

Aug. 6, 1957

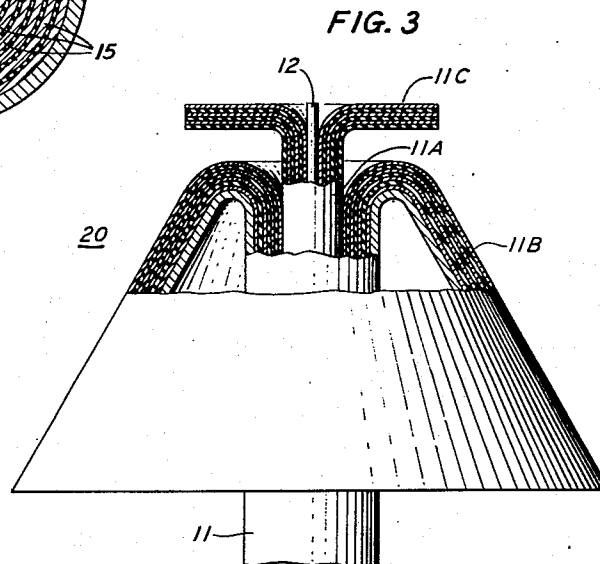
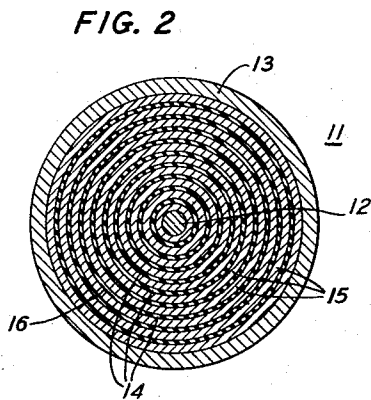
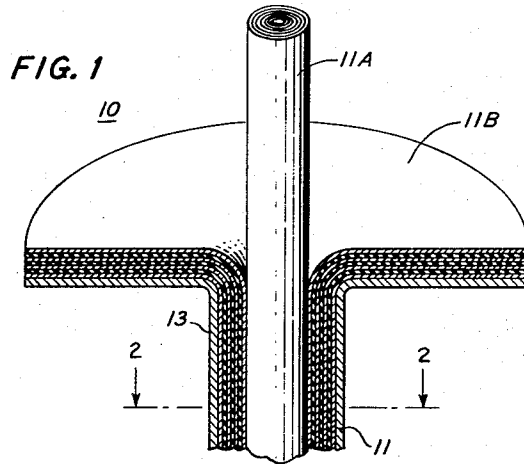
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ANTENNAS EMPLOYING LAMINATED CONDUCTORS

Filed May 29, 1952

2 Sheets-Sheet 1



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FIG. 4

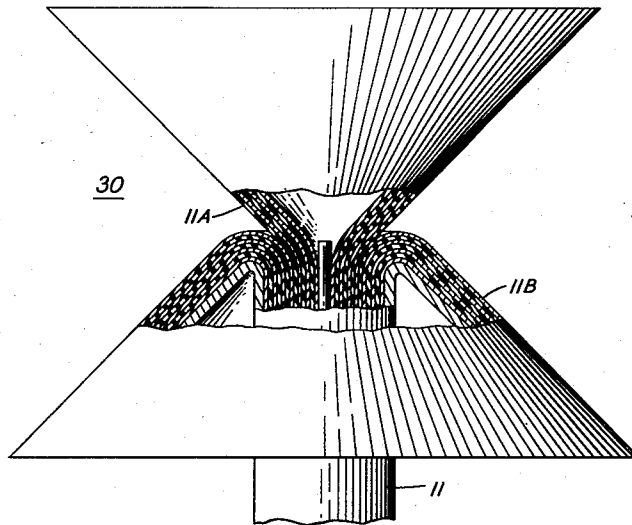


FIG. 5

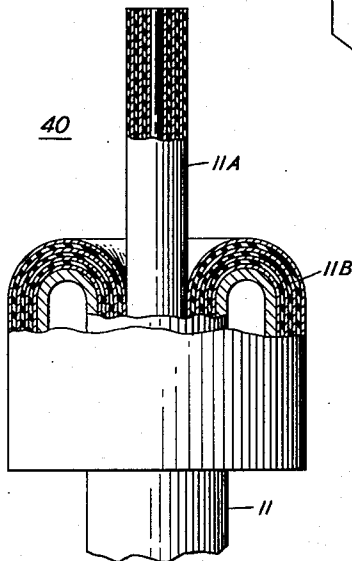
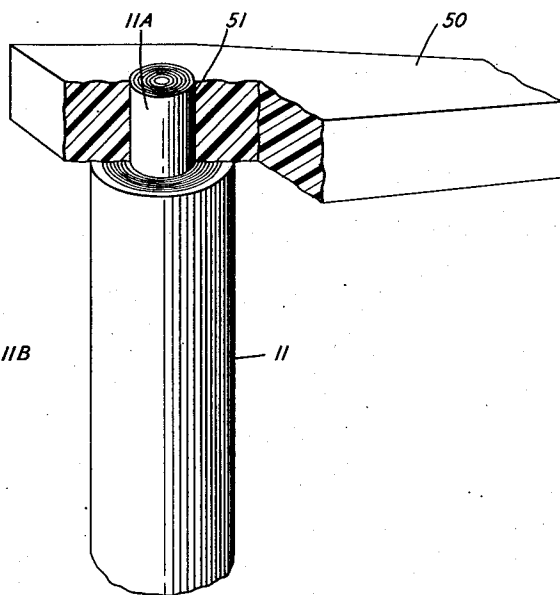


FIG. 6



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ANTENNAS EMPLOYING LAMINATED CONDUCTORS

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Application May 29, 1952, Serial No. 290,635

8 Claims. (Cl. 343—791)

This invention relates to antennas and more specifically to antennas employing laminated conductors.

In a copending application of A. M. Clogston, Serial No. 214,393, filed March 7, 1951, now United States Patent 2,769,148, issued October 30, 1956; there are disclosed a number of composite conductors, each of which comprises a multiplicity of insulated conducting elements of such number, dimensions, and disposition relative to each other and to the orientation of the electromagnetic wave being propagated therein as to achieve a more favorable distribution of current and field within the conducting material. In this application there is disclosed, among other embodiments, a cylindrical "stack" comprising a multiplicity of thin, coaxially arranged, metal laminations insulated from one another by thin insulating layers and arranged so that the smallest dimension of each of the laminations is in the direction perpendicular to both the direction of wave propagation and the magnetic vector. Each metal lamination is preferably many times (for example 10, 100, or even 1000 times) smaller than the factor δ which is called one skin thickness or one skin depth. The distance δ is given by the expression

$$\frac{1}{\pi f \mu \sigma} \quad (1)$$

where δ is expressed in meters, f is the frequency in cycles per second, μ is the permeability of the metal in henries per meter, and σ is the conductivity in mhos per meter. The factor δ measures the distance in which the current and field penetrating into a slab of the metal many times δ in thickness will decrease by one neper; i. e., their amplitude will become equal to

$$\frac{1}{e} = 0.3679 \dots$$

times their amplitude at the surface of the slab.

It is pointed out in the Clogston application that when a conductor has such a laminated structure, a wave propagated along the conductor at a velocity in the neighborhood of a certain critical value will penetrate further into the conductor (or completely through it) than it would penetrate into a solid conductor of the same material, resulting in a more uniform current distribution in the laminated conductor and consequently lower losses. The critical velocity for the type of structure just described is determined by the thickness of the metal and insulating laminae and the dielectric constant of the insulating laminae in the composite conductor.

When laminated conductors of the general type just described are utilized as lead-ins to antennas, a problem of connecting the laminated conductor to the antenna arises. The present invention is concerned with the alleviation of this difficulty.

It is an object of the present invention to provide antenna structures particularly suitable for use with laminated conductors serving as lead-ins.

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In accordance with the present invention, a number of antenna structures are provided each employing a "Clogston" conductor, that is, a conductor comprising a multiplicity of conducting portions having at least one dimension in a direction substantially transverse to the direction of wave propagation down the length thereof which is small compared to its appropriate skin depth at the highest frequency of electromagnetic wave to be propagated. In each of the embodiments to be described in greater detail below, the central portion of the Clogston conductor extends a greater axial distance than the outer laminated layers. A variety of antenna structures embodying the invention are possible and, by way of example, antennas of the ground plane, disc cone, biconical, coaxial and polyrod types are described herein.

The invention will be more readily understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof in which:

Fig. 1 is a schematic perspective view with portions broken away of a ground plane antenna in accordance with the invention;

Fig. 2 is an enlarged cross-sectional view taken in a plane through lines 2—2 of Fig. 1;

Fig. 3 is a perspective view with portions broken away, of a disc cone antenna in accordance with the invention;

Fig. 4 is a schematic perspective view, with portions broken away, of a biconical antenna in accordance with the invention;

Fig. 5 is a schematic perspective view, with portions broken away, of a coaxial antenna in accordance with the invention; and

Fig. 6 is a schematic perspective view, with portions broken away, of a polyrod antenna system in accordance with the invention.

Referring more specifically to the drawings, Fig. 1 shows in perspective a ground plane antenna 10 employing, or which is adapted to be connected to one of the general type of composite conductors 11 which have come to be known as "Clogston conductors." An example of one form of such a conductor is shown in cross section in Fig. 2. This conductor comprises a central core 12 of either conducting or dielectric material (in some cases the core can be omitted), an outer sheath 13 of any suitable shielding material coaxial with the core, and a cylindrical stack 16 of a multiplicity of insulating and metallic layers 14 and 15, respectively, completely filling the space between the core and the shield. As disclosed in the above-mentioned Clogston application, each of the metal layers 15 is very thin compared to the skin depth of the conductor being used, which for example, can be copper, silver or aluminum. The insulating layers 14 are also made very thin and may be of any suitable material. Examples of satisfactory material are: air, polyethylene, polystyrene, quartz and polyfoam. The layers 14 are of the order of one-half the thickness of each metal layer, although this is not necessarily true in all cases. The stack 16 has 10 or 100 or more metal layers 15 and a substantially equivalent number of insulating layers and since there are so many layers it makes no difference whether the first or the last layer in the stack is of metal or of insulation. A conductor of the type shown in Fig. 2 is shown in Fig. 17A of the above-mentioned Clogston application and reference is made to the application for more details thereof. More specifically, in that application it is shown that the conductor of Fig. 17A has a current distribution in the stack such that the current is in one direction in the outer portion and in the other direction in the inner portion, and zero at a point intermediate the inner and outer portions. It is explained that this distribution of currents permits regarding the inner and outer portions as separate current carrying

portions. In the present application, these portions are so regarded, and the region of zero current, as explained in the Clogston application, separates these two portions. While this specific type of conductor is being shown as an example of Clogston conductors suitable for use in the present invention, it is of course obvious that other conductors of this general type, many of which are also disclosed in this Clogston application, can be used as well.

Referring again to Fig. 1, the upper end, as shown in Fig. 1, of the conductor 11 (which either is the end of a lead-in conductor to transmitting apparatus or is connected by means such as are disclosed in the above-mentioned Clogston application to such a lead-in) is fashioned so that the inner portion 11A extends past the outer portion 11B thereof, the portion 11B being fashioned in the shape of a horizontal composite disc surrounding the inner portion 11A. By way of example, the radius of the disc 11B is made approximately one-quarter of a wavelength in the insulating material of the frequency to be radiated from the antenna and the inner portion 11A extends beyond the disc 11B by a similar amount. The radiation pattern from the antenna 10 is similar to that of corresponding antenna systems employing solid conductors, that is, it is in general similar to other ground plane antenna elements.

Fig. 3 shows another antenna system 20 suitable for use with a composite conductor 11. This antenna is of the disc cone type and has a radiation pattern somewhat similar to that of other disc cone antenna systems. The inner portion 11A of the conductor 11 has its top fashioned in a horizontal disc 11C the inner core 12 being cut off level with the top of the disc 11C. The outer portion 11B of the conductor 11 is fashioned in the form of a cone skirt which extends back and surrounds the conductor 11. The radius of the disc 11C is usually made less than one-quarter wavelength in the insulating material of the frequency to be radiated from the antenna and the length of the skirt 11B is somewhat greater than the radius of the disc.

Fig. 4 shows an antenna arrangement 30 which is somewhat similar to that of Fig. 3, the main difference being that the inner portion 11A of the composite conductor 11 is shaped in the form of a conical skirt as is also the outer conductor 11B. The skirts 11A and 11B their bases facing in different directions as shown in Fig. 4. The antenna system 30 gives a radiation pattern which is somewhat similar to biconical antenna systems using solid conductors.

Fig. 5 shows a coaxial type antenna system 40 suitable for use with composite conductors of the Clogston type. In this arrangement the inner portion 11A extends out past the outer portion by a distance equal to substantially one-quarter wavelength in the insulating material of the radiation frequency of the antenna while the outer portion 11B is fashioned in the form of a skirt which surrounds the conductor 11 and extends back a distance equal to approximately one-quarter wavelength in the insulating material of this frequency. The radiation pattern of this antenna is substantially similar to that of other coaxial antennas.

Fig. 6 shows one manner of connecting a composite conductor 11 to a polyrod antenna 50. In this arrangement, the inner portion 11A of the conductor 11 projects through an aperture 51 of matching size in the antenna 50. The radiation pattern from the polyrod 50 is substantially like that of polyrod antennas employing other forms of lead-ins.

It is obvious that many changes can be made in the embodiments described above without departing from the spirit and scope of the invention. The various embodiments are exemplary only and they do not by any means comprise a complete list of antennas to which the invention is applicable and it is obvious that many more will occur to those skilled in the art.

What is claimed is:

1. An antenna comprising a laminated conductor for the transmission of electromagnetic waves including a multiplicity of very thin coaxially arranged metallic laminations separated by very thin layers of insulating material, at least one of said metallic laminations being at least as thin as the skin depth of penetration of said waves at the frequency of operation of said antenna, said laminated conductor having inner and outer current carrying portions separated by a region of substantially zero current, said inner portion extending in the general direction of the longitudinal axis of said laminated conductor farther than said outer portion and forming a radiation element of said antenna, said outer portion terminating in a radiation element of said antenna, and at least one of said elements having a thin layer of said insulating material thereon.

2. An antenna as claimed in claim 1 wherein said outer portion terminates in a laminated circular member surrounding the inner portion.

3. An antenna as claimed in claim 1 wherein said outer portion terminates in a laminated flat circular plate surrounding the inner portion, said plate having a radius equal substantially to one-quarter of a wavelength in the insulating material of the frequency to be radiated by the antenna.

4. An antenna as claimed in claim 1 wherein said outer portion terminates in a laminated circular skirt in the form of a cylinder surrounding and coaxial with said inner portion and extending backwardly a distance equal substantially to one-quarter of a wavelength in the insulating material of the frequency to be radiated.

5. An antenna as claimed in claim 1 wherein said outer portion terminates in a circular skirt in the form of a truncated cone with its base remote from the radiation element formed by said inner portion.

6. An antenna comprising a laminated conductor for the transmission of electromagnetic waves including a multiplicity of very thin coaxially arranged metallic laminations separated by very thin layers of insulating material, at least one of said metallic laminations being at least as thin as the skin depth of penetration of said waves at the frequency of operation of said antenna, said conductor having inner and outer current carrying portions separated by a region of substantially zero current, said inner portion extending in the general direction of a longitudinal axis of said conductor farther than said outer portion and terminating in a circular member forming a radiation element of said antenna, said outer portion terminating in a circular skirt in the form of a truncated cone with its base remote from the termination of said inner member forming a radiation element of said antenna, and at least one of said elements having a thin layer of said insulating material thereon.

7. An antenna as claimed in claim 6 wherein said inner member terminates in a laminated flat circular plate.

8. An antenna as claimed in claim 6 wherein said inner portion terminates in a cone having its base at the outer extremity of the inner portion.

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