March 12, 1957 E. F. HARRIS 2,785,399

HIGH FREQUENCY ANTENNA

Filed Nov. 30, 1955

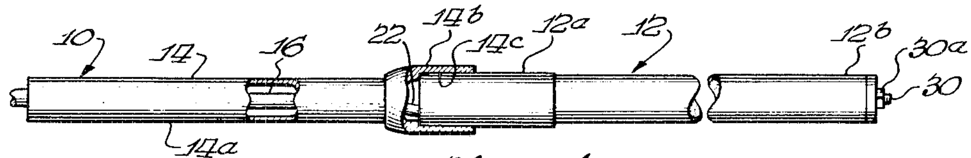

Fig. 1

Fig. 2

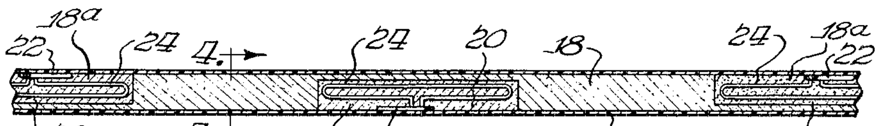

Fig. 3

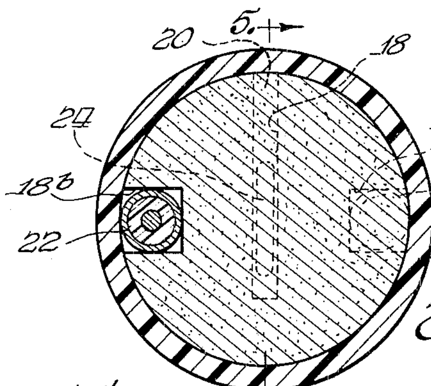

Fig. 4

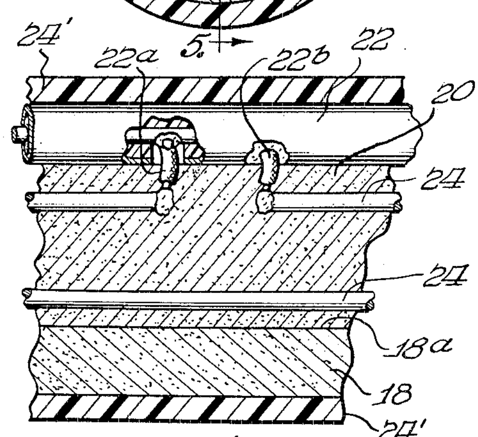

Fig. 5

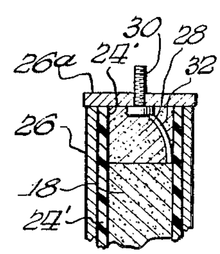

Fig. 6

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HIGH FREQUENCY ANTENNA

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4 Claims. (Cl. 343—796)

My invention relates to an omni-directional high frequency antenna for use in locations exposed to the weather, especially icing conditions.

In some communication systems it is necessary to radiate high frequency energy uniformly in all horizontal directions. Where such systems use comparatively high frequencies, such as 400 or 500 megacycles, such radiation demands the use of an array of comparatively small radiating elements. One especially effective array for this purpose consists of a plurality of vertically aligned vertical radiating elements, such as folded dipoles, which are fed by a common coaxial feed line to radiate effectively. The radiation pattern of such an array is horizontally uniform and has a comparatively small beam width in the vertical direction, such as for example ten degrees to the half power points. An array of this kind is very effective from the electrical standpoint.

However, in practical installation these arrays are subject to a number of problems. One of these is the problem of icing. For most effective antenna radiation it is, of course, necessary to mount the antenna in an exposed position, preferably on a comparatively high building or tower. In such position, however, ice frequently builds up on the exposed surfaces of the antenna unit, forming a coating which may be comparatively thick and in any event defines a high dielectric constant jacket about the entire antenna. Even if the radiating elements are protected against the direct contact of the ice, the ice may nevertheless detune the elements to an extent which greatly decreases the energy transfer and hence the radiated power of the antenna. Under such circumstances the effectiveness of the communication system is greatly reduced and may be completely destroyed. Moreover, such antennas are usually located in inaccessible places where it is not possible physically to remove ice formations.

In accordance with the present invention, the effects of icing conditions on an omni-directional high frequency antenna of the above type are greatly reduced. In the construction here shown and described, the antenna is formed by a lengthy cylindrical core of cellular material, such as cellular cellulose acetate. The core has a series of longitudinal slots spaced along its length and extending inwardly from the periphery. As the core is traversed, these slots spiral about the periphery. Radiating elements, such as folded dipoles, are embedded in these slots, each element being of comparatively small extent in the radial direction of the core and being centered in relation to the axis of the core. A coaxial feed line likewise spirals about the core to register with the slots at the feed points for the respective radiating elements. Connections extend radially inwardly from the feed line to each of the radiating elements. The radiating elements themselves are securely held in fixed position by the use of cellular material which is placed in the slots and thus embeds the respective radiating elements. The entire unit is jacketed with an impregnated fiberglass wrapping which serves to keep out all moisture.

In use, the antenna of the present invention is mounted in vertical position in a suitable radiating location. When and if ice builds up on the antenna, it does so on the outer exposed faces, rather than on the radiating elements. These faces are located a maximum distance and a uniform distance away from the radiating elements. In consequence, the increased dielectric constant of the ice does not greatly change the tuning of the antenna, so that effective radiation is obtained notwithstanding the presence of the ice.

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It is therefore a general object of the present invention to provide an improved high frequency omnidirectional antenna suitable for use in locations exposed to the weather.

A more specific object of the present invention is to provide an improved all-weather high frequency omnidirectional antenna which retains its effective electrical characteristics even though a coating of ice covers the exposed parts of the antenna.

Another object of the present invention is to provide an improved antenna suitable for all-weather use which is light in weight and yet is physically rugged with the radiating elements positively held in effective radiating positions.

It is still another object of the present invention to provide an improved antenna of the foregoing type having features of construction, combination and arrangement whereby it is inexpensive, can be accommodated to operation at various selected frequencies; is readily manufactured; and can be inexpensively shipped and handled as a unitary whole.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention, itself, however, both as to its organization and method of operation, will best be understood by reference to the following description taken in conjunction with the accompanying drawing in which:

Figure 1 is a view in elevation of a finished antenna constructed in accordance with the present invention, the antenna being broken away in portion to reduce the length of the figure, and other parts being broken away to show the interior construction;

Figure 2 is a view in elevation of the core portion of the antenna showing how it is slotted to receive the transmission line;

Figure 3 is a view in axial cross-section of a fragmentary portion of the antenna showing how the radiating dipole elements are embedded in place and connected to the feed line;

Figure 4 is an enlarged cross-sectional view through axis 4—4, Figure 3;

Figure 5 is a fragmentary view through axis 5—5, Figure 4, showing the connection of a radiating dipole to the feed line, and

Figure 6 is a fragmentary view showing how the end of the unit is constructed and sealed.

Referring now to Figure 1, the antenna is of two-part construction. One part, the base or support part, is identified at **10**. The other, the radiating part, is shown generally at **12**. The base **10** is defined by an aluminum casting **14** which has a tubular portion **14***a* and a head portion **14***b*. The head portion **14***b* has a cylindrical socket or bore **14***c* into which the base part **12***a* of the radiating portion **12** is seated and secured as hereinafter described. The portion **14***a* of base **10** is of tubular construction as shown and carries within it the coaxial or other feed line **16**. The feed line **16** is mechanically supported within the tube **14***a* by suitable means (not shown) as is well known in the art.

The radiating portion **12** of the antenna consists of an elongated cylindrical core **18**, Figure 2, formed of a cellular insulating material. Such material may be, for example, cellulose acetate, a material which can be obtained from the Strux Corporation of Hicksville, New York. This material is cellulose acetate in cellular form which makes it light in weight, comparatively strong, and gives it nearly the same electrical properties as air. In other words, the dielectric constant is very nearly unity and the losses in the material associated with a high frequency field are approxiately those of air. The dielectric constant, for example, of this material is about 1.1.

The core **18** has a series of slots **18***a*, each extending inwardly from its periphery. As shown in Figures 3 and 4, these slots are relatively thin and deep, each extending well beyond the center line of the core. Also, as shown in Figures 2, 3, and 4, the slots are located to extend radially inwardly from diametrically opposed points which spiral as the core is traced in the longitudinal direction. In other words, the lowermost slot faces one side of the core, the next higher slot faces the opposite side of the core, the third slot faces the same side of the core as the first slot, and so on. In addition, the core has a more shallow but somewhat wider groove **18***b* which extends over its entire longitudinal extent and spirals about the core as shown. The groove **18***b* is so positioned that it passes over the respective slots **18***a* at the points where radiating elements are to be electrically connected, as hereinafter described in detail.

Each of the slots **18***a* receives a radiating element. Preferably these are in the form of folded dipoles, although other elements such as simple dipoles may be used if desired. As will be seen from Figure 3, the dipole arms are comparatively close to each other, their spacing being less than one third of the outer diameter of the complete unit. The dipoles are held in aligned longitudinal position by the slot conformations and are similarly held in position in other directions. As is hereinafter described in detail, the interior of each slot **18***a* is filled with a cellular material after the dipoles are in position and electrically connected, this material being indicated at **20**, Figure 4.

The rigid feed line **16** is electrically connected to a flexible feed line **22**, Figure 1, which is received in the slot **18***b*, Figures 2 and 4, which spirals up the core **18**. As shown in Figure 5, the feed line **22**, preferably a coaxial feed line, has pairs of connecting terminals **22***a* and **22***b*, respectively, connected to its sheath or braid portion and to its central conductor, respectively. A pair of these conductors is positioned at the center portion or feed point of each of the dipoles **24** and is soldered thereto as shown in Figure 5. When the dipoles **24** have been positioned in their respective slots and have been connected to the feed line **22**, the dipole embedding material **20** is put in place.

The assembly of the unit is then continued by wrapping about the core, the dipoles **24**, and the feed line **22**, a plastic impregnated fiberglass jacket. This jacket is indicated at **24'**, Figure 4. It is put in place by affixing, by tape or otherwise, a length of fiberglass cloth having the requisite width and rolling the cloth about the assembled core, feed line, and dipoles. The fiberglass is painted with a polyester resin as it is wound up on the core. The winding process is continued until the outer diameter of the unit is of desired dimension. At that time the unit is placed in a suitable pressure mold and allowed to cure.

Just prior to closing the mold, the end **12***b*, Figure 1, of the radiating portion of the unit is made. Figure 6 shows how this is done. The bottom half **26** of the mold is of semi-cylindrical conformation and has an end cap **26***a* which is of full circular shape to extend over the entire end of the core **18** and wrapping **24'**. The wrapping **24'**, as shown, extends a few inches beyond the core **18**. A filler material is placed in the space **28** while the unit is in the lower half of the mold only. This filler material is preferably made of chopped glass fibers in a resin binder, such as polyester resin. The resultant mass has a molasses-like consistency and can easily be put in place. The headed conductor **30** is electrically connected to the braid **32** which connects to the grounded portion of the feed line **22**. The entire unit, including conductors **30**, is placed in the bottom half of the mold as shown in Figure 6, with the shank portion of conductor **30** passing through a suitable opening in the end cap **26***a* of the mold. The end of the unit is then formed by pushing the core **18** against the cap **26** so as to compress the material **28** to a solid mass. The top half of the mold is then forced on the unit and the plastic curing operation performed.

The stud **30** receives a nut **30***a*, Figure 1, which serves as a complete seal for the top end of the antenna. Moreover, since this stud is grounded, it forms an effective lightning arrestor which serves to protect the complete unit against the effects of lightning. Experience has shown that the unit with the stud **30** is capable of withstanding direct lightning strokes without substantial damage. It is normally connected to the jacket of the feed line **22**, Figure 5, which is grounded through feed line **16**. Other grounding means may be employed, if desired.

In practice, I have found it preferable to cure the plastic material at room temperature for about 24 hours. At the conclusion of this curing period the cellular core **18**, the feed line **22**, the wrapping **24'**, and the other portions of the unit form a solid mass which is rigid and yet light in weight. For purposes of appearance it is usually preferable to cut the sprue formed at the mating parts of the mold.

After the above operation the end **12***a* of the unit is given an additional wrapping of impregnated fiberglass material. This wrapping is made rather precise in outer dimension and shape and is cured in a second mold to an exact cylindrical conformation of predetermined diameter. When the additional wrapping has cured, the end **12***a* is of size to fit very snugly in the cylindrical recess **14***c* of the base portion **14**.

The assembly of the antenna is completed by placing the portion **12***a* of the radiating section into the recess **14***c* after being painted with a suitable resin material, such as polyester resin. Blind rivets may be then forced through the cap **14***b* into the portion **12***a* to provide additional anchorage. The result is a tightly adherent unitary construction which will withstand rough handling and the effects of the elements without damage. In a completed antenna, constructed in accordance with the present invention for use in the 450 to 470 megacycle frequency range the following dimensions have been used:

Outer diameter	2⅝ inches.
Outer diameter of core **18**	2¼ inches.
Dipoles **24**	12 inches long, ¾ inch deep, formed of ⅛ inch copper rod.
Slots **18***a*	2 inches deep, ¼ inch wide and 12 inches long.
Groove **18***b*	½ inch square.
Total length of radiating section **12***a*	12 feet.
Number of radiating elements **24**	6.
Feed line **22**	Type RG 8/U cable.
Total length of complete unit	15 feet approximate.

The slots **18***a* are filled with cellular material of the kind known as Nopco #B-607 Lockfoam, manufactured by Nopco Chemical Company of Harrison, New Jersey. This material consists of a resin and a foaming agent. Just prior to use the resin and foaming agent are mixed to a molasses-like consistency, at which time an exothermic reaction begins and the material heats up materially. In this state it is poured in a layer about one-fourth inch deep in the slots **18***a*—the dipole elements **24** having previously been placed in position. After a further period of time the resin foams to form a foamy material and finally a cellular solid. At this time the ends of slot **18***a* are preferably covered with masking tape to form a mold cover. Holes are put in the tape to relieve pressure. The cellular material thus formed has electrical characteristics much like those of air and yet has considerable mechanical strength.

It will be noted that the antenna of the present invention locates the radiating dipole elements **24** centrally of the axis of core **18**. In consequence, the conductors of the element **24** are spaced a maximum distance inwardly from the outer periphery of the unit. Since ice forms on the outer periphery, the smallest distance between the radiating elements and the ice is accordingly as large as possible. Moreover, the unit utilizes the cellular material which is very light in weight so that it is possible, without excess weight, to use a comparatively large outer diameter. Additionally, the plastic impregnated fiberglass has a dielectric constant of approximately three and one half, which itself tends to reduce the effect of high dielectric constant ice formed on the outer periphery of the unit. This is because the outer jacket is interposed between the radiating elements and any ice formation.

While the unit thus locates the radiating elements in most desirable position, it will be noted that the spiralling of the slots **18***a* serves to distribute the structural weakening associated with the slots so that the core **18** does not have a single axis of reduced bending strength. The structural weakening associated with the slots is further alleviated by the use of the cellular filler **18** as well as by the fact that the casing **24'** serves to provide a very strong outer jacket which imparts a high resistance to bending stress on the part of the unit as a whole.

While the radiating elements **24** may be of varying constructions, such as folded dipoles, straight dipoles, and the like, it is important that they have as small radial extent as possible. In other words, the radiating elements should be of conformation to reach a comparatively small distance outwardly from the longitudinal axis of the unit so that a maximum spacing is defined between each radiating element and the comparatively high dielectric constant jacket **24'** and any ice forming on jacket **24'**.

In the appended claims the jacket **24'** is defined as having a comparatively high dielectric constant and substantial physical thickness. In the embodiment of the invention herein described this dielectric constant is about 3.5, which is high in relation to air and to the cellular material of the core **18**. Likewise the thickness of jacket **24'** is about 3/16 inch which is substantial in relation to the 2⅝ inch diameter of the finished unit. The important point is that the jacket not only serves to provide a great deal of physical strength but also serves—through its dielectric constant and thickness—to provide an electric field path immediately inward of the points of ice collection and thereby reduces the proportionate change in antenna tuning when high dielectric constant ice is formed on the exposed surface of the antenna.

While I have shown and described a specific embodiment of the present invention it will, of course, be understood that various modifications and alternative constructions may be employed without departing from the true spirit and scope of the invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. An antenna array for use in a position exposed to icing, comprising in combination: a lengthy cylindrical core of cellular material having a longitudinal axis and a plurality of longitudinally spaced slots to receive radiating elements, the slots extending radially inwardly from the face of the core at positions spirally related as the core is traversed in the direction of said axis; radiating elements disposed in the slots, respectively, said elements being of comparatively small extent radially of the core and being in substantially centered relation to the axis of the core, each such element having a feed point; a coaxial feed line embedded in the outer periphery of the core and spiralling about the same to register with the slots at the respective feed points of the radiating elements; connecting elements extending from the feed line radially inwardly to the radiating elements, respectively; cellular material imbedding the radiating elements in the slots, respectively, to anchor the same in fixed positions; and a jacket of low loss rigid waterproof material having a comparatively high dielectric constant and substantial physical thickness enclosing the core to support the same physically and seal the contents against the entrance of moisture, and to define an electric field path immediately within the exposed surface of the antenna.

2. An antenna array for use in a position exposed to icing, comprising in combination: a lengthy cylindrical core of cellular material having a longitudinal axis and a plurality of longitudinally spaced slots to receive radiating elements, the slots extending radially inwardly from the face of the core at positions spirally related as the core is traversed in the direction of said axis; radiating elements disposed in the slots, respectively, said elements being of comparatively small extent radially of the core and being in substantially centered relation to the axis of the core, each such element having a feed point; a coaxial feed line embedded in the outer periphery of the core and spiralling about the same to register with the slots at the respective feed points of the radiating elements; connecting elements extending from the feed line radially inwardly to the radiating elements, respectively; cellular material embedding the radiating elements in the slots, respectively, to anchor the same in fixed positions; and a jacket of low loss rigid waterproof material enclosing the core to support the same physically and seal the contents against the entrance of moisture.

3. An antenna array for use in a position exposed to icing, comprising in combination: a lengthy cylindrical core of cellular material having a longitudinal axis and a plurality of longitudinally spaced longitudinally lengthy slots to receive radiating elements, the slots extending inwardly from the face of the core; dipole elements disposed in the slots respectively, said elements being of comparatively small extent radially of the core and being in substantially centered relation to said axis; a coaxial feed line embedded in the outer periphery of the core and registering with the slots at the respective center points of the dipole elements; connecting elements extending from the feed line radially inwardly to the radiating elements, respectively; cellular material embedding the dipole elements in the slots, respectively, to anchor the same in fixed position; and a jacket of low loss rigid water-proof material enclosing the core to support the same physically and seal the contents against the entrance of moisture.

4. An antenna array for use in a position exposed to icing, comprising in combination: a lengthy cylindrical core of cellular material having a longitudinal axis and a plurality of longitudinally spaced longitudinally lengthy slots to receive radiating elements, the slots extending inwardly from the face of the core at alternate diametrically opposed positions as the core is traversed in the direction of said axis; folded dipole elements disposed in the slots respectively, said elements having parallel radiating parts in closely spaced relationship to have comparatively small extent radially of the core, the elements being in substantially centered relation to said axis; a coaxial feed line embedded in the outer periphery of the core and spiralling about the same to register with the slots at the respective feed points of the dipole elements; connecting elements extending from the feed line radiating inwardly to the radiating elements, respectively; cellular material embedding the dipole elements in the slots, respectively, to anchor the same in fixed position; and a jacket of low loss rigid waterproof material enclosing the core to support the same physically and seal the contents against the entrance of moisture.

No references cited.