Oct. 23, 1928. 1,688,554

R. H. RANGER

RADIOTELEGRAPHY

Original Filed Aug. 15, 1921 4 Sheets-Sheet 1

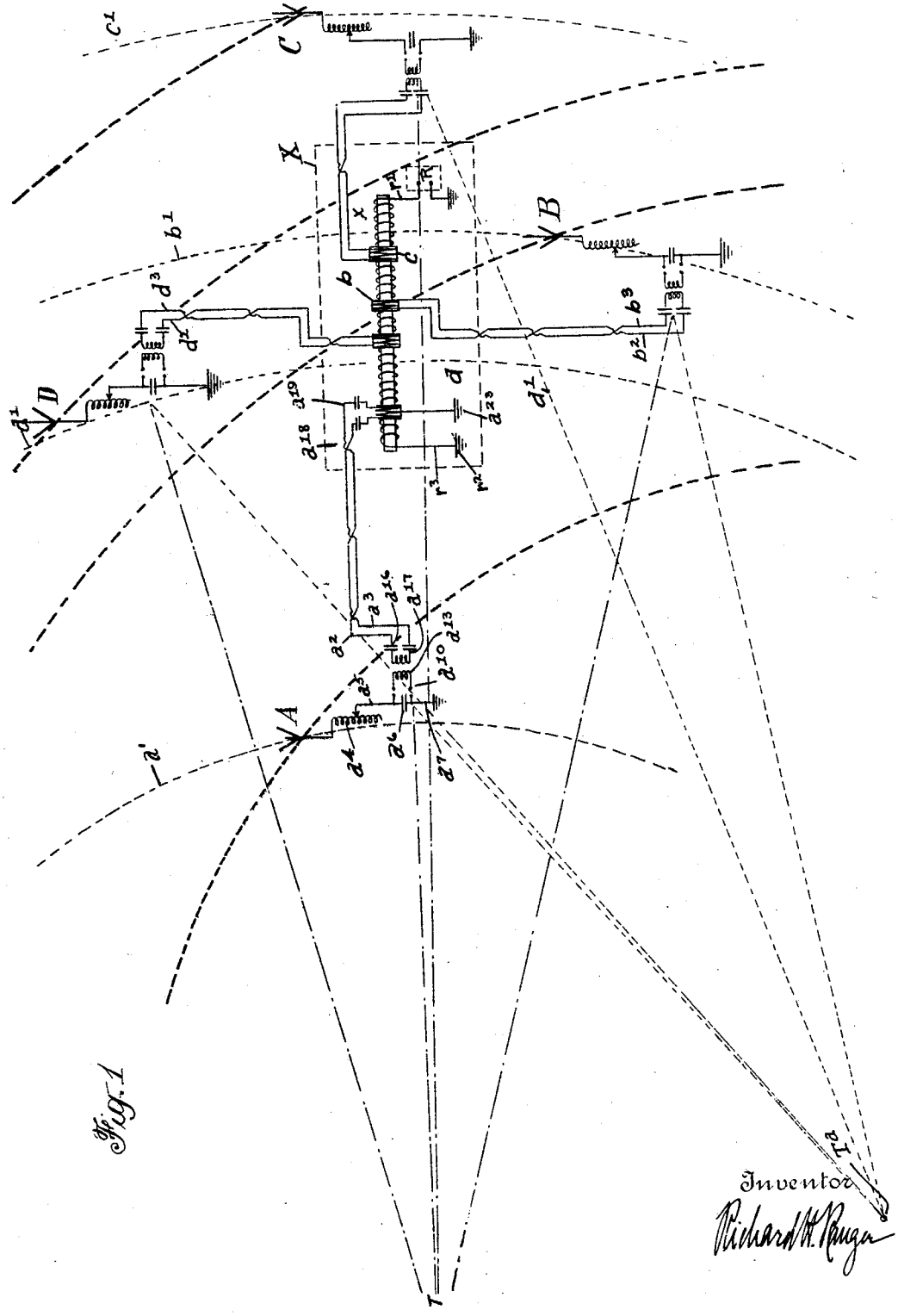


Fig. 1

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Fig. 2,

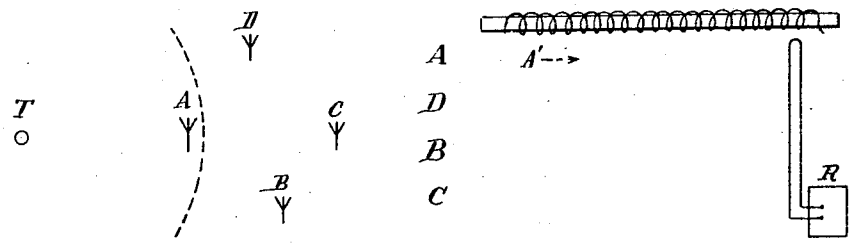


Fig. 3,

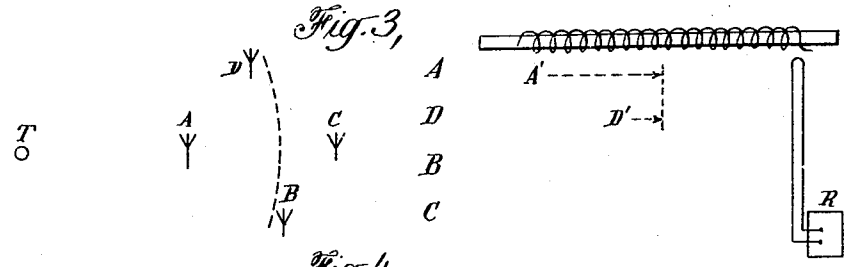


Fig. 4,

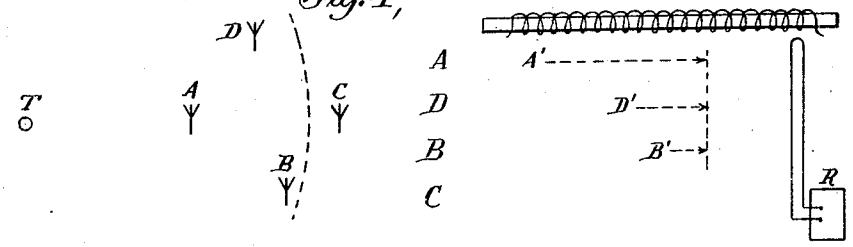


Fig. 5,

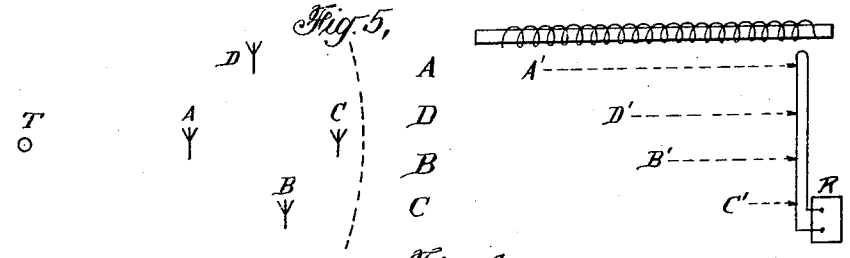
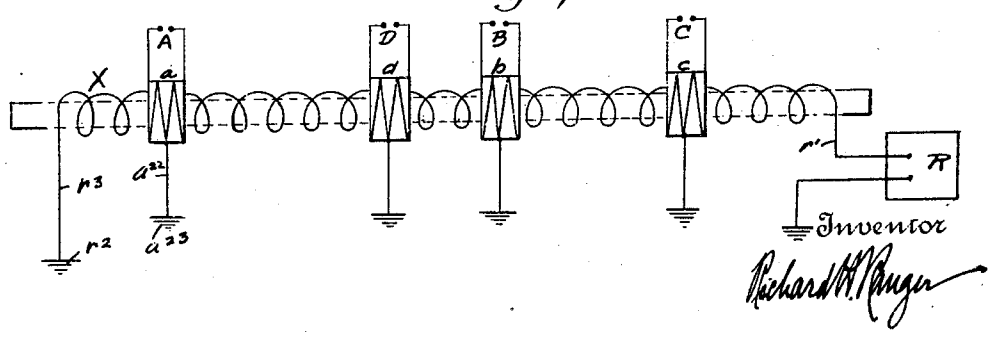


Fig. 6,



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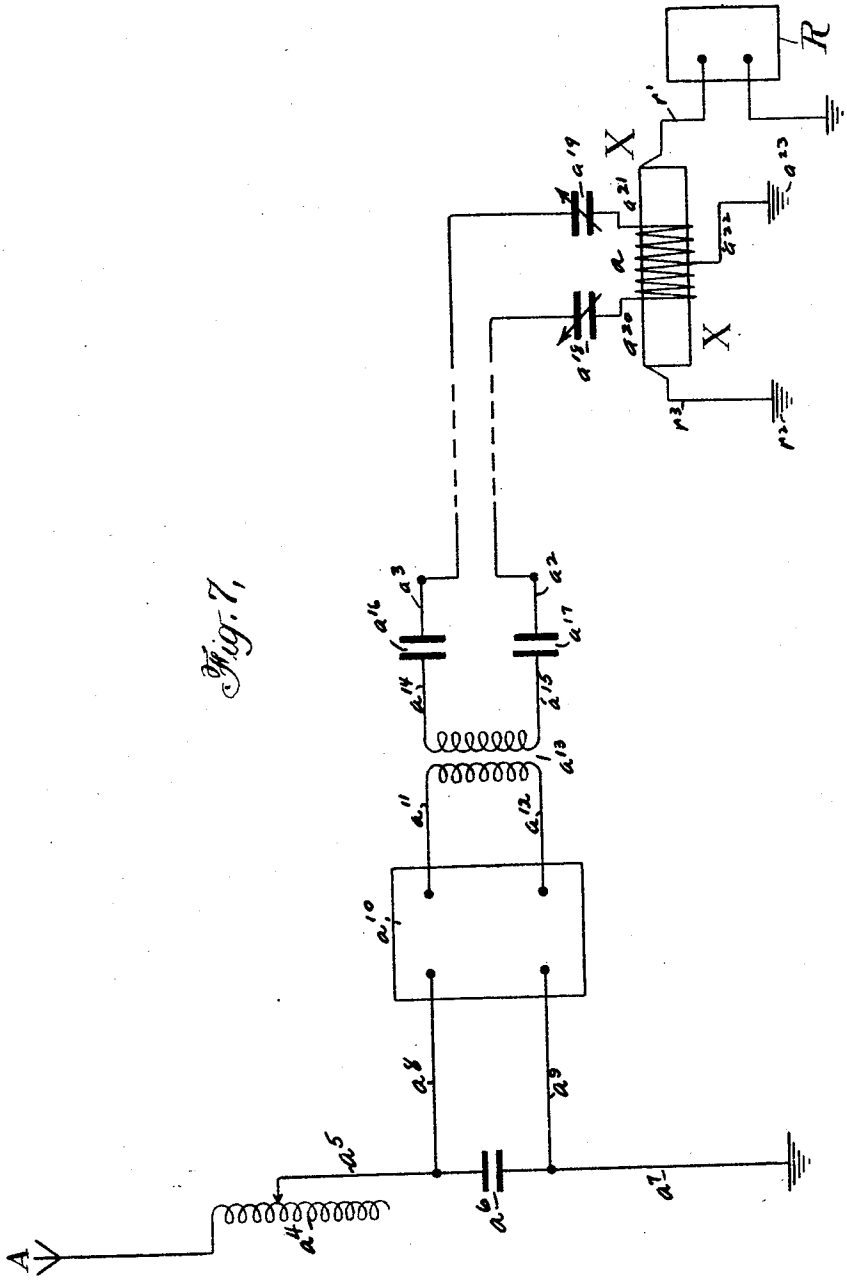


Fig. 7.

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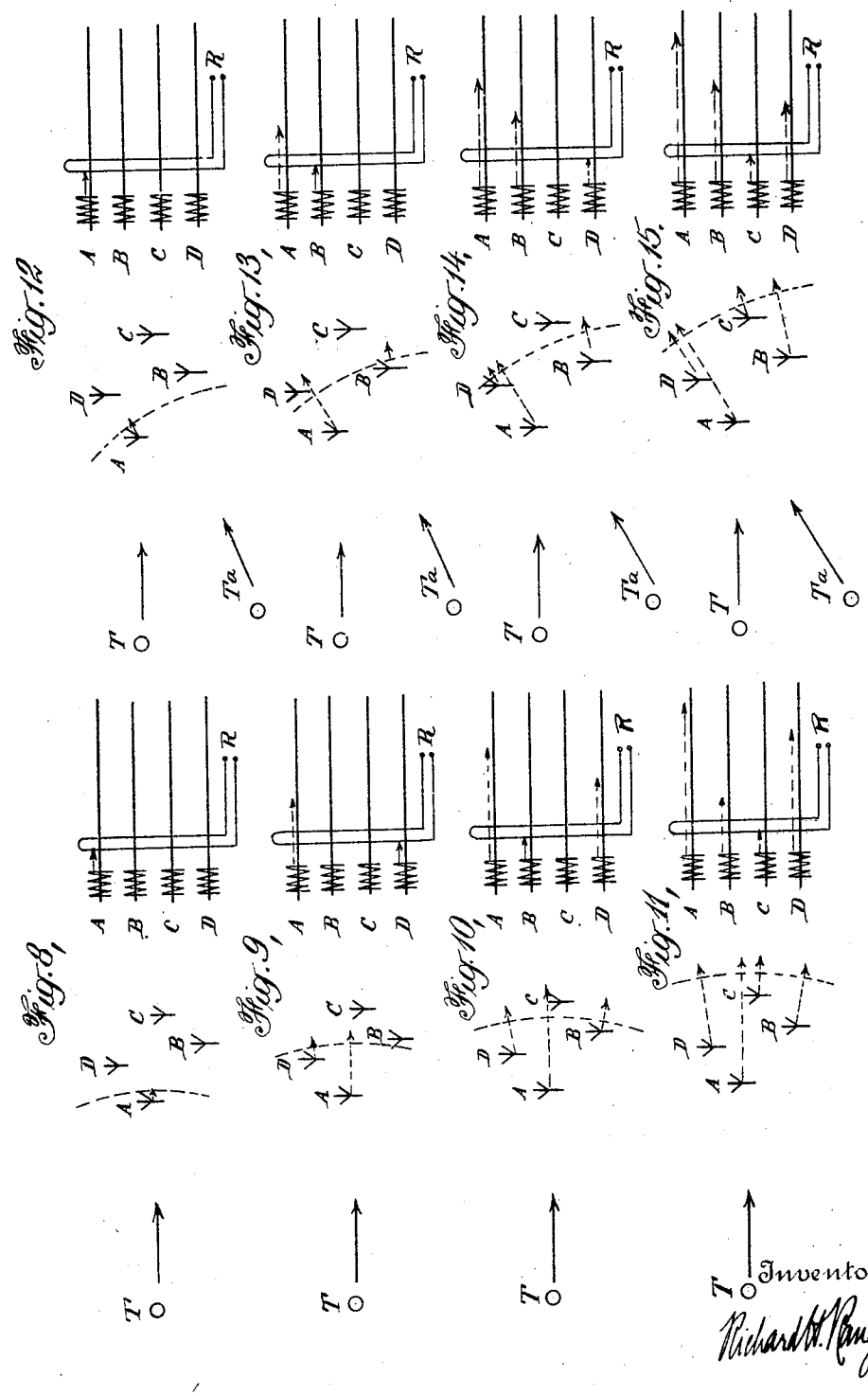
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RADIOTELEGRAPHY

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UNITED STATES PATENT OFFICE.

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RADIOTELEGRAPHY.

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The aim in view is to overcome the difficulties arising in radiotelegraphy from what is called "interference," that is to say the trouble which results when two stations working together are interfered with or "jammed" by other posts working at the same time.

Many methods for overcoming this difficulty have been proposed and the method universally adopted has been selectivity by syntonizing the sending and receiving stations to a given wave length. Now this method, although it has been fairly satisfactory up to the present for the relatively small number of stations established, is nevertheless subject to the criticism that it is limited, particularly as the number of stations increases. In fact, the range of possible wave lengths is not inexhaustible.

In order to introduce a new element of selectivity, radio goniometer loops giving a directional selectivity have been proposed. Their principal use has been for the determination of the direction of incoming transmissions, and this same direction factor has been used to a slight extent for the elimination of undesired signals. But this method has not become general, due to the low efficiency of goniometer loops and the complexities involved when refined adjustments are sought.

On the other hand, there have also been quite recently proposed, the systems designed by Weagant and Alexanderson, in which a receiving station is arranged in such a manner as to use not one, but two antennæ placed in a particular relation with respect to the direction of the transmitting station they are to work with, and to the direction of the transmitting station whose signals are to be rendered ineffective. In these systems, it is also necessary for the effective distance between the two antennæ to bear a definite relation to the wave lengths employed.

It should be noted that these means proposed by these two inventors have made a certain progress in the art of radiotelegraphy, but a receiving station designed by either of these two methods is limited to the wave length and transmission directions for which it was designed. Also, the arrangements given for the combining of the effects of the two separate antennæ leave much to be desired, particularly as to the difficulty of refined regulation and lack of flexibility.

The present invention overcomes the above mentioned difficulties by providing a plurality of receiving antennæ, separate and distinct from each other, the position of which is used for selecting between various transmitting stations.

The location of a receiving antenna with respect to a transmitting station determines the time interval between a transmission and the moment it reaches the receiving antenna. With several receiving antennæ separated from each other, the moment at which the impulses reach the various antennæ will vary with the distance of the transmitting station from each antenna. With transmitting stations at various localities, the moments of arrival of the impulses will change, due to the changes in these distances from these transmitting stations to the separate antennæ.

According to the invention, applicant makes use of these changes in the moment of arrival of the said impulses to select the transmissions desired. In other words, the location of a transmitting station constitutes, with respect to the group of antennæ, a factor by means of which the signals of such station can be brought into action or rendered ineffective, regardless of the wave length employed and even if the receiving set is tuned for that wave length.

This invention is based on the principle that, in order to receive a given station, the effects of the impulses which that station transmits must be brought collectively to the receiving set at the same instant and that in order to cancel the effects of an undesired station, the effects of that station must be neutralized by having them act separately over a relatively considerable range of time.

This result is accomplished, broadly speaking, by the application of a principle which consists in controlling at will the time of arrival of any of the said effects by varying the length of travel of the effect from a receiving antenna to the receiving set.

The separate antennæ used may be of any of the regular types and even loops may be used, whose added directional characteristics might be of advantage.

The accompanying drawings illustrate, by

way of an instance only, the manner in which the invention can be carried out.

Figure 1 is a diagram showing a receiving station organized in accordance with the principles of the invention.

Figures 2 to 5 are diagrams showing the effects successively produced by the passage of an impulse from a transmitting station to a receiving station.

Figure 6 is a diagram illustrating the arrangement of the coil used.

Figure 7 is a diagram showing in detail the electrical connections between an antenna and the receiving coil.

Figures 8 to 11 are diagrams illustrating the effect which would be produced if the coil levised in accordance with this invention were not used.

Figures 12 to 15 are diagrams illustrating the effects which would be produced if, with the installation adjusted as explained with reference to Figure 1, impulses were sent out from a different transmitting station.

Referring to Figure 1, T designates a given transmitting station and A, D, B, C, a number of separate antennæ. These antennæ may be at equal or different distances from each other and from the station T. For the purpose, however, of clearly illustrating a general case, it has been assumed here that the antennæ are not only at different distances from the station T, but also at different distances from each other. As will appear from the figure, antenna A is the closest to T, antenna D is further away, antenna B is a little further away and antenna C is further away still; and it will be seen that antenna D is nearer to A than are B or C.

a^1, b^1, c^1, d^1 illustrate the wave fronts of the impulse transmitted by T, as it reaches the respective antennæ. From each antenna starts a pair of wires a^2 a^3, b^2 b^3, c^2 c^3, and d^2 d^3 leading to the receiving station X. The connection between the antennæ and the wires leading to the receiving station may be effected in any manner suited to radiotelegraphy. But applicant has devised a particular connection which is illustrated in Figure 7, the characteristic feature of which resides in that the effects of the leading-in wires as antennæ are neutralized. In the said connection, antenna A leads to a loading coil a^4, from which starts a wire a^5 leading to a condenser a^6 and is then grounded by wire a^7. Across the condenser a^6 are taken two taps a^8 a^9 leading to a high frequency amplifier a^{10}, which has no detecting action and the outlet of which is taken by wires a^{11} a^{12} to a transformer a^{13}. From the latter start two wires a^{14} a^{15} leading to condensers a^{16} a^{17}, connected by the line wires a^2 a^3 to the receiving station X. At that station, these wires are led to variable condensers a^{18} a^{19} which are, in turn, connected by wires a^{20} a^{21} to a movable coil a adapted to be shifted along a long stationary coil x installed at the receiving station X. The coil a is grounded, by its middle point, by a wire a^{22} at a^{23}, the other coils being similarly grounded. Three other movable coils d, b, c also slidably mounted on the stationary coil x are connected to the corresponding antennæ D, B, C.

The remaining antennæ D, B, C, whatever may be their number, are connected to the stationary coil x in the same manner as antenna A, through the same elements, not herein illustrated, up to their respective movable coils d, b, c, Fig. 1: the latter are likewise grounded at their middle points, as above explained.

Figure 6 is a diagram illustrating the said coil x upon which are slidably arranged the set of movable coils a, d, b, c of Figure 1, each of the latter receiving the effects from the antennæ A, D, B, C respectively. The coil x is connected, at one end, to the receiving set R by wire r^1 and is, at the other, grounded at r^2 by a wire r^3.

The operation is as follows. If we consider an impulse transmitted from station T, it will, after a certain time interval, just pass antenna A, as shown in Figure 2, and an effect will have been transmitted along the wires a^2 a^3 to the movable coil a, Figure 1 and this effect will have thus travelled a certain distance A^1, Fig. 2, along the long coil x. At a certain time interval later, as indicated in Figure 3, the impulse will have passed antenna D and will likewise produce an effect which will, in the same manner, start to travel a certain distance D^1 along the said coil x. In the meantime, the first named effect will have continued to travel a further distance A^1, Fig. 3, along the coil. Due to the relative position of the movable coils a and d on the stationary coil x, found easily by trial, the two effects travel together. At a succeeding time, the impulse will have passed antenna B and produced an effect D^1, Fig. 4, adjusted to travel down the coil x with A^1 and D^1. Finally, when the impulse has passed antenna C, the effect C^1, Fig. 5, will join in and all four effects will reach the receiver R at the same moment to produce their maximum combined effect.

In view of the fact that each of the wires a^2 a^3, b^2 b^3, c^2 c^3, d^2 d^3, leading from the antennæ A, D, B, C, to the movable coils a, d, b, c besides normally conveying the effects to the long coil x, acts as an antenna itself, this would disturb the effects desired. It is therefore necessary to neutralize this undesired effect.

This result is accomplished by the hereinbefore described arrangement shown in detail in Figure 7 and consisting of the transformer a^{13}, the condensers a^{16}, a^{17}, the adjustable condensers a^{18} a^{19} and the grounding of the middle point of the movable coil a at a^{23}. With this arrangement, each wire such as a^2,

b^2, c^2, d^2, in conjunction with the adjustable condenser a^{18}, wire a^{20} and one half a^{23} of the movable coil a, acts as a regular antenna which may be tuned by the adjustable condenser a^{18}. In the same manner, the wire a^3, in conjunction with the adjustable condenser a^{19}, wire a^{21}, and the other half a^{24} of the coil a, may also be tuned as a regular antenna.

Inasmuch as the two wires a^2, a^3 occupy practically the same relation with respect to any transmitted impulse the effects produced in them as antennæ will be identical if they are tuned to exactly the same period. The movable coil a is a continuous winding, so that an effect entering it from wire a^{20} will produce an effect by magnetic induction in the long coil x exactly opposite to that which an equal effect would produce entering the coil by a^{21}. So that once these two circuits as antennæ are equally tuned, any impulse acting on them will produce effects which are cancelled automatically in the coil a. Coil a continues, however, to play its rôle of transferring to the long coil x any effect produced in the circuit a^{15}, a^{17}, a^2, a^{18}, a^{20}, a, a^{21}, a^{19}, a^3, a^{16} and a^{14} received from the transformer a^{13}. Also, in order to prevent the two wires a^2 a^3 from forming a single loop in which effects will be produced as with a goniometer, it is necessary that the two wires be transposed frequently, see Figure 1, in order to cancel any such effects, as is regularly done in telephony.

From the foregoing explanation, it will be readily understood that the distance travelled over the long coil x by the various effects A^1 D^1 B^1 C^1 (Figs. 2 to 5) are functions of the distances of the antennæ A, D, B, C, from the transmitting station T.

It will likewise be understood that there is a certain time interval between the reception of an impulse of an antenna as A and the delivery over the line wires to the receiving set of the effect of that impulse to the movable coil as a. But it has been assumed, for the sake of simplicity in illustration, that this time interval is the same for each of the antennæ, so that the effects are produced substantially as shown in Figures 2 to 5, neglecting this common time interval. If the paths between the antennæ and the movable coils are not the same, it merely means that a corresponding modification in the position of the movable coils is effected when the adjustment by trial produces its maximum effect.

In order that the hereinbefore described operation may be still further made clear, let us now explain what would happen if, in the case of the same installation and the same transmitting station T, no provision were made, i. e. no movable coils were used, for modifying the time of delivery of the separate effects from the antennæ to the receiving set R. This is shown in the diagrams of Figures 8 to 11, wherein separate coils a, b, c, d receiving the effects of the corresponding antennæ A, D, B, C, act directly on the receiving set R. Figure 8 illustrates the effect received when the impulse has passed antenna A. The effect is transferred immediately to the coil x^1 which delivers it to the receiving set R. At an instant later, the impulse will have passed D, as shown in Figure 9 and, in turn, will act upon the coil x which delivers it to the receiver, as above explained. Likewise, the effects of the impulse on B and C will, see Figures 10 and 11, be delivered to the coil x^1 and then to the receiver.

Now in view of the fact that, in the absence of any time control as provided under the present invention, the various effects arrive independently of each other at different times, no summing up of the effects is achieved, as will be clearly seen from an inspection of Figure 11.

And in order that the hereinbefore described operation according to the present invention may be still further made clear, let us assume, as illustrated in Figure 1, that another transmitting station T^a also sends an impulse to the same group of antennæ A, D, B, C and that the movable coils a d b c are adjusted on the long coil x to receive impulses from station T.

In such case, by an analysis analogous to that of the impulses received from T in Figures 2 to 5, the time of arrival of the separate effects for station T^a will be made to appear from Figures 12 to 15. It is evident that they arrive at odd moments and therefore their effects are not combined. In order to make them combine, an adjustment of the movable coils has to be made, as hereinbefore explained.

Having described my invention, what I claim is:

1. In radio receiving systems, the combination of a plurality of separated receiving antennæ, a common receiving apparatus, a relatively long coil connected thereto and a plurality of coupling coils, one associated with each antenna and with said long coil, said coupling coils being independently shiftable relatively to said long coil.

2. In radio receiving systems, the combination of a plurality of separated receiving antennæ, a common receiving apparatus, an artificial line connected thereto, and means associated with each of said antennæ for transferring energy to said artificial line, said means being independently adjustable with respect to each other and to said artificial line.

3. In radio receiving apparatus, the combination of a plurality of receiving antennæ, a common receiving apparatus to be controlled by said antennæ, a relatively long coil forming substantially an artificial line connected thereto, transmission lines connected to said antennæ, each of said lines terminat-

ing in means for transferring energy to said long coil, each of said means being independently adjustable with respect to each other and to said long coil.

4. In radio receiving systems, the combination of a plurality of receiving antennæ having different characteristics, a common receiving apparatus for said antennæ, a relatively long coil connected thereto, transmission lines for connecting said antennæ to said common apparatus, said transmission lines terminating in coils coupled to said relatively long coil and independently adjustable with respect thereto.

5. In radio receiving systems, the combination of a plurality of receiving antennæ having different characteristics, a common receiving apparatus, a relatively long coil connected thereto, and transmission lines for connecting said antennæ to said common apparatus, said transmission lines each terminating in a coil coupled to said long coil, and each of said coils being grounded substantially at the mid-point thereof and being independently adjustable with respect to each other and to said long coil.

6. In a radio receiving system, the combination of a plurality of separated receiving antennæ, a common receiving apparatus, means for transferring the energy received at each antenna to the said common receiving apparatus, said means being so constructed and arranged that energy absorbed thereon is without effect upon said receiver, and means for independently adjusting the phase relation of the currents from each antenna with respect to the currents from the other antennæ at said receiving apparatus.

7. In a radio receiving system, the combination of a plurality of separated receiving antennæ, a common receiving apparatus, means for causing said antennæ to control the response of said receiving apparatus, said means being constructed and arranged in a manner to prevent action thereof as an antenna, and means for controlling the phase relation of the current from each antenna with respect to the current from every other antenna at said receiving apparatus.

8. In radio receiving apparatus, the combination of a plurality of separated receiving antennæ, a common receiving apparatus to be controlled by said antennæ, a plurality of transmission lines connecting said antennæ to said receiving apparatus, said transmission lines being so constructed and arranged as to prevent action thereof as antennæ, and means for independently controlling the phase relation of currents from any antenna with respect to the currents from any other antenna at said receiving apparatus.

9. In radio receiving apparatus, the combination of a plurality of widely separated receiving antennæ, a common receiving apparatus for said antennæ, a plurality of transmission lines connecting said antennæ to said receiving apparatus, means for balancing said transmission lines to prevent the operation of said receiving apparatus in response to energy absorbed by said transmission lines, and phase shifting means for independently controlling the phase of current received from each antenna at said receiving apparatus.

10. In radio receiving systems, the combination of a plurality of receiving antennæ having different characteristics, a common receiving apparatus for said antennæ, transmission lines connecting said antennæ to said common apparatus, means for balancing said transmission lines comprising means for selectively tuning each side of said transmission lines, and means for independently regulating the phase of currents from said transmission lines at said receiving apparatus.

11. In radio receiving systems, the combination of a plurality of antennæ having different characteristics, a common receiving apparatus to be operated by said antennæ, transmission lines connecting each of said antennæ to said receiving apparatus, said transmission lines being coupled to said antennæ and said receiving apparatus, means for balancing each side thereof independently, and means for independently controlling the phase relation of currents from each of said antennæ to obtain any desired phase relation between said currents at said receiving apparatus.

12. In radio receiving systems, the combination of a plurality of antennæ having different characteristics, a single receiving apparatus to be operated by said antennæ, transmission lines connecting each of said antennæ to said receiving apparatus, said transmission lines being coupled to said antennæ and to said receiving apparatus and being provided with means for balancing each side thereof independently, and phase shifting means for controlling the phase relation of the various currents at said receiving apparatus.

13. In radio receiving systems, the combination of a plurality of antennæ having different characteristics, a common receiving apparatus to be controlled by said antennæ, a plurality of transmission lines for connecting said antennæ to said receiving apparatus, said transmission lines comprising a metallic circuit inductively coupled to said antennæ and to said receiving apparatus and provided with means for separately tuning each side thereof and being grounded substantially at the mid-point of the coupling to said receiver whereby currents due to the antenna effect of said wire will produce equal and opposite effects in said receiver, and means for independently controlling the phase relation of the various currents at said receiving apparatus.

14. The method of controlling the combination of electrical waves between two reception points which comprises applying said waves to a single path of variable length, varying a portion of the length of the said path effective for each wave, and utilizing the resultant of said waves in a portion of said path common to said waves.

15. The method of controlling the phase relation of two electric waves to be combined which comprises passing at least one of said waves through a single path of variable length with respect to each wave and varying the effective length of said path to produce a like phase relationship between both of said waves.

16. The method of regulating the phase relation of a plurality of electric waves to be combined, which consists in passing all of said waves through a single path having a portion common to all of said waves and varying the effective length of the path of each wave whereby the desired phase relation between said waves at the combining point is produced.

17. An arrangement for controlling the time of transmission of electric waves between two points comprising an artificial line having smooth concentrated inductance and capacitance interposed between said points, a source of electric waves at one of said points arranged to propagate electric waves along said line, and means for varying the effective length of said line, whereby the time of travel of said waves between the said points may be controlled at will.

18. An arrangement for controlling the time of passage of electric waves between two points comprising an inductance coil interposed between said points, said coil having sufficient uniformly distributed capacity and smoothly concentrated inductance to have the characteristics of an electrically long line, a source of electric waves located at one of said points and arranged to propagate electric waves along said coil, and means for varying the effective length of said coil to control the time of travel of said waves between said points.

19. An arrangement for controlling the time of passage of electric waves between two points comprising an inductance coil interposed between said points, said coil having sufficient uniformly distributed capacity to ground and uniformly concentrated inductance to constitute an artificial line, a source of electric waves located at one of said points and connected to said coil, and means for rendering ineffective any desired portion of said coil, whereby the time of travel of said waves between said points may be controlled.

20. In an arrangement for controlling the time of travel of electric waves along a wire line, an inductance coil having uniformly distributed capacity and inductance, the effective electrical length of the coil being at least an appreciable fraction of the length of the wave to be transmitted thereover.

21. In an arrangement for controlling the time of travel of electric waves along a wire line, a source of wave energy for propagating waves along said line, and means for causing any desired phase shift up to several complete cycles between the wave at the beginning and end of its path on said line.

22. The method of controlling the time transmission of electrical waves between two points which consists in passing said waves through an electrically homogeneous path producing a smooth wave-time change therein and removing wave energy therefrom by electro-magnetic induction.

23. The method of combining a plurality of waves which consists in inductively conveying said waves to an electrically homogeneous path at different points therein, producing smooth wave-time changes therein proportional to the point of application thereof, causing said waves to progress to a terminal point in zero phase displacement, and utilizing energy therefrom.

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