This invention relates to an antenna capable of adaptation to various radiation and reception applications, and without restricting the generality of the foregoing, is particularly suitable for receiving very high frequency television signals.

It is a principal object of this invention to provide an antenna of the non-resonant end-fire type which is physically small in comparison with conventional antennas which may be used for similar purposes.

An additional object is to provide an antenna which has a highly directional pattern and is capable of operating over a wide band of frequencies in the very high frequency range.

It is also an object to provide an antenna which can be directly connected to a standard transmission line without the use of a matching transformer.

A further object is the provision of such a device which is low in manufacturing cost and inexpensive to install.

In realizing the aforementioned objects the present invention provides an antenna which is pleasing in appearance, and accordingly of considerable sales appeal.

Other objects and advantages will be apparent to one skilled in the art from an examination of the present specification and the accompanying drawings, but it should be understood that the disclosure herein is by way of example only, and it will be seen that numerous changes may be made in the form shown and described without departing from the spirit of the invention within the scope of the appended claims.

For a better understanding of the invention the accompanying drawings will now be referred to, wherein the same reference numerals denote like parts in all figures.

In the drawings,

Figure 1 illustrates an oblique three-quarters view of a preferred embodiment of the present invention;

Figure 2 shows an end elevation view of the device illustrated in Figure 1, but in a slightly reduced scale, as would be seen by observing the device of Figure 1 along the part denoted by reference numeral 2 and toward the part denoted by reference numeral 1;

Figure 3 shows a fragmentary plan view of that part of the device shown in Figure 1 in the region of the parts denoted by reference numerals 15, 16, 25 and 26;

Figure 4 illustrates an example of a typical vector diagram of radiation, such as would preferably result from the operation of the present device at its optimum frequency;

Figure 5 shows an example of a vector diagram of radiation in the desired direction, when the device described herein is constructed according to the present disclosure; and

Figure 6 shows a fragmentary side elevation view illustrating a type of alternative construction which could be applied to the device illustrated in Figures 1, 2 and 3.

Referring first to Figures 1, 2 and 3, a portion of the 70 supporting mast is shown at 1. Mast 1 in the region of the antenna may be made either of insulating material, for example, wood suitably coated or impregnated with an insulating and weatherproofing substance, or, mast 1 may be made of conducting material, but if so such conducting material should be insulated from the radiating parts of the antenna.

A reflecting grid is preferably attached to mast 1. Such grid may be composed, for example of three conductors denoted by 3, 4 and 5. It is contemplated that the present antenna will operate over a range about an optimum central frequency, such frequency depending on the dimensions of the antenna. While such range is relatively wide, when there is a departure from the optimum central frequency there will be radiation in a direction opposite to that desired. It is, accordingly, the purpose of reflecting conductors 3, 4 and 5 to counteract this in a manner which will be well understood by one skilled in the art. Reflecting conductors 3, 4 and 5 are preferably of a length somewhat greater than a half wavelength at the central optimum frequency.

Attached to mast 1 is a supporting arm denoted by 2, the purpose of which is to carry the radiating parts as will be described below. Arm 2 may be made of insulating material, for example, wood suitably coated or impregnated with an insulating and weatherproofing substance.

Alternatively, arm 2 may be made of conducting material, as is particularly shown in Figure 6, where the arm is denoted by reference numeral 33. If arm 2 is made of conducting material, it should be insulated from the radiating parts of the antenna.

Mast 1 and arm 2 need not be in the form shown, and for example mast 1 could connect with arm 2 at the midpoint of the latter, and a separate support could be provided for reflecting conductors 3, 4 and 5.

The radiating parts of the antenna are in the form of two conducting members, denoted as radiators 6 and 7, connected to transmission line 8, which might, for example be a 300 ohm line.

Transmission line 8 is in turn attached to an electronic device shown at 9, which will be either a transmitter or receiver, depending on the use to which the antenna is put.

Each radiator 6 and 7 is formed into a configuration consisting of a succession of a diagonal member, a curved portion and a diagonal member, repeated in size and direction a number of times, depending upon the characteristics desired. Each radiator 6 and 7 is, of course, a continuous conductor from end to end.

The linear diagonal members of radiator 6 are denoted by reference numerals 10-19, and the linear diagonal members of radiator 7 by reference numerals 20-29.

One of the curved portions is numbered, by way of example, that shown at 32 joining linear portions 15 and 16, the other curved portions of the antenna being of similar shape and size.

In order to conveniently disclose the structure and operation of the present device, each radiator 6 and 7 will be divided into a plurality of elements, some term being used to denote a part of a radiator 6 or 7 from the central vertical plane of arm 2 out around the curved portion and back to such central vertical plane. An example of such an element is shown in Figure 5 where reference numerals 30 and 31 denote vertical lines on the central vertical plane of arm 2 at the points where radiators 6 and 7 intersect such vertical plane. Such an element is the part of radiator 6 on the side of the central vertical plane indicated by a line joining 30 and 31, and made up of such part of linear portions 15 and 16, and curved portion 32.

The present invention is not limited to any particular number of elements, nor any particular size of such elements, nor to any particular size of the antenna as a
A manner of arriving at suitable values for these for a given type of operation will be set out below. All the elements of radiator 6 and 7 lie in a plane and all the elements of radiator 7 lie in another plane, such planes being parallel in space and having their center lines (which also pass through the central vertical planes of arm 2) parallel in space. This invention is not limited to any particular distance between the plane of radiators 6 and 7, nor is it limited to any other particular spatial disposition therebetween, but it has been found satisfactory in practice if the planes of radiators 6 and 7 are parallel and are disposed apart a distance of the order of one-tenth of a wavelength at the central optimum frequency.

Each end of radiators 6 and 7 terminate substantially in arm 2, or just protruding therethrough. Transmission line 8 is preferably connected to the radiators 6 and 7 at the end nearest mast 1. The other ends of radiators 6 and 7 are left open or shorted as may be desired, it being immaterial to the operation of the antenna which is done so long as the antenna is reasonably long, such as, of the order of a wavelength or more. If the antenna is considerably shorter than of the order of a wavelength, for example of the order of half a wavelength, it may be preferable to insert a terminating resistor between the ends of the radiators and 7 to match the characteristic impedance of the antenna.

The alternative construction shown in Figure 6 will now be referred to. This is particularly applicable to the case where it is desired to use an arm of conducting material. Such arm is shown at 33 and may be for example, a metal tubular member. Insulators for carrying radiators 6 and 7 are shown at 34, and may be, for example, annular in shape. Insulators 34 are attached to arm 33 by means of supports 35. Where annular insulators are used, supports 35 will preferably be in the form of yokes passing around insulators 34 and having a rod projecting therefrom, which may threadably engage arm 33.

The method of constructing an antenna for a particular application according to this invention will be referred to. The general overall size is first chosen and the dimensions and number of elements are then arrived at to give good performance at the frequency desired to be used. Without limiting the present invention to any particular dimensions, it has been found satisfactory if the overall length is of the order of one wave length and the overall width of the order of 0.6 wavelength at the central optimum frequency. The following example will be given using actual numerical values which has proven satisfactory, but the invention is in no way limited to such values. In the following example, particular reference will be made to Figures 3, 4 and 5.

Example—An antenna of the type described herein is required to operate at a central optimum frequency of 200 megacycles, and the requirements of space available dictate that it should have a length between four and six feet. At 200 megacycles, the wave length is 1.5 meters or approximately 60 inches, and since this is in the range of lengths required, it will be satisfactory to use 59 inches as the overall length.

For end-fire operation, the increments of radiation from each element must add up in phase, as indicated in Figure 5.

\[ 2\pi L - 2\pi d = \frac{\lambda}{2} + \pi = 2\pi n \]

where \( L \) is the conducting length of one element of the antenna (in Figure 3, the distance from point 30 along the element through curved portion 32 and back to point 31), \( d \) is the length of an element along the central vertical plane of arm 2 and \( n \) is an integer which for the lowest mode of operation will equal unity.

Equation 1 becomes

\[ L - d = \frac{\lambda}{2} \]

The approximation may now be made (which does not introduce any significant error) that the sides of each element, for example 15 and 16, meet abruptly at the angle between them instead of in a curve. Denoting this angle by \( 2\theta \), it is apparent that \( d = L \sin \theta \), and Equation 2 becomes

\[ L(1 - \sin \theta) = \frac{\lambda}{2} \]

But the antenna overall width is \( L \cos \theta \), or in terms of wave lengths, \( 0.6\lambda \)

i.e. \( L \cos \theta = 0.6\lambda \)

Substituting (4) in (3) gives

\[ \theta = 10.5 \text{ degrees} \]

and

\[ L = 0.61\lambda \]

or, 364 inches.

To achieve the preferred number of elements, it is assumed that there should be no radiation to the rear, i.e. the increments of back radiation from each element will add up vectorially so as to produce a closed figure, such as is shown in Figure 4.

The phase of field radiated to the rear by each element differs between adjacent elements by an amount represented by

\[ \frac{2\pi L}{\lambda} + 2\pi \frac{d}{\lambda} \]

or, \( 360(0.613+0.110)+180 \) degrees which is 80 degrees.

If there are \( n \) elements, then for zero back radiation the vectors will form a closed figure, or

\[ n(80) = 9n(360) \]

where \( n \) is an integer.

But the overall length has already been chosen as \( \lambda \) and accordingly \( n \) is approximately equal to

\[ \frac{\lambda}{0.11\lambda} \]

which is 9

\[ 0.11\lambda \]

\( n(80) \) is accordingly 720, which is 2(360).

It will be seen that for zero back radiation, the antenna length is preferably \( \frac{\lambda}{2} \), \( 1.2\lambda \), \( 1.5\lambda \), .. etc., but if some other length is chosen, reflecting conductors 3, 4 and 5 will substantially counteract such back radiation.

The antenna disclosed herein need not be in the form of two radiators such as 6 and 7 placed above one another in space. It is also contemplated that where it is desired to use the present invention for frequencies in the region of or approaching ultra high frequencies, the elements will be much smaller and may be placed side by side in the same plane. In such a case, the general conditions referred to herein still prevail, and the resulting antenna will be as herein described except that one radiator will be moved laterally and vertically until it coincides with the plane of the other.

In addition, no special shape of elements is necessary to realizing the advantages of this invention, so long as the general matter of the relation of the conducting length of each element is arrived at as herein disclosed.

1. A non-resonant linearly-polarized antenna particularly for operation in the very high frequency range, comprising an aperiodic radiating grid having a continuous conducting path therethrough, said grid consisting of a plurality of elements in succession but on opposite sides of the longitudinal axis of said grid, each of said elements consisting of a conductor having an acute-angled configuration and each of said elements lying substantially in a plane, a second aperiodic radiating grid similar in size and shape to said first-mentioned grid, said grids being disposed substantially parallel in space and further disposed such that elements of one grid are adjacent to spaces between elements of the other grid.
2. A non-resonant linearly polarized antenna particularly for operation in the very high frequency range, comprising an aperiodic radiating grid having a continuous conducting path therethrough, said grid consisting of a plurality of elements in succession but on opposite sides of the longitudinal axis of said grid, each of said elements consisting of a conductor having an acute-angled configuration and each of said elements lying substantially in a plane, a second aperiodic radiating grid similar in size and shape to said first-mentioned grid, said grids being disposed substantially parallel in space and further disposed such that each element of one grid is adjacent to a space between two elements of the other grid over substantially the whole length of the antenna.

3. A non-resonant linearly-polarized antenna particularly for operation in the very high frequency range comprising a supporting member, an aperiodic radiating grid attached to said supporting member said grid having a continuous conducting path therethrough, said grid consisting of a plurality of elements in succession but on opposite sides of the longitudinal axis of said grid, each of said elements consisting of a conductor having an acute-angled configuration and each of said elements lying substantially in a plane, a second aperiodic radiating grid attached to said supporting member, said second-mentioned grid being similar in size and shape to said first-mentioned grid, said grids being disposed substantially parallel in space and further disposed such that each element of one grid is adjacent to a space between two elements of the other grid over substantially the whole length of the antenna.

4. A non-resonant linearly-polarized antenna particularly for operation in the very high frequency range comprising a supporting member, an aperiodic radiating grid attached to said supporting member, said grid having a continuous conducting path therethrough, said grid consisting of a plurality of elements in succession but on opposite sides of the longitudinal axis of said grid, each of said elements consisting of a conductor having an acute-angled configuration and each of said elements lying substantially in a plane, a second aperiodic radiating grid similar in size and shape to said first-mentioned grid, said grids being disposed substantially parallel in space and further disposed such that each element of one grid is adjacent to a space between two elements of the other grid over substantially the whole length of the antenna.

5. A non-resonant linearly-polarized antenna having an optimum operating frequency in the very high frequency range, comprising an aperiodic radiating grid having a continuous conducting path therethrough, said grid consisting of a plurality of elements in succession but on opposite sides of the longitudinal axis of said grid, each of said elements consisting of a conductor having a V-shaped configuration whose dimensions are represented by the relationship

\[ L - d = \frac{\lambda}{2} \]

Where \( L \) is the length of the conducting path around said V-shaped configuration, \( d \) is the distance across said V-shaped configuration along said longitudinal axis and \( \lambda \) is the wave length of said optimum operating frequency, and each of said elements lying substantially in a plane, a second aperiodic radiating grid similar in size and shape to said first-mentioned grid, said grids being disposed substantially parallel in space and further disposed such that elements of one grid are adjacent to spaces between elements of the other grid.

References Cited in the file of this patent

UNITED STATES PATENTS

1,898,661 Hagen --------------- Feb. 21, 1933
1,899,410 Bruce --------------- Feb. 28, 1933
2,145,024 Bruce --------------- Jan. 24, 1939
2,213,692 Cork et al. ------------- Sept. 3, 1940
2,366,195 Kandoian ------------- Jan. 2, 1945