupling which is located in the center of one or more inductance coils comprised in a closed circuit or circuits, preferably having very small distributed inductance and distributed capacity.

My invention resides in the apparatus hereinafter described and claimed.

For an illustration of some of the various forms my apparatus may take, reference is to be had to the accompanying drawing, in which:

Fig. 1 is a diagrammatic view illustrating apparatus embodying my invention.

Fig. 2 is a diagrammatic view of a modified form embodying my invention.

Referring to Fig. 1, A is a coil, preferably rotatable, as for example, about a vertical axis, of one or more turns constituting a lumped inductance connected in series with the variable tuning condenser C. The distributed inductance and distributed capacity of this closed circuit are preferably substantially nil. The closed circuit, and particularly the coil A thereof, constitutes a capacity area with which may cooperate, if suitable or desired, an additional capacity area B of any suitable form, in the example illustrated an antenna-like capacity area.

When the additional capacity area or antenna B is employed, the switch *g* is closed, thereby connecting it to the aforesaid capacity area, such connection preferably being made at the middle of the coil A, as indicated at the point *b*. In shunt to the variable condenser C are serially connected the variable auxiliary or balancing condensers C¹ and C², variable complementarily to each other, that is, in such manner that when the capacity of one of them is increased the capacity of the other is decreased or varied in opposite sense. From a point between the auxiliary condensers is a connection to earth or other capacity E through the variable inductance L. To ensure that the coil A shall have, as a coil, minimum or substantially no distributed capacity and yet, as a capacity area, a maximum or large capacity with respect to earth or other capacity E, the coil A may have its neighboring convolutions or turns separated from each other by a suitable or considerable space *a*, whereby the distributed capacity effect due to capacity between neighboring turns or convolutions is reduced to a negligible amount or is substantially nil.

In shunt to the condenser C is connected any suitable detector D, here shown as a thermionic detector or audion, of any suitable structure or type, having the grid *i*, filament *f*, heated by current from battery *g* and regulated by resistance *h*, and a plate, wing or anode *j* in whose circuit is the battery *k* and the device T, which may be a telephone receiver or any other suitable device, as for example, a primary of a transformer or other suitable means for cooperation with one or more additional thermionic devices for effecting any suitable degree of amplification, and for beat reception, if desired.

The apparatus thus far described is substantially similar to apparatus described and claimed in my prior Patent No. 1,447,165, February 27, 1923, having for reception the directive or uni-lateral effects therein described.

With this apparatus is associated transmitting apparatus whereby spoken or other messages or signals may be received without interference by energy simultaneously transmitted and which may represent spoken or other messages, whereby a telegraphic or

telephonic communication may simultaneously be carried on between two widely separated stations without interference by the transmitted energy with the simultaneously received faint energy.

The transmitting apparatus may be of any suitable character, and is here generically represented diagrammatically by any suitable source S of high frequency oscillations controlled by any signaling instrument, as for example, a telephone transmitter or microphone m , the modulated high frequency energy being impressed by inductive action of the primary p only upon the secondary L , which is associated with the radiating structure comprised in part of the closed circuit, which is associated with the receiving apparatus or detector. The oscillations produced by the transmitting apparatus may be of the same frequency as the received energy, and though relatively very powerful as compared with the simultaneously received energy, cause no interference or conflict with the latter. In other words, the transmitter oscillations due to the symmetry of connection of the inductance L to the closed circuit will not cause interference with simultaneously received weak energy. Accordingly a person may hold to his ear the telephone associated with the detector D or the associated amplifying means, and speak into the microphone m , and so carry on a conversation, as in the case of ordinary wire telephony, with a party equipped with similar or equivalent apparatus at a distant station. It will be noted that no switches or changes of connections are necessary to alternate between receiving and transmitting relations, but that both transmission and reception may simultaneously occur without confusion.

It is preferable that around the oscillation producing means or around the transmitting apparatus be placed a conducting shell or screen, indicated in dotted lines by c , to prevent direct effect upon the receiving circuits of the locally produced oscillations of relatively high power. By use of such screen the oscillations produced in the inductance L have no effect upon the receiving apparatus, but flow in symmetrical or divided paths into the capacity area A , or A and B if the latter be used.

Referring to Fig. 2, the arrangement is in general the same as regards simultaneous transmission and reception of both spoken and telegraphic or other messages, the transmitting apparatus being as before associated with the inductance L and again preferably enclosed in a screen or shell c .

In this case there may be employed or not, as may be suitable or desired, any suitable capacity area B . In this instance illustrated, by way of example merely, as a plate or equivalent capacity area. The coil or

lumped inductance of the closed circuit is in this instance divided into a plurality of lumped inductances or coils A^1 and A^2 , whose distributed capacity and distributed inductances are preferably substantially nil. These coils A^1 and A^2 may be considered as a single coil or inductance, or as a plurality of coils or inductances, which may be parallel with each other or which may be disposed at an angle with respect to each other. In any event, the coil structure A^1 , A^2 is preferably rotatable so as to procure the directive effects hereinbefore referred to. Disposed preferably at the physical and electrical center of the inductance or coil structure A^1 , A^2 is an inductive coupling between the closed circuit, comprising the coils A^1 , A^2 and the adjustable condenser C , and the receiving circuit or apparatus including a detector D with which may be associated the telephone T or which may communicate to any number of steps of thermionic amplifying apparatus. The inductive coupling comprises the transformer windings t and t^1 , the latter being variable and connected in series with the coils A^1 , A^2 , and preferably located at their center, the capacity area B if employed, being brought into operation by closure of the switch g , the connection of this capacity area being preferably at the electrical center of the system, that is, preferably at or near the middle of the transformer winding t^1 . In circuit with the transformer secondary t is the variable condenser C^3 , for tuning such circuit to the first mentioned closed circuit. In shunt to the condenser C^3 is connected the grid circuit of the audion or similar thermionic detector D . In shunt to the variable condenser C , for tuning the closed circuit including the inductances A^1 and A^2 , are serially connected the condensers C^1 and C^2 , each variable, and varied generally in opposite senses or complementarily. The inductance L is again connected to a point between these last named balancing or auxiliary condensers.

By employing the inductive coupling t , t^1 , particularly when electro-magnetic waves of great length are to be received, and connecting it and placing it as described, extremely high selectivity is obtainable and extremely highly effective directional effects are obtainable, and when the closed circuit is unsymmetrical with respect to the open or antenna path, uni-lateral reception is obtained.

It will be understood that this inductive coupling arranged and disposed as described is of general application to reception, regardless of simultaneous transmission and reception. However, it does not interfere with simultaneous transmission and reception of the character referred to in connection with Fig. 1.

In both Figs. 1 and 2 the closed circuits including the inductances are connected symmetrically to the open antenna path, electrical symmetry between the closed circuit and the antenna path being with nicety obtainable by variation of condensers C^1 and C^2 .

While I have herein indicated two forms of capacity areas B, it will be understood that any other suitable form or type may be employed, and that all types may be interchangeably used with those indicated, and the forms indicated in Figs. 1 and 2 may be interchanged.

The coil or inductance structures hereinbefore referred to may be relatively small, such as may be suitable for portability, or may be relatively larger for permanent or stationary installations, and in either case may be rotatable.

As described in my aforesaid application, the dimensions of these coils or inductances may be very small as compared with the wave length received or transmitted.

The path through the inductance L of both figures and including the closed circuit as a capacity area may for brevity be referred to as an antenna path or structure, with the understanding that, particularly when the additional capacity area or antenna B is employed, such antenna path may have the structure or characteristics of high antenna structures now commonly employed in the art and thus have considerable distributed capacity and distributed inductance but, preferably, are of such structure, arrangement or size as to have relatively small or substantially no distributed capacity or distributed inductance.

As to both the open or antenna path and the closed circuit or path, and particularly the latter, it will be understood that it is preferred that the ratio of inductance to capacity shall be large, whereby higher selectivity is procured; and as to the closed circuit associated with the receiving apparatus or detector such ratio affords a higher potential for impression upon the detector of potential operated type, as a thermionic device.

Both the open or antenna path and the closed circuit or path may be attuned or adjusted to the same or substantially the same wave length or to different wave lengths for both transmission and reception, and for simultaneous transmission and reception.

With the closed circuit electrically symmetrical with respect to the open or antenna path, great amounts of energy may be impressed upon the open or antenna path for transmitting purposes without in any way affecting the closed circuit and the receiving apparatus or indicating means associated therewith. If there should be lack of

perfect symmetry, some of the energy of the transmitting apparatus will be transferred to the closed circuit and so interfere with reception of weak signal energy arriving from a distant station. In such case, however, it is only necessary to vary the condensers C^1 and C^2 , or either of them, to attain perfect electrical symmetry. It is preferred, however, that the condensers C^1 and C^2 be varied complementarily so that when varied they will not affect or destroy the tuning of the closed circuit.

When the coils A or A^1 , A^2 are rotatable, they may be so positioned that their vertical plane or planes coincide substantially with the vertical plane embracing also the distant transmitting station, in which case a directional reception effect is obtained.

What I claim is:—

1. The combination with a closed circuit including a coil absorbing energy directly from the natural media and a condenser, of a plurality of reactances in series with each other and in shunt to said condenser, an antenna path connected to a point between said reactances, means for impressing oscillations upon said antenna path, and receiving apparatus controlled by said closed circuit.

2. The combination with a closed circuit including a rotatable coil absorbing energy directly from the natural media and a condenser, of a plurality of reactances in series with each other and in shunt to said condenser, an antenna path connected to a point between said reactances, means for impressing oscillations upon said antenna path, and receiving apparatus controlled by said closed circuit.

3. The combination with a coil having a plurality of turns absorbing energy directly from the natural media, of a closed circuit including said coil, an antenna connected to a mid-point between the remote terminals of said coil, serially connected reactances associated with said coil, a second antenna connected to a point between said reactances, receiving apparatus controlled by said closed circuit, and means for impressing oscillations upon one of said antennae.

4. The combination with a coil having a plurality of turns absorbing energy directly from the natural media, of a closed circuit including said coil and a condenser, an antenna connected to a mid-point between the remote terminals of said coil, serially related reactances in shunt to said condenser, a second antenna connected to a point between said reactances, means for impressing oscillations upon one of said antennae, and receiving apparatus controlled by said closed circuit.

5. The combination with a closed circuit comprising rotatable inductive means ab-

sorbing energy directly from the natural media and capacity, of receiving apparatus affected by energy received in said circuit, an antenna path symmetrically connected
5 with respect to said inductive means, and transmitting apparatus associated only with said antenna path.

6. The combination with a closed circuit comprising rotatable inductive means having a plurality of turns absorbing energy
10 directly from the natural media and capacity, the distributing inductance and capacity of said circuit being substantially nil, of receiving apparatus affected by energy received in said circuit, an antenna path symmetrically connected with respect to said
15 inductive means, and transmitting apparatus associated with said antenna path only.

7. The combination with a closed circuit comprising an inductance coil and capacity, of receiving apparatus affected by energy
20 received in said circuit, an antenna path comprising capacities between which said closed circuit is symmetrically connected, and transmitting apparatus associated only
25 with said antenna path.

8. The combination with a closed circuit comprising rotatable inductive means and capacity, of receiving apparatus affected by
30 energy received in said circuit, an antenna path comprising capacities with respect to which said inductive means is symmetrically connected, and transmitting apparatus associated only with said antenna path.

9. The combination with a closed circuit comprising an inductance coil and capacity, of receiving apparatus affected by energy
35 received in said circuit, an antenna path comprising capacities between which said closed circuit is symmetrically connected, transmitting apparatus, and an inductive
40 coupling between said transmitting apparatus and said antenna path only.

10. The combination with a closed circuit comprising an inductance coil and a plurality
45 of capacities, of receiving apparatus affected by energy received in said circuit, an antenna path symmetrically connected to said closed circuit at a point between said capacities, and transmitting apparatus associated only with said antenna path.
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11. The combination with a closed circuit comprising a plurality of capacities and rotatable inductive means having a plurality
55 of turns absorbing energy directly from the natural media, of receiving apparatus affected by energy received in said circuit, an antenna path symmetrically connected with respect to said inductive means at a point
60 between said capacities, and transmitting apparatus associated only with said antenna path.

12. The combination with a closed circuit comprising an inductance coil and a plurality
65 of capacities, of receiving apparatus af-

ected by energy received in said circuit, an antenna path symmetrically connected to
said closed circuit at a point between said capacities and at substantially the mid point
of the entire inductance in said closed circuit, and transmitting apparatus associated
70 only with said antenna path.

13. The combination with a closed circuit comprising capacity and inductance coils
absorbing energy directly from the natural
75 media, of receiving apparatus, and an inductive coupling between said receiving apparatus and said closed circuit, said coupling comprising a winding disposed at substantially the center of said inductance
80 coils in the circuit thereof.

14. The combination with a closed circuit comprising capacity and inductance coils
absorbing energy directly from the natural
85 media, of receiving apparatus, and an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, said inductance coils being rotatable
90 independently of said coupling.

15. The combination with a closed circuit comprising capacity and inductance coils
absorbing energy directly from the natural
95 media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit, said coupling comprising a winding disposed at substantially the center of said inductance coils, and an antenna circuit symmetrically connected to
100 said closed circuit.

16. The combination with a closed circuit comprising capacity and inductance coils
absorbing energy directly from the natural
105 media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, said inductance coils being rotatable independently of said coupling, and an antenna circuit symmetrically connected to said
110 closed circuit.

17. The combination with a closed circuit comprising capacity and inductance
coils, of receiving apparatus, an inductive
115 coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit comprising capacities connected to said closed circuit at symmetrically opposite points thereof, one of
120 said capacities connected to substantially the middle of a coil of said coupling.

18. The combination with a closed circuit comprising capacity and rotatable inductance coils absorbing energy directly
125 from the natural media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit com-
130

prising capacities connected to said coils at symmetrically opposite points thereof, or of said capacities connected to substantially the middle of a coil of said coupling.

19. The combination with a closed circuit comprising capacity and inductance coils absorbing energy directly from the natural media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit symmetrically connected to said closed circuit, and transmitting apparatus associated only with said antenna path.

20. The combination with a closed circuit comprising capacity and rotatable inductance coils absorbing energy directly from the natural media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit symmetrically connected to said coils, and transmitting apparatus associated only with said antenna path.

21. The combination with a closed circuit comprising capacity and inductance coils, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit comprising capacities connected to said closed circuit at symmetrically opposite points thereof, one of said capacities connected to substantially the middle of a coil of said coupling, and transmitting apparatus associated only with said antenna path.

22. The combination with a closed circuit comprising capacity and rotatable inductance coils, absorbing energy directly from the natural media, of receiving apparatus, an inductive coupling between said receiving apparatus and said closed circuit disposed at substantially the center of said inductance coils, an antenna circuit comprising capacities connected to said coils at symmetrically opposite points thereof, one of said capacities connected to substantially the middle of a coil of said coupling, and transmitting apparatus associated only with said antenna path.

23. The combination with a closed circuit including capacity and a divided inductance coil absorbing energy directly from the natural media, of receiving apparatus affected by said closed circuit, and means for coupling said receiving apparatus to said closed circuit comprising a coupling coil connected between the parts of said inductance coil and in series with them in said closed circuit.

24. The combination with a closed circuit including capacity and a divided in-

ductance coil absorbing energy directly from the natural media, of receiving apparatus affected by said closed circuit, and means for coupling said receiving apparatus to said closed circuit comprising a coupling coil connected between the parts of said inductance coil and in series with them in said closed circuit, an antenna path connected to said closed circuit, and means for varying the symmetry of said closed circuit with respect to said antenna path.

25. The combination with a closed circuit comprising an inductance, an antenna path, means for symmetrically relating said path and said closed circuit with respect to each other, receiving apparatus co-acting with one of them, and transmitting apparatus co-acting only with the other of them, said means comprising a plurality of complementarily variable condensers at a point between which said antenna path and said closed circuit are connected to each other.

26. Apparatus for transmitting and simultaneously directly receiving high frequency energy, as electro-radiant energy, comprising a closed circuit including a rotatable coil, signal translating means controlled by the energy received in said closed circuit from a predetermined direction with respect to which said coil is positioned, an antenna path symmetrically related to said closed circuit, and transmitting apparatus associated only with said antenna path.

27. Apparatus for simultaneous transmission and reception of high frequency energy, as electro-radiant energy, comprising a circuit including an inductance coil and capacity, of indicating means affected by energy absorbed in said circuit, an antenna path, transmitting apparatus associated only with said antenna path, and means for preventing effect of the transmission upon the reception comprising a plurality of means, one for shielding the receiving apparatus from direct effect of the energy of said transmitting apparatus and another for symmetrically relating said circuit with respect to said antenna path.

28. The combination with a closed circuit including capacity and a divided inductance coil absorbing energy directly from the natural media, of a coupling coil connected between the parts of said inductance coil and in series therewith in said closed circuit, receiving apparatus controlled by said coupling coil, and an antenna connected to a point intermediate the terminals of said coupling coil.

29. The combination with a closed circuit including capacity and a divided inductance coil absorbing energy directly from the natural media, of a coupling coil connected between the parts of said inductance coil and in series therewith in said closed circuit,

receiving apparatus controlled by said coupling coil, a plurality of serially related reactances associated with said closed circuit, and an antenna path connected to a point between said reactances.

30. The combination with a closed circuit including capacity and a divided inductance coil absorbing energy directly from the natural media, of a coupling coil connected between the parts of said inductance coil and in series therewith in said closed circuit, receiving apparatus controlled by said coupling coil, a plurality of serially related reactances associated with said closed circuit, and an antenna path connected to said closed circuit.

31. The combination with a closed circuit including capacity and a divided inductance coil absorbing energy directly from the natural media, of a coupling coil connected between the parts of said inductance coil and in series therewith in said closed circuit, receiving apparatus controlled by said coupling coil, a plurality of serially related reactances associated with said closed circuit, an antenna path connected to said closed circuit, and means for varying the natural period of said antenna path.

32. The combination with a closed circuit including a loop antenna and a reactance, of reactances connected in series with each other in a path in shunt to said reactance, an antenna connected to a point between said serially related reactances, transmitting apparatus for effecting oscillations in one of said antennæ, and receiving apparatus controlled by the other of said antennæ.

33. The combination with a closed circuit comprising a loop antenna and a capacity, of a plurality of reactances connected in series with each other in a path in shunt to said condenser, an antenna connected to a point between said serially related reactances, transmitting apparatus for effecting oscillations in one of said antennæ, and receiving apparatus controlled by the other of said antennæ.

34. The combination with a closed circuit comprising a loop antenna and a capacity, of a plurality of capacities connected in series with each other in a path in shunt to

said capacity, an antenna connected to a point between said serially related capacities, transmitting apparatus for effecting oscillations in one of said antennæ, and receiving apparatus controlled by the other of said antennæ.

35. The combination with a closed circuit including capacity and inductance coils in direct energy-transfer relation with the natural media, of a circuit, means for coupling said circuit to said closed circuit at a region between said coils, and an antenna connected to said closed circuit at a region thereof remote from said coupling means.

36. The combination with a closed circuit including capacity and inductance coils, said inductance coils effecting direct transfer between themselves and the natural media of a substantial portion of the entire energy interchanged between said closed circuit and the natural media, of a circuit, and means for coupling said circuit to said closed circuit at a region between said inductance coils.

37. The combination with a closed circuit including capacity and inductance coils, said inductance coils effecting direct transfer between themselves and the natural media of a substantial portion of the entire energy interchanged between said closed circuit and the natural media, of a circuit, means for coupling said circuit to said closed circuit at a region between said inductance coils, and an antenna connected to said closed circuit.

38. The combination with a closed circuit including capacity and inductance coils, said inductance coils effecting direct transfer between themselves and the natural media of a substantial portion of the entire energy interchanged between said closed circuit and the natural media, of a circuit, means for coupling said circuit to said closed circuit at a region between said inductance coils, and an antenna connected to said closed circuit at a point between the terminals of said coupling means.

In testimony whereof I have hereunto affixed my signature this 22nd day of May, 1919.

FREDERICK A. KOLSTER.