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SHORT WAVE RADIO BEACON

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My invention relates to radio beacons for sending out a layer or layers of ultra-short waves for indicating to ships or aircraft the location of the beacon.

5 The object of my invention is the provision of a specially designed antennæ array or assembly producing a rotating field such that the intensity of radiation is the same in all directions, perpendicular to the axis of the array in a limited layer. The beacon comprises a plurality of n groups of antennæ so arranged that each antenna of one group is spaced $\frac{\lambda}{2n}$ from one of the next

15 group, while those of the same group are spaced half a wave length apart. In order to simplify the discussion, the explanation which follows is confined to two groups of antennæ, but it is to be understood that the application may be extended without restriction to n groups.

20 The antennæ are so connected to a source of oscillating current that the currents in one group of antennæ are equal and in phase. The currents in the other group are also equal and in phase. The currents in one group of antennæ have the same amplitude as the currents in the other group and are in quadrature with them as to phase.

Various features of my invention will be noted from the description to follow.

30 My invention is illustrated in the accompanying drawing which shows the essential features: Fig. 1 shows an array of antennæ.

Fig. 2 shows the plan of antennæ radiation.

Fig. 3 is a horizontal projection of Fig. 1.

35 Fig. 4 shows the connections to the antennæ and the compensation device.

Fig. 1 shows an array or grouping of antennæ.

40 Axes o, x, y, z are rectangular. A transmission line placed along oz feeds the antennæ 1, 2, 3, 4, etc. parallel to oz , and antennæ a, b, c, d parallel to oy . The antennæ x parallel to oz are spaced half a wave length. The antennæ y parallel to oy are spaced half a wave length and separated by a quarter of a wave length from the antennæ parallel to oz .

45 The currents in the antennæ x are equal and in phase. The currents in the antennæ y are also equal and in phase. The currents in the antennæ y have the same amplitude as the currents in the antennæ x and are in quadrature with them, as will be explained later.

50 The array of antennæ x only transmit in the vicinity of the horizontal plane. In this plane and at a point M located at a large distance away

(see Fig. 2) the field is proportional to the $\sin \theta$, I shall represent it by

$$\sin \theta \sin \omega t.$$

In the same way the array of antennæ y only 60 transmit in the neighborhood of the horizontal plane and, since the antennæ xy are in quadrature, I can represent the field at the point M by

$$\cos \theta \cos \omega t.$$

The resulting field at the point M is

$$\sin \theta \sin \omega t + \cos \theta \cos \omega t = \cos (\omega t - \theta).$$

In the horizontal plane along a circumference whose center is the antenna array the amplitude 70 of the field is constant. The field turns around the antenna array. The intensity of radiation is the same in all horizontal directions.

The horizontal layer of ultra-short waves is obtained which becomes more highly focused as the number of antennæ is increased. By means of a two-phase system of antennæ I have thus developed a rotating field. The same result could be obtained in a more general manner with a poly-phase system. 80

Fig. 3 represents the horizontal projection of the antenna group. The supply line consists of a double transmission line made up of four straight conductors AB, CD, a portion of which is represented in the figure. 85

The conductors AB feed the antennæ 1, 2, 3, 4, etc. It is seen that antennæ of the same periodicity (1, 3, 5---) are placed in a similar manner. With the set-up indicated in the figure, it is seen that two antennæ of different periodicity, although they are separated by a piece of line at AB of length equal to an odd number of half wave lengths, are traversed by currents in the same sense. Thus, the parallel antennæ 1, 2, 3, 4, etc. are separated by half a wave-length and 95 are traversed by currents in phase.

The conductors CD feed the antennæ a, b, c, d in an analogous manner; these antennæ are separated by half a wave-length and are traversed by currents in phase. 100

The two lines AB and CD are joined to the source of oscillations in such a way that the currents in the antennæ x and the antennæ y shall be of equal amplitude and in quadrature as to phase. Fig. 4 represents schematically a part of the antenna groups. If the junction of lines AB and CD were made without certain precautions, the currents in the antennæ x and in the antennæ y would have suitable phases, but their amplitudes would be quite different. For ex- 110

ample, suppose that the junction is made at N, at a distance of half a wave-length from the antenna 1 and at a distance of three-quarters of a wave length from the antenna α .

5 Let T be the radiation resistance of each antenna, n be the number of antenna of each series (x or y), and Z is the characteristic impedance of each line (AB or CD). At N the line AB is equivalent to a resistance

$$10 \quad \frac{T}{n}$$

and the line CD is equivalent to a resistance

$$15 \quad Z^2 \frac{T}{n}$$

In order that these resistances shall be equal it is necessary that Z equal

$$20 \quad \frac{T}{n}$$

In practice

$$25 \quad \frac{T}{n}$$

would be small, of the order of a few ohms, and it would be impossible to make a line with straight conductors having an impedance Z equal to a few ohms. This difference is overcome by means of the arrangement represented by the lower part of Fig. 4. Rectangle NPQ comprises a portion of the line with concentric conductors whose characteristic impedance can be easily made equal to

$$35 \quad \frac{T}{n}$$

Under these conditions the impedances looking into these two lines at the junction point Q are equal, that is, each has an impedance equal to

$$40 \quad \frac{T}{n}$$

Moreover, the lengths NPQ and NQ differ by a multiple of half a wave length and the feeding of the antenna group is correct. Other equivalent compensation devices could be utilized, if desired.

The axis of symmetry of the antennae array may be oriented either in a horizontal or in a vertical plane, depending upon the application to be made of the array for beacon purposes.

What is claimed is:

1. A radio beacon comprising a plurality of antennae divided into two groups disposed symmetrically about a central axis, the antennae of each group being in parallel relation and spaced an odd number of half wave lengths apart and so arranged that the antennae of one group are separated by an odd number of quarter wave lengths from the antennae of another group.

2. A radio beacon comprising a plurality of antennae divided into two groups about a central axis, the antennae of each group being in parallel relation and spaced half a wave length apart and so arranged that the antennae of one group are separated by a quarter of a wave length from the antennae of another group.

3. A radio beacon comprising a plurality of antennae divided into groups, the antennae of one group being spaced a quarter of a wave length apart from those of another group and so arranged that the antennae of each group are in parallel relation.

4. A radio beacon comprising a plurality of antennae divided into groups, the antennae of one

group being spaced a quarter of a wave length apart from those of another group and so arranged that the antennae of each group are in parallel relation, means for applying oscillating current to the antennae so the amplitude of current is the same in each group and the phase in one group in quadrature in respect to the phase in the other group.

5. A radio beacon comprising a plurality of antennae divided into two groups disposed symmetrically about a central axis, the antennae of each group being in parallel relation and spaced an odd number of half wave lengths apart and so arranged that the antennae of one group are separated by an odd number of quarter wave lengths from the antennae of another group, a source of oscillations for said antennae, leads from said source to each of said groups, and compensating means connected in one set of said leads for producing the same amplitude of current in the two groups and comprising a transmission line having an electrical length equal to an odd multiple of a quarter wave length and having a characteristic impedance equal to

$$\frac{T}{n}$$

where T is the radiation resistance of each antenna and n is the number of antennae in each group.

6. A radio beacon comprising a plurality of antennae divided into n groups about a central axis, each antenna of one group being spaced a distance equal to one-half a wave length from the next antenna of the same group, each antenna of one group being spaced a distance equal to a wave length divided by two times n from an antenna of the next adjacent group, and so arranged that the antennae of each group are in parallel relation.

7. A radio beacon comprising a plurality of antennae divided into n groups about a central axis, each antenna of one group being spaced a distance equal to one-half a wave length from the next antenna of the same group, each antenna of one group being spaced a distance equal to a wave length divided by two times n from an antenna of the next adjacent group and displaced in a plane perpendicular to the axis of the array through an angle equal to

$$\frac{180^\circ}{n}$$

with respect to an antenna of the next adjacent group and so arranged in the antennae of each group are in parallel relation.

8. A radio beacon comprising a plurality of antennae divided into n groups about a central axis, the spacing in each group being such that one antenna thereof is spaced a distance equal to an odd multiple of a half wave length from the next antenna, and each antenna of one group being spaced a distance equal to an odd multiple of a wave length divided by two times n from an antenna of the next adjacent group and so arranged that the antennae of each group are in parallel relation, and means for applying oscillating current to the antennae of said groups so that the amplitude of current is the same in each group and the phase in one group with respect to the phase in another group is as $1:2n$.

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