

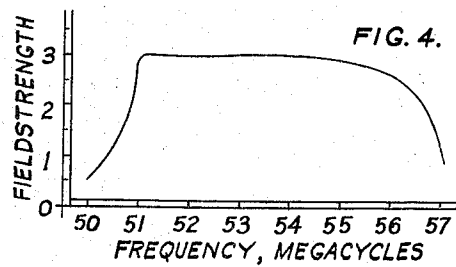
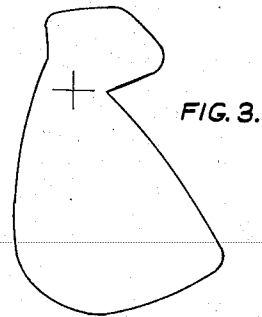
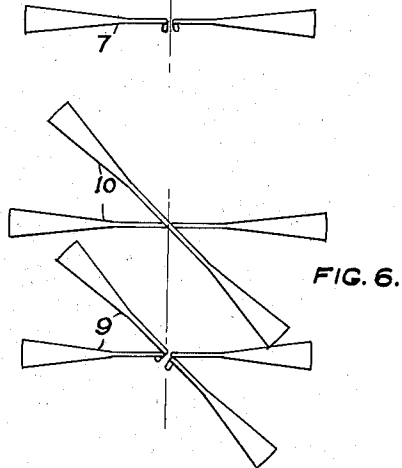
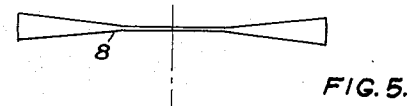
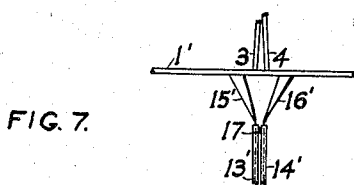
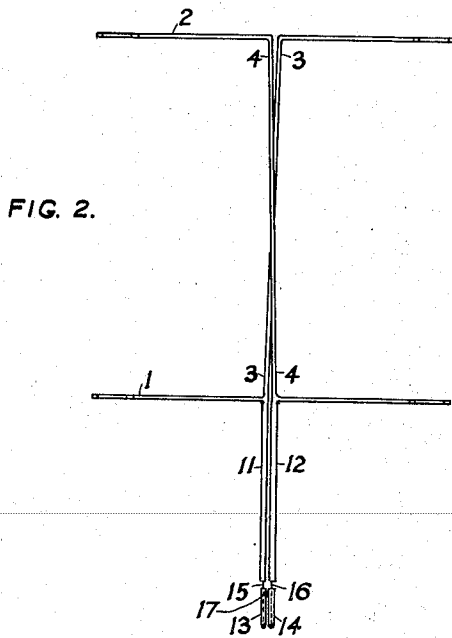
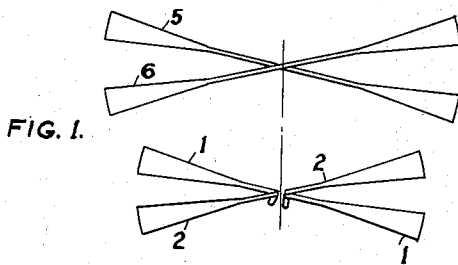
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2,274,149

TELEVISION ANTENNA

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TELEVISION ANTENNA

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12 Claims. (Cl. 250—33)

This invention relates to broad-band antennas, particularly for use with ultra-high frequency waves and for applications where such waves extend over a considerable frequency spectrum, as in television.

An object of this invention is to provide an antenna responsive to a relatively broad frequency spectrum.

Another object of this invention is to provide an antenna having maximum radiation if used for transmission, or maximum efficiency of interception if used for reception, in a horizontal plane. It is well known that this type of space pattern is desired in almost every antenna application.

Still another object of this invention is to provide a strong mechanical structure, with certain antenna elements acting as structural elements.

Still another object of this invention is to provide means whereby considerably different radiation patterns may be obtained by mechanical adjustment of the elements.

Still another object of this invention is to provide a broad-band antenna having a small value of wind resistance.

Still another object of this invention is to provide a broad-band antenna of relatively simple and compact structure yet having a high value of effectiveness (so-called "gain").

A final object of this invention is to provide an antenna system having broad-band impedance matching characteristics to the necessary feeder lines to the transmitter or receiver.

The ways in which these objects are attained are shown in connection with the accompanying drawing in which:

Fig. 1 shows a plan view of the antenna.

Fig. 2 shows a front elevation of the same.

Fig. 3 shows a representative polar coordinate graph of the energy distribution in a horizontal plane as radiated by the antenna when used for transmitting. The sensitivity in intercepting electromagnetic waves follows, of course, the same pattern when the antenna is used for receiving.

Fig. 4 shows a rectangular coordinate graph of the bandwidth of the antenna.

Fig. 5 shows a plan view of an alternate arrangement of radiating elements.

Fig. 6 shows a plan view of a second alternate arrangement of radiating elements.

Fig. 7 shows a front elevation view of an alternate means of connecting the feeder lines to the antenna.

In meeting the need for a wide frequency band

antenna I have experimentally determined that the energy response vs. frequency characteristic of an antenna element is proportional to the cross-sectional surface area of the conductor.

For instance, at a mean carrier frequency of 53 megacycles, the band of frequencies over which the response of one paddlewheel element 1, Fig. 1, is within 16% of the maximum value is 5.7 megacycles. Correspondingly, the bandwidth of a 1 inch diameter tubing element (not having the fan-like ends) is 3.8 megacycles. Further, the bandwidth of a $\frac{1}{2}$ inch diameter element (without ends) is 2.2 megacycles. A wire, of even smaller cross-section has a narrower bandwidth, but this is of little interest here because of structural considerations.

Since the present standards for television transmission call for a bandwidth of 4.75 megacycles without substantial variation of response, the element 1 will be seen to be ideally suited for television transmission antennas. For this purpose the paddles are 9" wide at the ends, 32" long, and $1\frac{1}{8}$ " thick, being supported in the center by a $1\frac{1}{2}$ " outside diameter section of tubing. It is to be understood that this and subsequent recitations of dimensions do not restrict this invention, but that wide variations of bandwidth, and operating frequency may be obtained according to the teaching of this specification.

The configuration in which four of the above described elements are arranged I call "reflected double-stack" and is shown in Figs. 1 and 2. Elements 1 and 2 are disposed one above the other a half-wavelength apart. Energy is conveyed from one to the other element by the structurally strong and electrically matched transposed pair of conductors 3 and 4. These are everywhere equally distant from each other and curve around through 180° so that the upper element 2 will be fed out-of-phase electrically from the lower element 1. This causes cancellation of the waves emitted into space below element 1 and above element 2 and consequent reinforcement of waves emitted at right angles to the plane containing elements 1 and 2. In this way maximum radiation in transmission and maximum sensitivity in reception are obtained in a horizontal plane. Elements 1 and 2 are disposed at an angle of 25 degrees one to the other in this embodiment for field-pattern reasons disclosed later.

Conductors 3 and 4 may conveniently be formed of duraluminum pipe, as may the central portions of elements 1, 2, 5 and 6. In this event duraluminum screw thread elbows may be

used to form the right angle bend at the top of conductor 3 to the right hand side of element 2, etc., and similar T's used at the lower junction of conductor 3 with element 1 and conductor 11. Split blocks of an insulator such as mycalex or Bakelite (not shown) may be used to clamp conductors 3 and 4 at a fixed distance apart at several points throughout the length thereof.

Elements 5 and 6 are each disposed $\frac{1}{4}$ wavelength behind elements 1 and 2, respectively. This causes cancellation of the waves emitted into space behind elements 5 and 6 consequent reinforcement of waves emitted in front of elements 1 and 2. Waves emitted into space above and below the groups of elements 1 and 5, 2 and 6 are partially cancelled in addition, the energy being emitted with maximum intensity in the horizontal plane.

The distribution of energy in the horizontal plane is shown in Fig. 3 in polar coordinates. This is a curve plotted from field-strength measurements made at a five mile radius from an operating television station. The orientation of the curve is the same as that of Fig. 1. The reduction of radiation of energy behind elements 5 and 6 and the increase in front of elements 1 and 2 postulated above is seen to be borne out in fact.

This type of energy distribution is usually desirable, since it is a rare occurrence that an ultra-high frequency transmitter is located in the center of the population it serves. High mountains are usually found at one side of the city and high buildings likewise, since the better class residential district is the prime service area of such transmitters.

The radiation pattern of Fig. 3 may be altered by changing the relative mechanical positions of the elements. The staggering of pairs of elements 1 and 5, 2 and 6 by 25 degrees was for the purpose of obtaining an appreciable radiation behind elements 5 and 6 to serve a small populated area in that direction. By aligning all elements, as shown in Fig. 5, the rear radiation drops to a small value and the maximum front radiation is symmetrical with respect to the axis perpendicular to the length of the elements. Similarly, in Fig. 6, is shown an alternate arrangement wherein elements 2 and 6 are both disposed at 45 degrees from the elements 1 and 5. This arrangement results in a radiation pattern similar to Fig. 3 except on a greater angle to the axis and somewhat greater radiation transverse thereto.

In the configurations described, certain dimensions were found to be optimum. These are given below in order to fully describe this invention. It is to be understood; however, that they apply to a mean frequency of 53 megacycles and will be proportionately different for different frequencies of operation.

The separation between elements 1 and 2 was found to be uniformly 111 inches. This is a half wavelength at the frequency of operation and was the optimum dimension for maximum field-strength in a horizontal plane. For horizontal polarization of the emitted waves this dimension is vertical, with the elements laying in horizontal planes.

The separation of elements 1 and 2 from elements 5 and 6 has an optimum value of 40" for 53 megacycles, or $\frac{1}{4}$ wavelength for all embodiments.

The elements 5 and 6 have no metallic connection with elements 1 and 2, or to the trans-

mitter feeder system, but are parasitically excited by radiant energy from elements 1 and 2.

The length of the driven elements 1 and 2 is 90" for 53 megacycles, or $\frac{1}{2}$ wavelength for all embodiments. The length of the parasitic elements 5 and 6 however varies for each embodiment. For the configuration of Fig. 1 this is $\frac{1}{2}$ wavelength, for Fig. 5 (elements 8) this is slightly less than $\frac{1}{4}$ wavelength, and for Fig. 6 (elements 10), slightly more than $\frac{1}{4}$ wavelength.

In any antenna installation the useful energy must be either conveyed to the antenna from the transmitter or conveyed from the antenna to a receiver. In the present invention this is accomplished by an impedance matching section 11 and 12 and feeders 13 and 14.

Each part 11 and 12 is one-quarter wavelength long and of a cross-sectional surface area approximately three times as great as the conductors 3 and 4, the latter being somewhat over one inch for the frequency of 53 megacycles. Parts 11 and 12 are arranged to hinge together or apart like two doors to allow exact adjustment of the impedance match. This adjustment varies the characteristic impedance of the matching section and is a convenient means by which to match the impedance of the antenna structure 1, 3, 4, to the feeders 13 and 14. The impedances of the latter are conveniently 70 ohms for each line, thus the impedance presented to the lower end of the matching section is 140 ohms. The inner conductors 15 and 16 are connected to the matching section. Parts 11 and 12 may also be arranged for adjustment by a translating motion mutually together and apart.

I have found that the most important condition to be met in the proper functioning of this antenna assembly is that the two outer conductors 13 and 14 be close together physically and that a good electrical bond 17 be provided between the two. This bond may be attached to an electrical ground, if available, thus allowing the structure to be firmly based on a tower or other grounded structure. The top and bottom of parts 11 and 12 may be similarly attached by means of insulators. Mechanical supports for the parasitic elements 5 and 6 have not been shown for sake of clarity, but these may also be held by insulators attached to supports preferably above the top of the upper elements and below the lower elements, respectively.

In addition to the arrangement shown in Fig. 2 the antenna may be fed according to Fig. 7. Conductors 3 and 4 are attached to an unbroken radiating element 1'. The spacing between adjacent surfaces throughout the length of these conductors in either figure is approximately one-half of the radius thereof. In Fig. 7, however, the inner conductors 15' and 16' of the feeders 13' and 14' are spaced outward in joining the element 1' and increase in cross-sectional area from the usual 70 ohm dimension at the juncture with 13' and 14' to approximately the element dimension at the element. This maintains the characteristic impedance substantially constant and the inner conductors are attached to the element at a physical separation corresponding to this value.

Another essential characteristic of the antenna is the frequency response shown in Fig. 4. This is the overall characteristic of matching section and antenna with the radiated fieldstrength determined with a linear rectifier intercepting the emitted energy at a considerable distance from the structure. Two desirable characteristics are

noted; first, the response is uniform over a wide band of frequencies, and second, that the response drops to a small value beyond this band of frequencies, particularly on the low frequency side. The latter greatly aids, if not largely accomplishes, the function of a single sideband filter as used in television transmission practice. This operation has been proven by the continued use of the antenna structure in regularly scheduled television broadcasts. For this application the carrier frequency is conveniently located between 51 and 52 megacycles.

Finally, the measured field-strength gain of this antenna over the usual reference half-wave antenna is 5.5. That is, a given amount of power fed to this antenna will result in 5.5 times the field-strength voltage obtained over the service area as would be obtained were the same power fed to a single half-wave antenna.

Thus far, the considerations have been for horizontally polarized waves. It is evident to those skilled in the art that the antenna structure may be utilized for emitting or intercepting vertically polarized electromagnetic wave energy by turning the whole assembly through 90 degrees in the vertical plane so that the radiating elements 1, 2, 5 and 6 are vertical. The alignment of the elements as shown in Fig. 5 is preferable. Since the vertical as well as horizontal radiation pattern is substantially the same as shown in Fig. 3 the same performance over a service area will be secured.

In considering the wind resistance of this antenna it is evident that it is of small value because of the flattened cross-section of the broad-band radiating elements. For horizontal polarization, the major dimension of the cross-section is horizontal, as shown in Figs. 1 and 2. The projected area exposed to the wind is thus a minimum in relation to the external surface effective in producing a broad-band electrical characteristic. For vertical polarization, the "paddles" may be set to give the minimum projected area in the direction of prevailing strong winds in any locality. While the antenna described comprised two pairs of element spaced a half-wavelength apart, it will be understood that the same construction may be duplicated to produce three or more pairs similarly successively spaced, or "stacked."

In considering cross-sectional areas of elements and conductors in this specification it is the external surface of such areas which is of importance; the center being hollow according to recognized practice to give a favorable strength to weight ratio. Also, the cross-sectional areas need not be circles and ellipses, but may be squares and rectangles, etc.

It will be noted in Figs. 1 and 2 that elements 1 and 2, have been shown as separated into two halves by connection to conductors 3 and 4. This is preferable in this embodiment. However, from the standpoint of electromagnetic radiation, 1 and 2 may be considered as an unbroken metallic surface, thus an element approximately a half-wavelength in length.

Having thus fully described my invention, I claim:

1. A broad-band antenna system comprising; a group of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the

other; and a second group of similar elements similarly spaced and not conductively coupled one to the other, located approximately three-sixteenths wavelength from the first said group.

2. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other such that one-half of one-half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other, located approximately three-sixteenths wavelength from the first said plurality.

3. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other such that one half of one half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other located approximately in a plane parallel to and spaced approximately three-sixteenths wavelength from the first said plurality.

4. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other such that one half of one half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other, located approximately three-sixteenths wavelength from said plurality, successive pairs of each plurality laying in planes at an angle to the preceding pair of said pluralities.

5. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other such that one half of one half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other, located approximately three-sixteenths wavelength from said plurality, successive pairs of each plurality laying in planes at an angle of the order of forty-five degrees to the preceding pair of said pluralities.

6. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced one-half wavelength apart with successive elements of the plurality contained in planes intersecting at an angle of approximately twenty-five degrees, and being conductively coupled one to

the other such that one half of one half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other, each located approximately three-sixteenths wavelength from an element of the first said plurality.

7. A broad-band antenna system comprising; a group of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately four-tenths wavelength long spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other; and a second group of similar elements approximately one-half wavelength long similarly spaced and not conductively coupled one to the other located approximately three-sixteenths wavelength from the first said group.

8. A broad-band antenna system comprising; a stack of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately four-tenths wavelength long, stacked one-half wavelength apart, and being conductively coupled one to the other; and a second stack of similar elements approximately seven-sixteenths wavelength long, not conductively coupled one to the other, located approximately three-sixteenths wavelength from the first said stack and at an angle thereto.

9. A broad-band antenna system comprising; a plurality of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, said elements being approximately one-half wavelength long, spaced approximately parallel one-half wavelength apart, and being conductively coupled one to the other by conductors of substantial mechanical rigidity spaced surface to surface less than the radius thereof apart, such that one half of one half-wave element is connected to the opposite half of the succeeding half-wave element; and a second plurality of similar elements similarly spaced and not conductively coupled one to the other, each located approximately three-sixteenths wavelength from an element of the first said plurality.

10. A broad band antenna system comprising; a stack of radiating elements having a greater cross-sectional surface area at the extremities

than at the center thereof, each element being slightly less than one-half wavelength long and stacked one-half wavelength apart; conductors of substantial mechanical rigidity positioned adjacent one to the other, connecting said elements of said stack; conductors of greater surface area one-fourth wavelength long connected at one extremity to the junction of an element and said first conductors; and feeders for conveying radio frequency energy to said system connected at the other extremity of said conductors of greater surface area.

11. A broad-band antenna system comprising; two radiating elements slightly less than one-half wavelength long spaced one-half wavelength in approximately a common plane, two conductors connecting said elements, the conductors positioned adjacent one to the other, such that one-half of one element is connected to the other half of the second element; two conductors one-quarter wavelength long of greater cross-sectional surface than said first conductors, each connected at one extremity to an adjacent junction of an element and said first conductor; a pair of coaxial feeders, the inner conductors thereof connected to the other extremity of said conductors of greater cross-sectional surface and the outer conductors thereof connected together; two more radiating elements approximately one-half wavelength long located in approximately a common plane and approximately three-sixteenths wavelength from said first common plane.

12. A broad-band antenna system comprising; a stack of radiating elements having a greater cross-sectional surface area at the extremities than at the center thereof, each element being slightly less than one-half wavelength long and stacked one-half wavelength apart; conductors of substantial mechanical rigidity positioned closely adjacent one to the other, connecting said elements of said stack; feeders for conveying radio frequency energy to said system having inner and outer conductors, a conductor connecting said outer conductors at the extremities thereof, said inner conductors extending beyond said outer conductors, and increasing in cross sectional surface area approximately proportional to said extension and connecting to an element of said stack.

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