

April 28, 1936.

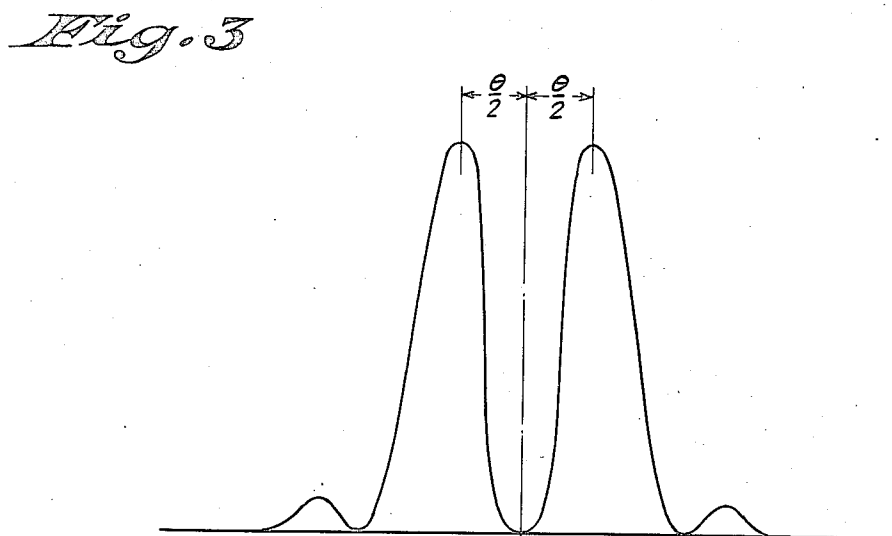
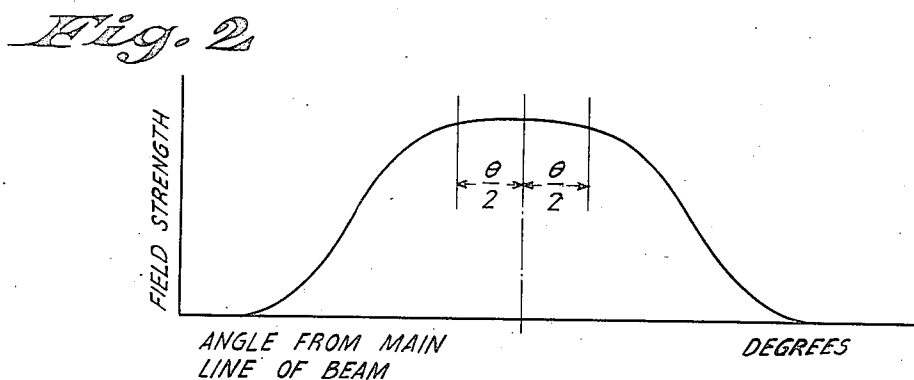
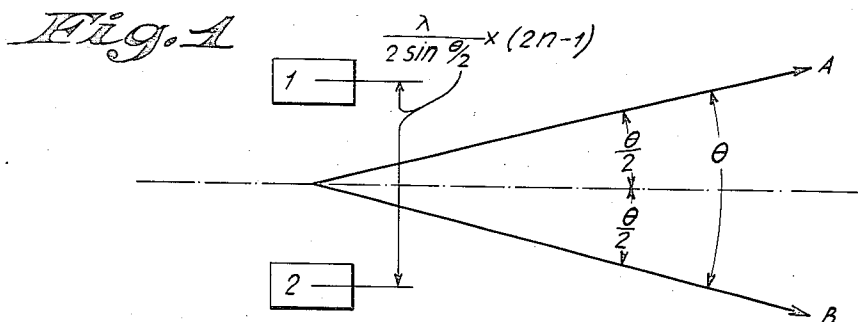
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2,038,539

ANTENNA

Filed Dec. 16, 1933

4 Sheets-Sheet 1



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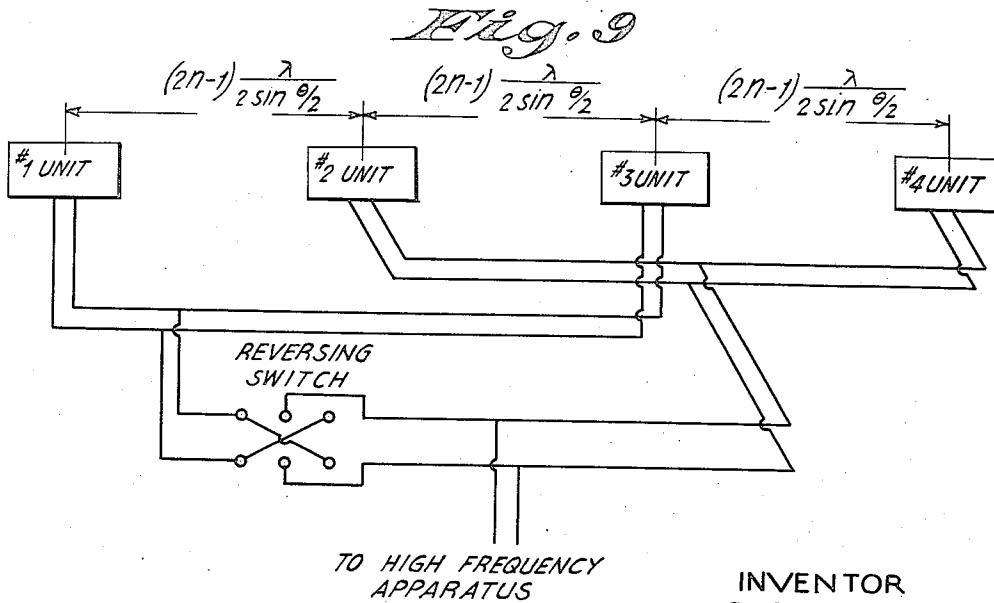
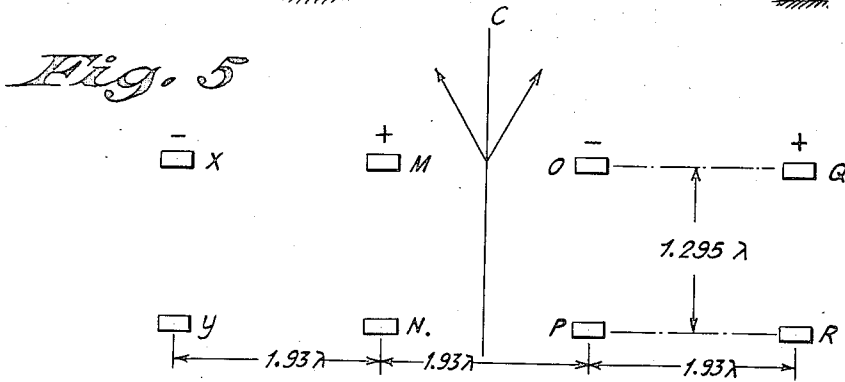
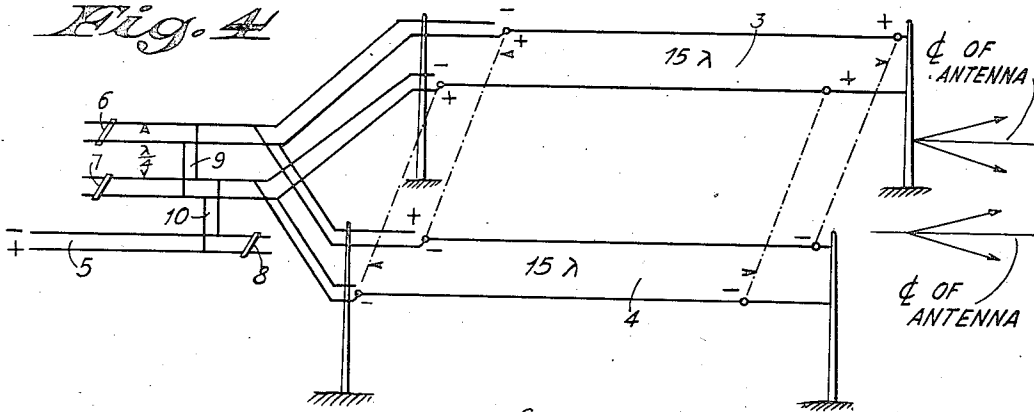
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4 Sheets-Sheet 2



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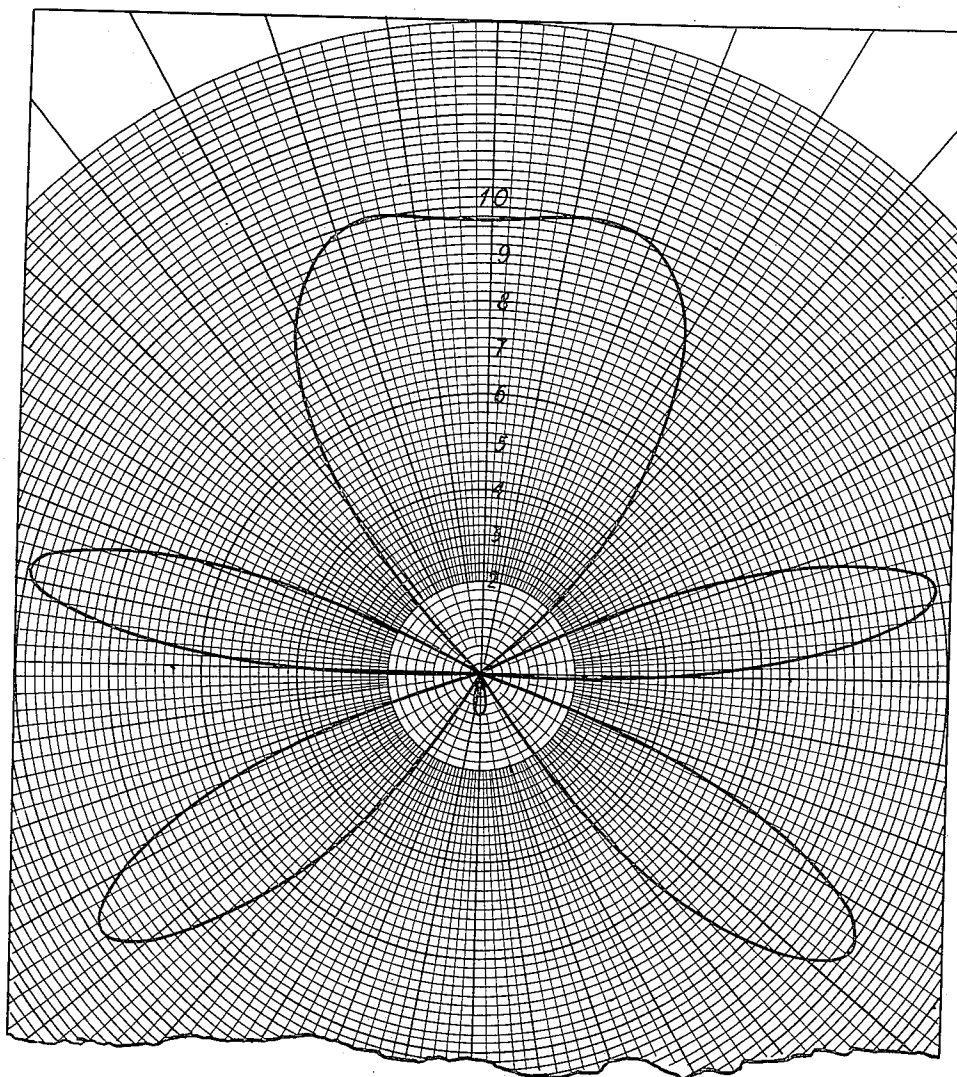
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Fig. 6



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Fig. 7

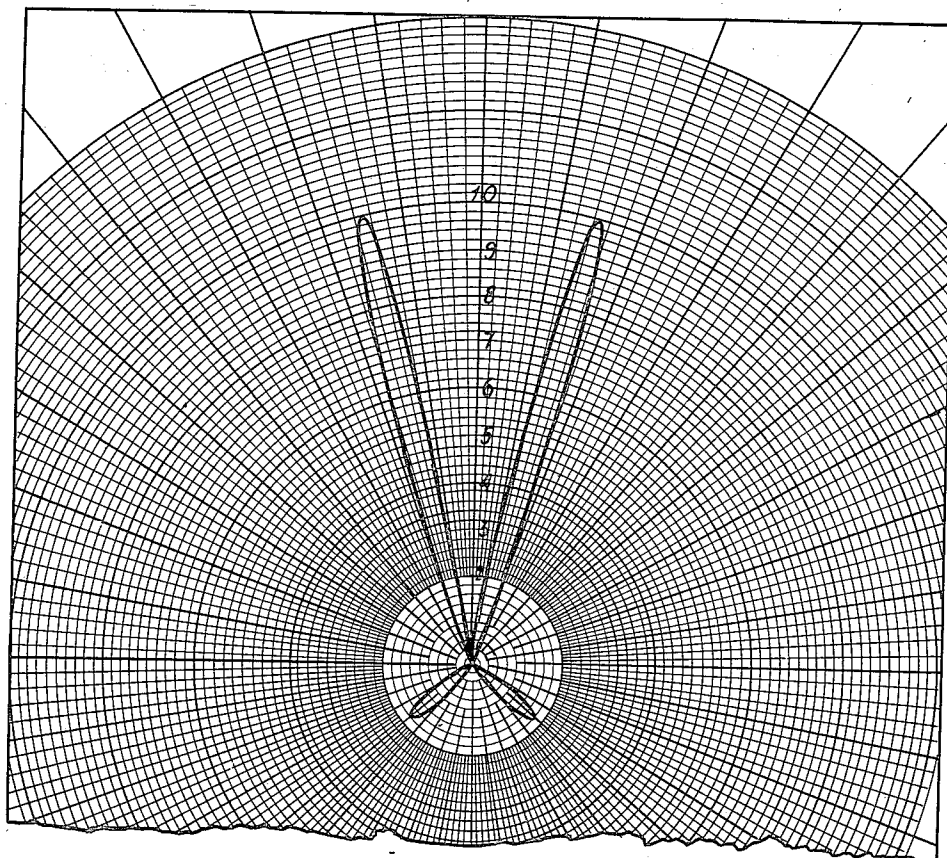
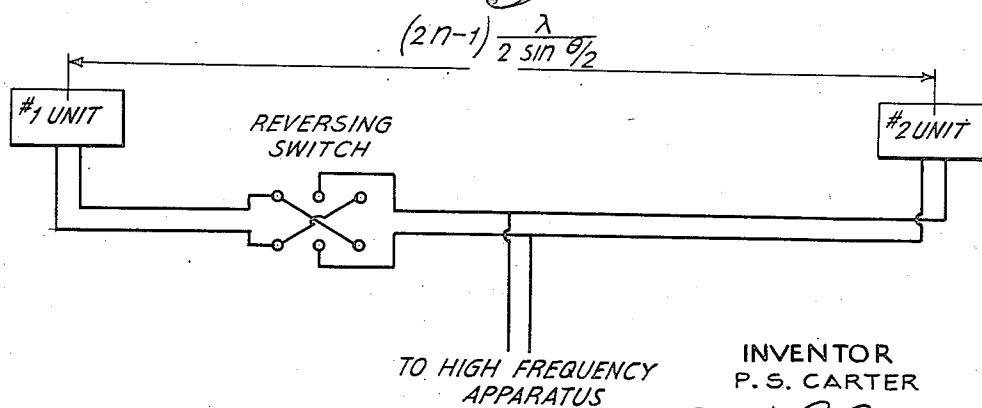


Fig. 8



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UNITED STATES PATENT OFFICE

2,038,539

ANTENNA

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Application December 16, 1933, Serial No. 702,711

8 Claims. (Cl. 250—33)

This invention relates to antennæ and, in particular, to a method of and means for obtaining maximum radiation in two different directions which form an angle with respect to one another appreciably less than 180 degrees. More specifically, the invention relates to a broadside arrangement of antennæ placed adjacent one another and so spaced as to give a double beam of radiation with high gain in the two directions of the double beam.

In the past, antennæ have usually been designed for transmission in one direction only. Occasionally, there have arisen in practice cases where it is desirable to transmit message waves simultaneously to two receiving stations whose directions differ by an angle too great for the ordinary directional antenna to cover, unless the antenna is built to have a wide radiation characteristic, in which case the system will have a low gain radiation pattern. As an illustration of the need to transmit signal waves simultaneously to two receiving stations in two different directions, it has been found necessary in the past to transmit a service between New York and both Buenos Aires and Rio de Janeiro.

Since it is well known that an antenna may be made to be unidirectional, it might appear, without a complete analysis of the difficulties involved, that the desired result of transmitting in two different directions with high gain could be effected by connecting two antennæ in parallel to the same transmitter, each of the antennæ being conditioned to transmit in a different direction. It has been found, however, that the resultant radiation characteristic depends upon the combination of the fields of both antennæ, taking into account the effects of their spacing upon phase, and that the combined system is, in general, very much inferior to either antenna alone. The present invention overcomes the foregoing difficulty and enables the transmission of message waves simultaneously in two directions with high gain.

From a broad aspect, the present invention provides a system wherein any two or more similar antennæ which are spaced and phased in a particular manner to be described later can be combined to transmit a double beam of radiation with high gain in the two directions of the double beam, no matter what type of construction or particular radiation characteristic the antennæ have to start with. These antennæ may constitute any odd or even number of units provided that only adjacent units are energized in phase opposition.

In the accompanying drawings, Figure 1 illus-

trates, schematically, a simple broadside antenna construction consisting of two antenna bays or units arranged in accordance with the principles of the present invention; Figure 2 is a curve explanatory of the power distribution pattern of each bay or unit of Figure 1 taken alone; and Figure 3 is the resultant power distribution pattern of the two antennæ of Figure 1. Figure 4 is an illustration of one particular type of broadside antenna arrangement which has been used in practice with excellent results, and Figure 5 of another construction comprising several antenna bays or units in broadside. Figure 6 shows the radiation characteristic for each antenna, bay or unit of Figure 5, and Figure 7 the resultant characteristic when the antenna units of Figure 5 are fed and spaced in accordance with the invention. Figures 8 and 9 are modifications of the invention and show switching mechanism for enabling communication in one direction or in two directions at equal angles with the first direction, as desired.

Referring to Figure 1 there are shown, schematically in box form, two similar antennæ of any type, each having a field distribution pattern as shown in Figure 2. Assuming that it is desired to transmit simultaneously and with high gain in two directions A and B which differ from each other by a desired angle of θ degrees, it has been found, in accordance with the principles of the invention, that this may be done by placing the two bays of similar antennæ 1 and 2 in broadside to a direction midway between the two receiving points and feeding these antennæ in phase opposition after spacing them apart a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where λ is the length of the communication wave and η is any integer. By such an arrangement, the field waves emanating from each antenna will add perfectly in the desired directions and will nullify each other in the middle direction whereby beams of radiation are obtained which have higher gains than those obtainable by the use of one antenna alone. The law of separation for the two bays of antennæ, stated in another way, is that the projection of the spacing between the two bays upon the two desired directions of radiation should be

$$\frac{\lambda}{2}$$

or an odd multiple thereof, whereby the radiation from each bay in the desired direction differs in phase from the radiation from the other bay by 180 degrees due to spacing and 180 degrees due to being fed in phase opposition. Figure 3 shows the resultant distribution pattern of the two antennae of Figure 1 when spaced apart, fed, and energized in the manner outlined above. In order to increase concentration in the two desired directions, additional systems may be added, alternate antenna bays or units of which are fed in phase opposition. The latter arrangement is shown in Figure 5 to be described later.

In Figure 4, which merely illustrates one embodiment of the invention, are shown two individual antenna units 3 and 4 connected in broadside, each comprising a pair of wires in the vertical plane which are long relative to the working wave length, the lower wire of each pair being staggered back and energized in quarter phase relation with respect to the upper wire so as to eliminate back radiation. The particular antenna unit used in this figure is described and claimed in a copending application Serial No. 598,124, filed March 11, 1932 by C. W. Hansell and results in a double lobe pattern in the horizontal to start with, these lobes, however, being cross sections of a thick cone. Upon combining the two antennae units 3 and 4 in phase opposition, however, with a spacing between them equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

the radiation at all angles in the vertical plane parallel to the wires is eliminated and there is obtained a gain of about 2 to 1 in power in the desired directions over a single unit.

In the system of Figure 4 the corresponding wires of the two units 3 and 4 are connected to opposite sides of the transmission line 5 in order to obtain a perfect balance to neutral. There is also provided an impedance matching and phase adjusting structure 6, 7, 8, 9, 10 which is located at the center line or mid-direction of the system. For energizing the antennae there are connected to the transmission line 5 feeder pairs, rather than single wires, which extend from the high frequency apparatus, not shown, to the individual antenna wires of the two units for preventing radiation from the feeder system.

If each bay or unit is of a type giving a broad lobe of radiation, provision may be made to have the two bays or units fed in phase or in phase opposition at will, thus making it possible to use the system for transmission in one direction only or in two directions at equal angles with the first direction. To do this it is only necessary to provide a polarity reversing switch in the feed line to one of the two units as indicated in Figure 8. Figure 9 shows another embodiment for accomplishing this object wherein more than two antenna units are employed.

Figure 5 illustrates how the principles of the present invention can be applied to antennae of most any type. Each bay or unit may be designed to have a particular radiation characteristic to start with and then these units can be combined according to the invention. As an illustration, assuming that it is desired to transmit in two directions differing by 30 degrees, as shown in Figure 7, then each unit, like x, y, m, n, o, p, q, r , may consist of two vertical dipoles located one ahead of the other on a line having

the middle direction, as shown by C in Figure 5, the individual wires of each unit being spaced from each other by a distance equal to

$$\frac{(2\eta - 1)\frac{\lambda}{4}}{\cos 15^\circ}$$

and fed in quarter phase relation, where η is any integer. The formula

$$\frac{(2\eta - 1)\frac{\lambda}{4}}{\cos 15^\circ}$$

is merely used in order to obtain a predetermined characteristic of radiation, whereas actually any spacing between individual wires of dipoles may be used. If the integer 3 is chosen for the spacing the formula then becomes

$$\frac{5\lambda}{4 \cos 15^\circ} = 1.295\lambda$$

The radiation characteristic for each unit will then take the form shown in Figure 6. We may now combine any even number of these units in broadside at a spacing of

$$\frac{\frac{\lambda}{2}}{\sin 15^\circ}$$

or 1.93λ and feed adjacent units in phase opposition, as shown in Figure 5, the formula

$$\frac{\frac{\lambda}{2}}{\sin 15^\circ}$$

being obtained from

$$\frac{\lambda}{2 \sin 15^\circ} (2\eta - 1)$$

if the integer 1 is used for η .

From the foregoing, it will be apparent that numerous modifications of the various arrangements may be made without departing from the spirit and scope of the present invention and that the invention is not limited to transmitting antennae alone, since it is equally applicable to receiving structures.

I claim:

1. An antenna system for radiation in two different directions differing by an angle of θ degrees, said angle being appreciably less than 180 degrees, comprising two highly directional antenna bays spaced apart in broadside by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where λ is the length of the communication wave and η is any integer, said bays being fed in phase opposition.

2. An antenna system for radiation in two different directions differing by an angle of θ degrees, said angle being appreciably less than 180 degrees, comprising two highly directional antenna bays spaced apart in broadside by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where λ is the length of the communication wave and η is any integer, said bays being fed in phase opposition and being placed in broadside to a

direction midway between the two desired directions.

3. An antenna system for radiation in two different directions comprising two similar unidirectional antenna units separated such that the projection of the spacing between the units upon the two desired directions of radiation is one half the length of the communication wave or an odd multiple thereof, whereby the radiation from each unit in the desired direction differs in phase from the other unit by 180 degrees due to spacing and 180 degrees due to being fed in phase opposition.

4. An antenna arrangement for radiation in two different directions differing by an angle of θ degrees comprising a pair of wires arranged in a vertical plane, said wires being staggered with respect to each other and fed in quarter phase relation for eliminating back radiation, and another similar structure spaced away from said first pair of wires by a distance substantially equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where λ is the length of the communication wave and η is any integer, said second structure being fed in phase opposition with respect to said first structure, the planes in which said antenna structures lie being parallel to each other.

5. An antenna system for communication in two different directions comprising a plurality of highly directional antenna sections spaced in broadside to a direction midway between the two desired directions, said sections being separated from one another by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where η is any integer, λ the length of the communication wave and θ the angle in degrees between the two desired directions of communication adjacent antenna sections being activated in phase opposition, said angle being appreciably less than 180 degrees.

6. An antenna system for communication in two different directions comprising a plurality

of directional antenna sections spaced in broadside to a direction midway between the two desired directions, said sections being separated from one another by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where η is any integer, λ the length of the communication wave and θ the angle in degrees between the two desired directions of communication, and means for energizing adjacent antenna sections in phase or in phase opposition, as desired.

7. An antenna system for communication in two different directions comprising a plurality of directional antenna sections spaced in broadside to a direction midway between the two desired directions, said sections being separated from one another by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where η is any integer, λ the length of the communication wave and θ the angle in degrees between the two desired directions of communication, high frequency apparatus, and connections extending between said high frequency apparatus and said antenna sections, said connections including a reversing switch located between adjacent sections for enabling activation of said adjacent sections in phase or in phase opposition with respect to one another, as desired.

8. An antenna system for radiation in two different directions differing by an angle of θ degrees, said angle being appreciably less than 180 degrees, comprising two antenna bays spaced apart in broadside to a direction midway between the two desired directions by a distance equal to

$$\frac{\lambda}{2 \sin \frac{\theta}{2}} \times (2\eta - 1)$$

where λ is the length of the communication wave and η is any integer, and means for feeding said bays in phase opposition.

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