

April 8, 1941.

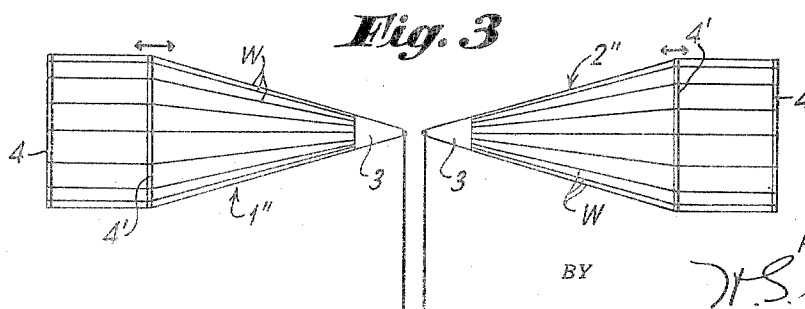
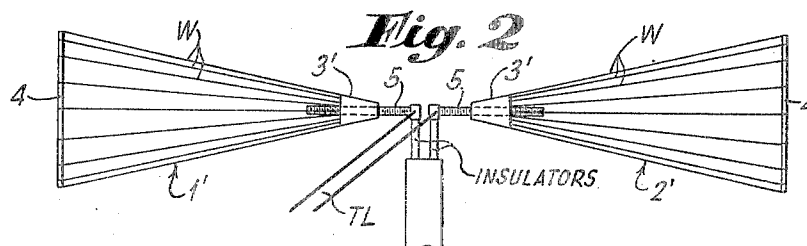
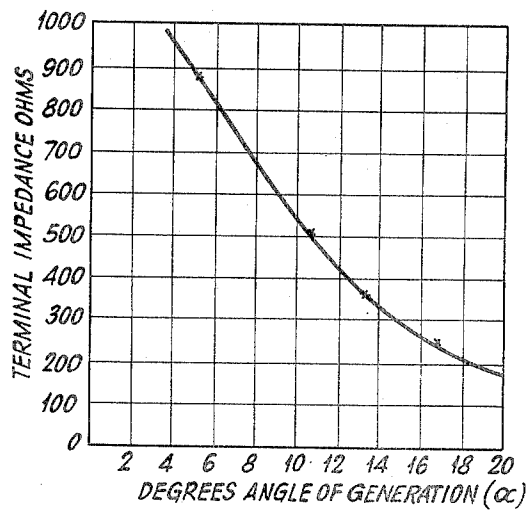
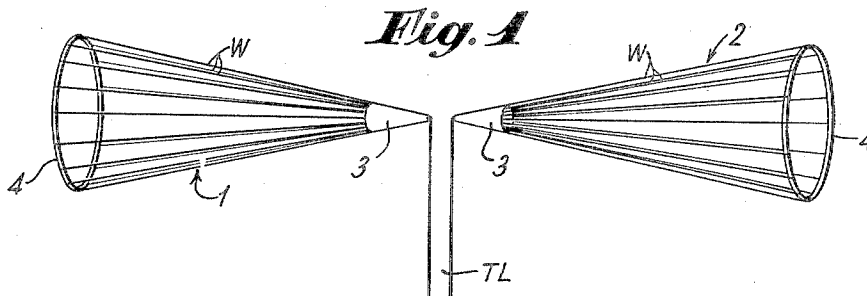
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2,237,778

SHORT WAVE ANTENNA

Original Filed Jan. 29, 1938

2 Sheets-Sheet 1



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Fig. 4

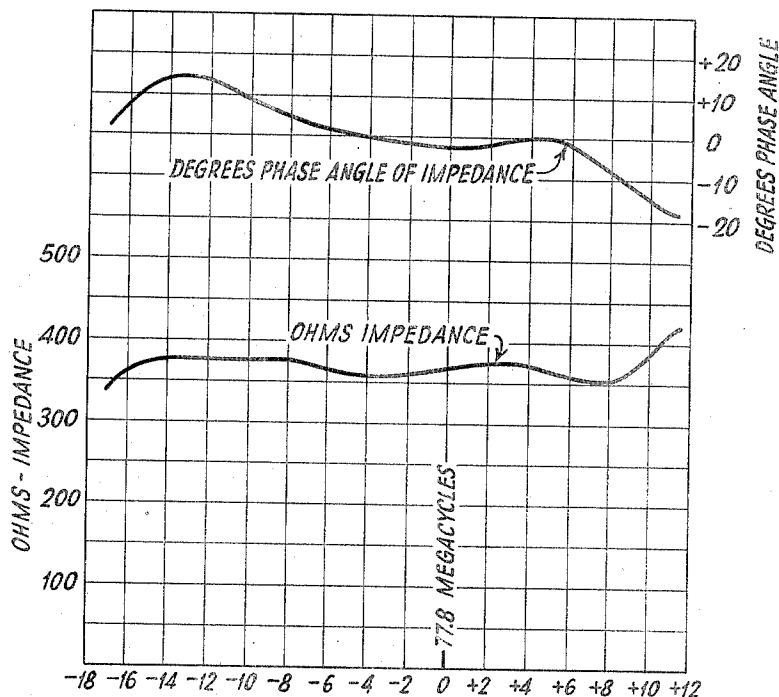


Fig. 5

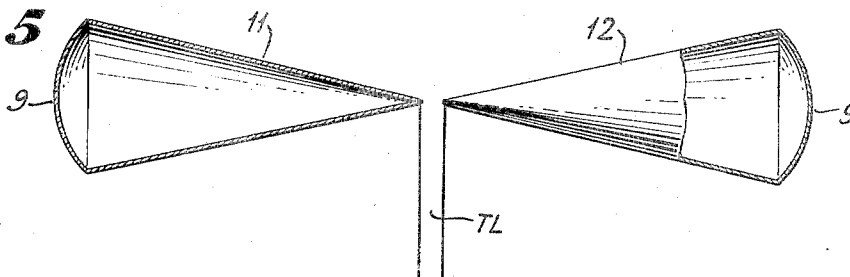
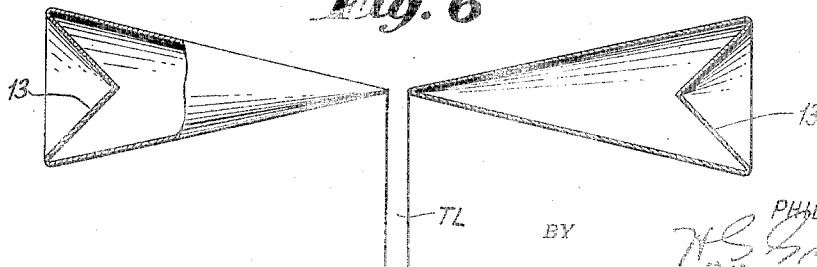


Fig. 6



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UNITED STATES PATENT OFFICE

2,237,778

SHORT WAVE ANTENNA

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Application January 29, 1938, Serial No. 187,594
Renewed January 25, 1940

14 Claims. (Cl. 250—33)

The present invention relates to short wave antennas, and particularly to an antenna which will present negligible reactance and practically constant resistance at its terminals over a wide range of frequencies, such as may be used in television transmission or reception. Specifically, the invention relates to antennas having, generally, conical surfaces of revolution of the type described in my copending applications Serial Nos. 147,817, filed June 12, 1937; 190,939, filed February 17, 1938; and 188,821 filed February 5, 1938.

One of the objects of the present invention is to provide an antenna and transmission line system which presents to the transmitter an impedance of substantially constant magnitude over a wide range of frequencies. To achieve this object, I provide an antenna in the form of one or more conical surfaces of revolution having predetermined angles, whereby the impedance of the antenna at its terminals is substantially a pure resistance equal to the characteristic or surge impedance of the transmission line.

To more readily understand the foregoing object, one should bear in mind that in prior arrangements it has been impossible to obtain an antenna and transmission line system having an extremely flat impedance versus frequency characteristic, over a wide band of frequencies, because of the reactances presented by the antenna to the transmission line, and also because of deleterious effects of the impedance matching circuits at frequencies other than the mid-band frequency. Inasmuch as any reactance at the end of a transmission line produces reflection on the line, reactance introduced either by the antenna or an impedance matching circuit will result in a variable impedance at the transmitter end of the line. By means of the present invention, however, I eliminate the use of and the need for auxiliary impedance matching circuits, by providing an antenna whose impedance at its terminals matches the characteristic or the surge impedance of the transmission line over a wide range of frequencies.

Another object of my invention is to disclose the proper dimensions for my antenna, including lengths and angles, to give the correct impedance to match the impedance of any particular transmission line.

A further object of the present invention is to provide my antenna in the form of a cage of wires regularly distributed around and lying in a conical surface of revolution.

A still further object is to provide a short wave antenna having the desirable characteristics mentioned above, which can be adjusted after construction to change the average impedance at its terminals over a considerable range. An antenna which will satisfy this object is particularly desirable under practical working conditions in the field, where due to the influence of such factors as ground, height of the antenna above ground or a roof, etc., may change the impedance of the antenna from the original values considered in the design of the antenna.

A feature of the invention comprises an antenna system having a pair of conical surfaces of revolution arranged with their apices adjacent one another, with means for varying the effective average angle of generation of the surfaces of revolution as seen from their terminals. The term "angle of generation," when herein after referred to, is intended to define the angle between the axis of revolution and the generatrix of the surface of revolution.

Another feature of the invention comprises an antenna having a conductive structure, the main portion of which is in the form of a cone and the other portion of which is in the form of a cylinder.

Other objects, features and advantages will appear from a reading of the following detailed description, which is accompanied by drawings wherein:

Figs. 1, 2 and 3 illustrate different antenna embodiments constructed in accordance with the principles underlying the present invention;

Fig. 1a is a curve giving terminal impedance versus angles of generation for an antenna constructed in accordance with the present invention;

Fig. 4 graphically illustrates the impedance versus frequency characteristic obtained by measurement made on a typical antenna constructed in accordance with the present invention; and

Fig. 5 and Fig. 6 illustrate other types of conical antenna structures, in accordance with my invention.

Referring to Fig. 1 in more detail, there is shown an antenna comprising two similar conductive radiating structures 1 and 2, each of which consists of a plurality of wires W regularly distributed around and lying in a conical surface of revolution. These wires are connected at their closely adjacent ends to, and terminated in a solid, short, metallic element 3 forming the apex, and at their more widely spaced ends

connected to a metallic ring 4 which maintains the wires in suitable spaced relation with respect to one another. The number of wires W in each cone will vary, depending upon the angle of the cone desired. It is preferred, however, that there be at least eight wires in each cone, and preferably more, so as to simulate a continuous current sheet having the form of the surface of revolution. Cones 1 and 2 are shown in the horizontal plane with their longitudinal axes extending in the same straight line, the apices of which are adjacent each other and connected to a suitable transmission line TL extending to high frequency translating, transmitting, or receiving apparatus, not shown.

The length of each cone 1 or 2 along the surface thereof from apex to base (i. e. large end) is preferably of the order of 0.36 wavelength for the frequency corresponding to the center of the band width to be used. With a system of the type herein described, and having the length of approximately 0.36 wavelength, the antenna is substantially non-reactive over an extremely wide band of frequencies, for example, a band width of the order of 20%, and the resistance is very nearly constant over this range. Although a length of the order of 0.36 wavelength is preferred, it should be understood that this recommended length can be departed from to some extent and the advantages of the present invention still obtained, although the resistance may have a considerable variation with frequency. For example, if the length of each cone is of the order of .23 wavelength, the impedance will be found to be nearly non-reactive, although the resistance may vary plus or minus some 15% with average frequency range. The ideal antenna desired should have a constant resistance and negligible reactance over the complete band of frequencies for which it is to be used.

The antenna of Fig. 1 has a radiation pattern which is similar to the radiation pattern of an ordinary half wave dipole antenna, which, it will be appreciated, is a figure 8 in any plane including the dipole.

I have found that by varying the angle of generation of my cones 1 and 2, the impedance of the antenna system at its terminals (at the apices) may be made to match the characteristic or surge impedance of the transmission line TL. This variation in angle of generation of the cone is accompanied by a variation in the resistance or impedance of the antenna at its terminals.

Fig. 1a is a curve showing terminal impedance in ohms versus angle of generation in degrees, for the cones of the antenna, and gives the angle of generation required for the cones to produce a desired terminal impedance at the adjacent apices for matching the characteristic or surge impedance and the transmission line. The curve of this figure was obtained from actual measurements made on an antenna of the type shown in Fig. 1 at a height of one-half wavelength above ground. It should be understood that the curve will differ from that shown for different heights above ground, and also to some extent for different conditions of ground.

Fig. 2 shows another embodiment of the present invention wherein two cones 1' and 2' are provided at the center, with means for adjusting the average impedance of the antenna at its apices over a considerable range. The apices of both cones, which comprise solid metallic elements 3', 3', have threaded through them metal-

lic rods 5, 5 which extend from the terminals of the transmission line TL into the interior of the cones. In effect then, each half of the antenna of Fig. 2 is not a perfect cone but consists of a small cylinder comprising the threaded rod 5 and a more or less perfect cone 1' or 2' extending from the rod 5 to the metal ring 4. In order to obtain a moderate range of adjustment of antenna resistance so as to match the characteristic or the surge impedance of the transmission line TL, the radiating structures 1', 2' can be moved over the lengths of the metallic rods 5, 5. Each half of the antenna has a smaller effective angle, seen from the terminals of the transmission line TL than the actual angle of the cone per se, seen from the apex comprising the solid threaded metal apex element 3'.

In this instance, the effective angle of generation may be considered as that angle which is formed between the axis of revolution and an assumed line passing through the point of connection of the transmission line and the major diameter of the surface of revolution. The assumed line referred to may be considered the generatrix of the effective cone.

The arrangement of Fig. 2 is found to be particularly advantageous where it is difficult to determine the actual conditions to be encountered in the field, such conditions being the height of the antenna, the characteristics of the ground, etc. In such a case, it is desirable to design the cones of the antenna to have an actual angle of generation greater than the angle determined by the graph of Fig. 1, in order to give a smaller terminal impedance, and then to adjust these cones over their respective metallic rods 5 to provide the correct terminal impedances which will match the characteristic or surge impedances of the transmission line. In this way we obtain an impedance match without the need for any of the well known types of auxiliary matching circuits commonly employed in the art.

Fig. 3 is another embodiment which has an adjustable terminal impedance. The arrangement of this figure is preferred over that of Fig. 2 since it is superior in its impedance-frequency characteristic. Fig. 3 comprises two conductive structures 1'', 2'', which are first built with cones having angles of generation somewhat smaller than the proper load to give the desired impedance. The antenna will then be found to have a load impedance somewhat higher than the surge or characteristic impedance of the transmission line TL. Adjustable rings 4', 4' having preferably approximately the same diameter as the outer rings 4, 4 are inserted in the cones in the conductive structures 1'', 2'' near the ends so as to distort the shape into a form similar to that shown in the drawings; that is, a cone from the apex 3 to the ring 4', and a cylinder from the ring 4' to the metallic end ring 4. In this way the angle of generation of the conical portion of the structures 1'', 2'' may be increased and the impedance presented to the transmission line TL at its terminals can be adjusted to make a perfect impedance match. Ring 4' may be made either of metal or an insulating material.

The method hereinabove described in connection with Fig. 3 for matching the impedance and the antenna to the transmission line can be carried out to an extent wherein the inserted ring 4' is a distance from the outer ring 4 equal to about one-third of the original length of the radiating structures 1'', 2'' without appreciably narrowing the impedance frequency character-

istic. It is preferred that the conical portion of the structures 1'', 2'' be greater than the cylindrical portion thereof, otherwise the band width of the antenna may be appreciably decreased, which will happen if the larger portion of the original length of each radiating structure 1'', 2'' becomes cylindrical. Even in this case, however, where the band width is decreased because of a larger cylindrical portion than a conical portion, the band width of the antenna will still be much wider than many simple types of antennas. It is preferred that the overall length of each conductive radiating structure 1'', 2'' be approximately 0.36 wavelength at the mid frequency of the desired band.

Fig. 4 shows the actual impedance versus frequency characteristic as measured on an antenna of the general type shown in Fig. 1, having an angle of generation of the cone of 13.5° and overall length of 0.36 wavelength at a frequency of 77.8 megacycles. It should be noted from this figure that the impedance over a range of 25%, as measured from minus 16 to plus 10, is extremely flat and does not vary more than 10 ohms from its average value of 365 ohms, approximately. The phase angle, which is the measure of the reactance of the antenna over this same range, varies from approximately plus 14° to minus 14°. The variation in the phase angle of impedance is less than plus and minus 5° over a range of 15%. It will thus be seen that the antenna of the present invention presents negligible reactance and practically constant resistance at its terminals over a wide frequency range.

Fig. 5 shows another modification of my invention, wherein the conical surfaces of revolution are composed of a metallic sheet material. In this figure, each of the cones 11, 12 is terminated in a hemisphere 9 for the purpose of decreasing wind resistance and for mechanical considerations, such as aiding in supporting the structure, and in preventing snow, ice and water from entering the large end or base. When such a hemisphere is used, then the overall dimensions along the surface of the cone and sphere will be somewhat greater than the previously indicated preferred value.

Fig. 6 is another modification wherein each conical surface of revolution is enclosed at its large end by another conical surface or dished-in portion 13.

Of course, other types of closures for the bases of the cones, such as a flat surface, may be employed.

Although the drawings illustrate antennas of the wire or cage type, it should be distinctly understood that the principles of the invention explained hereinabove, such as those which relate to angle of generation, and means for adjusting the average impedance of the cones over a considerable range, are not limited solely to the wire cage type, but are equally applicable to antennas of my general type employing a solid sheet of metal of the kind illustrated and described in my copending applications supra.

The term "order of 0.36 wavelength," used in the specification and appended claims, is intended to cover a range of 40% above and below this value.

What is claimed is:

1. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising a conductive structure in the form of a conical surface of revolution, a transmission line connected to the apex

of said structure, means for adjusting the effective angle of generation of said structure so that the impedance thereof at its connection to said transmission line matches the impedance of said transmission line.

2. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, means for adjusting the effective angles of generation of said structures so that the impedance of said antenna at its connection to said transmission line matches the impedance of said transmission line.

3. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, said structures comprising a plurality of wires distributed around and lying in the surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, means for adjusting the effective angles of generation of said structures so that the impedance of said antenna at its connection to said transmission line matches the impedance of said transmission line.

4. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the lengths of said structures as measured along said surfaces from apex to base being of the order of 0.36 wave-length at the mid-frequency of the band, the apices of said structures being adjacent each other and connected to terminals of a transmission line, means for adjusting the effective angles of generation of said structures so that the impedance of said antenna at said terminals matches the impedance of said transmission line.

5. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, each of said structures being in the form of a cone for the major part thereof, and a cylinder for the remaining part, said cone being located nearest said transmission line terminals and means for varying the ratio between the length of said cylinder and said cone whereby the impedance of said antenna at said terminals matches the impedance of said transmission line.

6. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, and means at said apices for varying the distances of said cones from the terminals of said transmission line.

7. A short wave antenna in accordance with claim 6, characterized in this that said means comprises a pair of threaded rods which adjustably extend into the interior of said cones.

8. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of

revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, means at said terminals for varying the distances of said cones from the terminals of said line, the actual angles of generation of said cones seen from the apices thereof being greater than the effective angle seen from the terminals of the transmission line.

9. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, each of said structures being in the form of a cone for approximately two-thirds the length thereof, and a cylinder for the remaining third part and means for varying the ratio between the length of said cylinder and said cone whereby the impedance of said antenna at said terminals matches the impedance of said transmission line.

10. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies, comprising two conductive structures in the form of conical surfaces of revolution, the apices of said structures being adjacent each other and connected to terminals of a transmission line, means for adjusting the effective angles of generation of said structures so that the impedance thereof at said terminals matches the impedance of said transmission line, the apices of said structures comprising short, solid, metallic elements.

11. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies comprising a conductive structure in the form of a surface of revolution, both ends of the generatrix intersecting the axis of revolution of said surface, a transmission line connected to the apex of said structure, the effective

angle of generation of said structure being such that the impedance thereof at its connection to said transmission line matches the impedance of said transmission line.

12. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies comprising a conductive structure in the form of a surface of revolution having at least a portion thereof conical, both ends of the generatrix of said structure intersecting the axis of revolution thereof, a transmission line connected to the apex of said structure and means for adjusting the effective angle of generation of said structure so that the impedance thereof at its connection to said transmission line matches the impedance of said transmission line.

13. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies comprising a conductive structure in the form of a conical surface of revolution, a transmission line connected to the apex of said structure, the effective angle of generation of said structure being such that the impedance thereof at its connection to said transmission line matches the impedance of said transmission line, the base end of said structure being closed by a substantial hemisphere.

14. A short wave antenna having a substantially flat impedance characteristic over a wide range of frequencies comprising a conductive structure in the form of a conical surface of revolution, a transmission line connected to the apex of said structure, the effective angle of generation of said structure being such that the impedance thereof at its connection to said transmission line matches the impedance of said transmission line, the base end of said structure being closed by another conical surface.

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