May 3, 1938. A. D. BLUMLEIN 2,115,761

DIRECTIONAL WIRELESS AERIAL SYSTEM

Filed Feb. 25, 1936

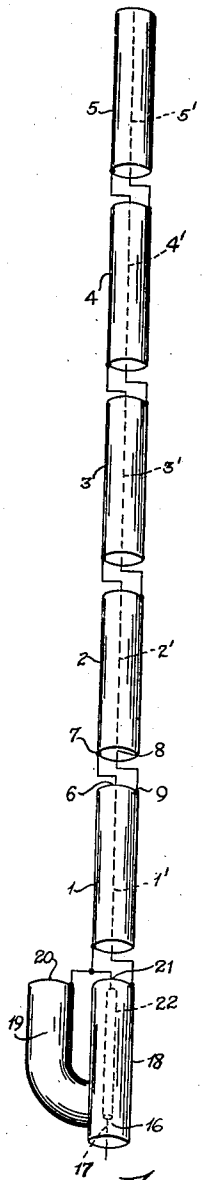


Fig. 1.

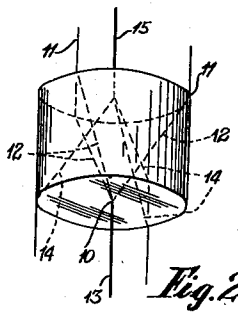


Fig. 2.

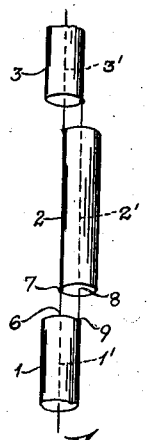


Fig. 3.

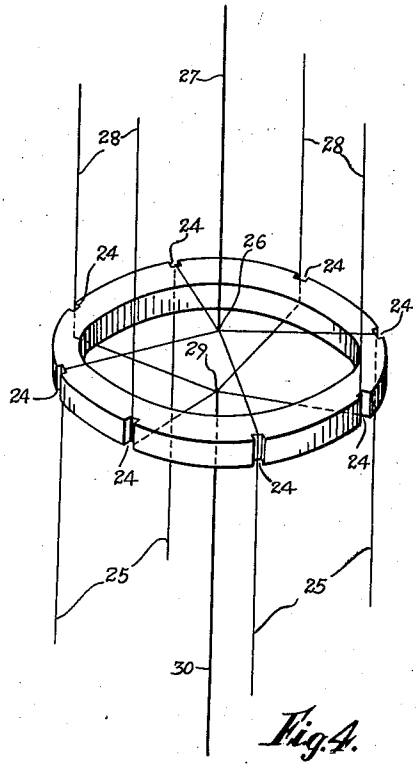


Fig. 4.

INVENTOR
ALAN DOWER BLUMLEIN

BY W. S. Brower

ATTORNEY

Patented May 3, 1938 2,115,761

UNITED STATES PATENT OFFICE

2,115,761

DIRECTIONAL WIRELESS AERIAL SYSTEM

Alan Dower Blumlein, Ealing, London, England, assignor to Electric and Musical Industries Limited, Hayes, England, a company of Great Britain

Application February 25, 1936, Serial No. 65,555
In Great Britain February 28, 1935

10 Claims. (Cl. 250—33)

The present invention relates to directional wireless aerial systems such as can be used either for transmission or reception of electromagnetic waves.

One array of known type comprises a series of half wave aerial elements arranged in line one above the other. The top of each half wave element is joined to the bottom of the half wave element above it by a half wave auxiliary element, the half wave auxiliary elements being folded either so as to neutralize their radiation, or to ensure that their radiation adds to that of the straight half wave aerial elements. When this type of array is fed at one end, say the lower end, the radiation from the lower elements seriously attenuates the currents flowing to the upper elements, so that the upper elements are not fully effective in radiating as desired. Similar troubles are experienced with other types of aerial array where the power for one radiating element is fed through other radiating elements.

It is an object of the present invention to eliminate or reduce this difficulty.

According to the invention an aerial array comprises two or more radiating or receiving elements at least one of which is composite and has at least two conductors which are adapted to operate as a feeder for another radiating or receiving element, it being arranged that one of said two conductors is adapted to radiate or receive more than the other of said two conductors.

According to a feature of this invention an aerial array comprises a first radiating or receiving element having two or more conductors, one of said conductors being arranged as a partial or complete shield for the other of said conductors, and said two conductors being adapted to operate as a feeder for a second radiating or receiving element of the array.

The conductor which is arranged as a shield may be in the form of a conducting tube which surrounds another conductor and is insulated therefrom.

Alternatively the shield may comprise a group of conductors located around a central conductor or group of conductors.

According to a further feature of the present invention there is provided an aerial array comprising a plurality of radiating or receiving elements arranged end to end, wherein each of said elements comprises an outer conductor surrounding an inner conductor and wherein the outer conductor of each element is connected to the inner conductor of an adjacent element.

The invention will now be described with particular reference to transmitting aerial arrays, but it is to be understood that the systems discussed are also applicable to reception. The phasing of an aerial array is most simply considered by treating it as a transmitting array and adjusting the lengths of the elements and the phasing connections so as to obtain correct currents in and voltages on the elements: the array so designed may then be used as a receiving array by replacing the generator by a suitable receiver.

In the accompanying diagrammatic drawing

Fig. 1 shows an aerial array according to the present invention,

Figs. 2 to 4 show portions of modifications of Fig. 1.

Referring to Fig. 1 of the drawing, an aerial array comprises five lengths 1, 2, 3, 4, 5 of copper tube, each substantially equal in electrical length to half a wavelength of the waves to be transmitted, arranged in a line one above the other, giving a total electrical length of about 2½ wavelengths, there being short insulating gaps between the consecutive tubes. The tubes 1, 2, 3, 4, 5 contain central conductors 1', 2', 3', 4', 5' insulated from them, thus forming five lengths of concentric feeder of known type. At each gap the inner conductor of the lower element is joined to the outer tube of the element above, and similarly, the inner conductor of the upper element is joined to the outer tube of the element below it. Thus, for example, the upper end 6 of inner conductor 1' is connected to the lower end 7 of outer conductor 2 and the lower end 8 of inner conductor 2' is connected to the upper end 9 of outer conductor 1'. The combined arrangement forms a total of 2½ wavelengths of feeder in which the inner and outer conductors interchange each half wavelength. The interchange may be effected by inserting an insulator of the type shown in Fig. 2 between adjacent tubes.

The insulator is in the form of a solid cylinder and has a plurality of slots radiating from the centre 10 of its lower surface to points 11 on the periphery of its upper surface. Through these slots are passed copper strips 12 which are joined together and to the upper end of a central conductor 13 at point 10 and to the lower end of an outer conductor at points 11. A similar plurality of slots accommodate strips 14 for connecting the lower end of central conductor 15 to the upper end of the outer conductor surrounding inner conductor 13.

Fig. 3 shows a modification of a part of Fig. 1. It will be seen that by slightly displacing alter-

nate elements the connections 6, 7 and 8, 9 may be shortened and more easily held spaced apart from one another.

The whole array may be fed by connecting a concentric or balanced feeder to the inner and outer conductors of the bottom radiating element 1, 1'. If, as shown in Fig. 1 a concentric feeder 16 is used, the inner conductor 17 of the feeder may be connected to the outer tube 1 of the bottom element and the sheath 18 of the feeder to the inner conductor 1' of the bottom element.

The feeder has preferably an auxiliary quarter wave conductor 19 joined to it at one quarter wavelength from its junction with the aerial, and arranged to extend, substantially parallel to the feeder towards the aerial, the free end 20 of the quarter wave conductor 19 being thus adjacent the bottom of the aerial. Further, if this quarter wave conductor be made of the same outside dimension as the feeder as shown, the end 20 of the quarter wave conductor adjacent the aerial is advantageously connected to the end 21 of the inner conductor 17 of the feeder. Also the length of the quarter wave element 19 may be altered from an exact quarter wavelength in order to tune the aerial. The use of the auxiliary quarter wave conductor 20 serves to render the aerial end of the feeder 16 substantially symmetrical and to prevent distortion of the polar diagram of the array by currents flowing on the outside of the sheath of the feeder. Arrangements of this kind are described in United States application, Serial No. 6,190, filed February 12, 1935.

In general it is necessary to provide an impedance matching transformer between the feeder and the aerial. In the arrangement shown the transformer is a quarter wave transformer which is constructed by making the quarter wavelength section 22 of the central conductor 17 of suitable diameter different from the diameter of the main part of the central conductor and which operates in known manner. Alternative arrangements by which impedance matching between the feeder and the aerial may be realized are by suitably altering the length of auxiliary conductor 19 and by connecting the aerial to suitable points in auxiliary conductor 19 and sheath 18 other than their ends. Such arrangements are described in copending United States application Serial No. 100,986, filed September 16, 1936.

In the aerial described above, the inner conductor 5' may obviously be omitted from the top element 5 as it serves no useful purpose unless a further element is to be connected to the array shown. Although described for five elements, this type of aerial may be used for any number of elements from two upwards. In each of the elements 1, 1', 2, 2', 3, 3', 4, 4' the outer conductors 1, 2, 3, 4 act as shields for the inner conductors 1', 2', 3', 4' and the outer conductors therefore radiate or receive more than the inner conductors.

The elements need not necessarily be arranged in a vertical line, but can be arranged, say, horizontally, to give a horizontally polarized radiation. Such an array may be fed from one end, or from some point along its length. A voltage feed may be applied by connecting a feeder to adjacent ends of outer tubes of adjacent elements, or a current feed may be introduced by breaking the inner or outer conductor at the centre of an element and connecting the ends so formed to the two conductors of a feeder.

The elements need not necessarily be arranged in a straight line; some of the elements may extend at a right angle to others, and may if desired consist of a pair of similar conductors so as to form a non-radiating length of feeder. Similarly aerials of the type described may be used with other groups of elements to form a more complex array.

In another construction shown in Fig. 4, a plurality of wires is employed for each outer conductor. A spreader 23 in the form of a ring is employed at the junction of two elements and is provided with eight slots 24 equally spaced around its periphery. Four wires 25 which form the outer conductor of the lower element pass through four alternate slots and are drawn together to a point 26 where they are joined to the inner conductor 27 of the upper element. The four wires 28 forming the outer conductor of the upper element pass through the remaining slots and are drawn together to a point 29 where they are connected to the inner conductor 30 of the lower element. A similar arrangement may be employed at each junction between two elements.

Instead of connecting the four wires of an outer conductor to a single wire of an inner conductor at points 26 and 29, the four wires may simply be drawn together and themselves constitute the inner conductor. Each outer conductor may be constituted by a suitable number of conductors other than four.

When the arrays described above are required to radiate most strongly in the horizontal direction, they are arranged vertically and it is necessary that all the half wave radiators operate in the same phase, that is, the upper ends of all half waves should be positive together when their lower ends are negative together. Now the upper end of one half wave element is joined through an effective feeder to the bottom of the half wave element next but one above it. Since the feeder length is half a wavelength however, the feeder will produce a reversal of phase thus rendering the top of one element positive at the same time as the bottom of the element next but one above it is rendered negative, and so giving the required phasing. Owing to the proximity of the ends of the adjacent aerial elements it may be found necessary to add additional reactances to the aerial in order to tune it to the required frequency.

Other phasings can be arranged by employing suitable lengths of feeder elements, or the effective feeder length of an element can be increased without increasing its length as a radiator by folding the inner conductor, or by folding both the inner and outer conductors and short circuiting the fold of the outer conductor.

In one construction employing tubular outer elements the tubes have a diameter of 4 inches and the inner conductor has a diameter of about ¾ inch in the lowest element 1 decreasing to about ½ inch in the uppermost element 4 or 5. It has been found that the elements operate as half wave elements if their lengths are about 85% of half a wavelength. The capacity at the junctions and the length added by the connections cause the electrical length to be greater than the physical length of the elements themselves.

A multi-element tubular array as described, may for short wavelengths be made partially or wholly self-supporting by making the outer tubular members of sufficient diameter and strength.

Also this diameter may be reduced for the higher members which have less weight to support and are less stressed by wind.

The present invention is not limited to the above-described examples and many modifications within the scope of the invention will be apparent to those versed in the art.

I claim:

1. An aerial array for radio transmission and reception comprising a first aerial element, and a second aerial element consisting solely of a tubular conductor and a coaxially positioned inner conductor, said tubular conductor being arranged to radiate or receive more than said inner conductor, and said second element being constructed and arranged to constitute a feeder of electrical energy for said first element.

2. An aerial array for radio transmission and reception comprising a first aerial element, and a second aerial element consisting solely of a tubular conductor and a coaxially positioned inner conductor, said tubular conductor being arranged as at least a partial shield for said inner conductor, and said second element being constructed and arranged to constitute a feeder of electrical energy for said first element.

3. An aerial array for radio transmission and reception comprising a first aerial element in the form of a hollow member and a second aerial element comprising first and coaxial conductors, said first conductor being of substantially the same size and shape as said first aerial element and enclosing said second conductor, said second conductor being connected at one of its ends to one end of said first aerial element, said first conductor at its other end being connected to a feeder of electrical energy.

4. A radio aerial array comprising a first aerial element having an outer and an inner conductor, a second aerial element also having an outer and an inner conductor, and a third aerial element, a connection between one end of said third element and one end of the inner conductor of said second element, a connection between the other end of the inner conductor of said second element and the outer conductor of said first element, and a connection between the inner conductor of said first element and the outer conductor of said second element.

5. A radio aerial array comprising a plurality of aerial elements arranged end to end each substantially electrically one-half the length of the operating wave and consisting of an inner conductor and an outer conductor and a connection between each end of each outer conductor and the adjacent end of the inner conductor of the adjacent element.

6. An aerial array for the transmission and reception of radio signals comprising a first aerial element, and a second aerial element having at least two conductors, one of said conductors being arranged as at least a partial shield for the other of said conductors, said second element being constructed and arranged to constitute a feeder of electrical energy for said first element, the electrical length of said first and second elements being substantially one half wavelength of said signals.

7. An aerial array including a first aerial element comprising an inner conductor and an outer conductor, and a second aerial element comprising an inner conductor and an outer conductor, said outer conductors each comprising a plurality of wires arranged around and extending substantially parallel with the corresponding inner conductor, an insulating spreader co-operating with one end of each of said wires and each conductor of said first and second elements to maintain said wires and conductors in spaced relationship, and connections in the neighbourhood of said spreader between the ends of the wires of said first element and the adjacent end of the inner conductor of said second element and between the ends of the wires of said second element and the end of the inner conductor of said first element.

8. An aerial array for radio transmission or reception comprising a first aerial element, and a second aerial element spaced from said first element, said aerial elements being arranged substantially end to end, said second aerial element having at least two conductors one of which is arranged to radiate or receive more than the other of said conductors, a feeder of electrical energy having two electrically conducting paths, and connections from the paths of said feeder to the conductors of said second aerial element at one end thereof, and a connection from the other end of said second aerial element to said first aerial element.

9. An aerial array including a first aerial element comprising an inner conductor and an outer conductor, and a second aerial element comprising an inner conductor and an outer conductor, said aerial elements being arranged substantially end to end, a connection from one end of the inner conductor of said first aerial element to the adjacent end of the outer conductor of said second aerial element, and a connection from the same end of said first aerial element from the outer conductor thereof to the adjacent end of the inner conductor of said second aerial element.

10. An aerial array for the transmission or reception of radio signals comprising first and second spaced aerial elements arranged substantially end to end, said second aerial element having at least two conductors, one of said conductors being arranged to radiate or receive more than the other of said conductors, the physical lengths of said first and second aerial elements being substantially 85% of one-half wavelength of said signals, said second element being constructed and arranged to constitute a feeder of electrical energy for said first element.

ALAN DOWER BLUMLEIN.