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METHOD OF MANUFACTURING A LIGHTWEIGHT MICROWAVE ANTENNA

Original Filed Feb. 24, 1960

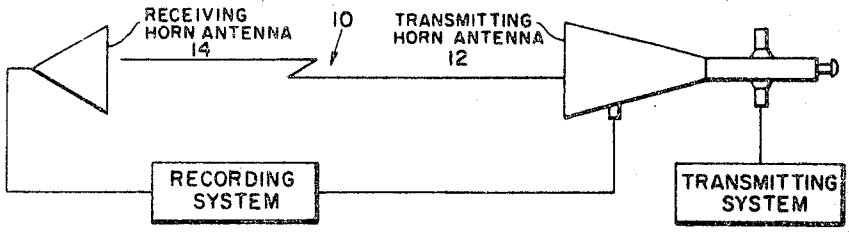


Fig. 1

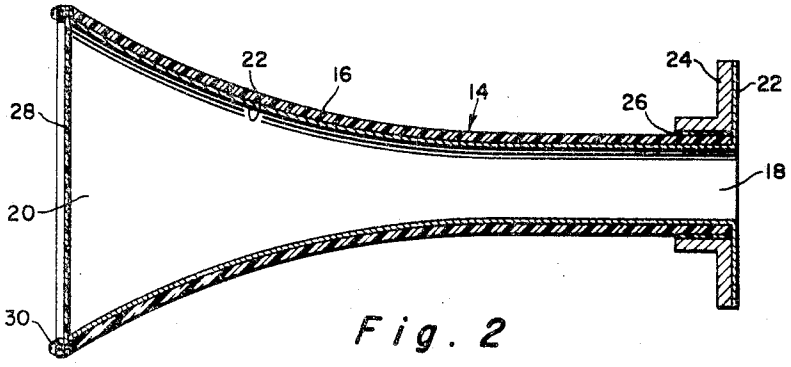


Fig. 2

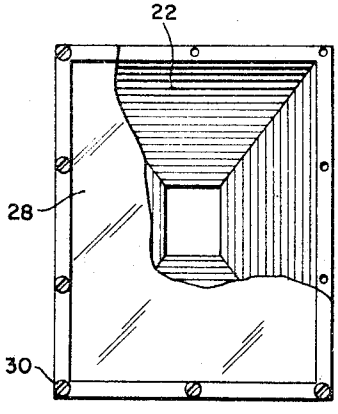


Fig. 3

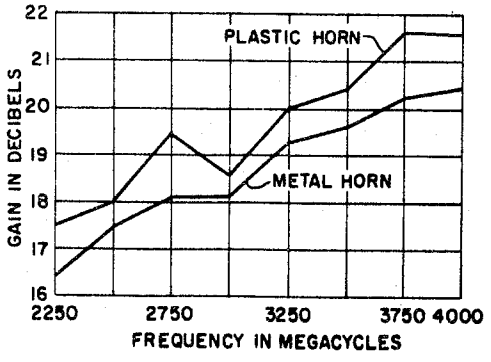


Fig. 4

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METHOD OF MANUFACTURING A LIGHT-WEIGHT MICROWAVE ANTENNA

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Original application Feb. 24, 1960, Ser. No. 10,815. Divided and this application Dec. 26, 1963, Ser. No. 333,767

1 Claim. (Cl. 264—104)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention is a division of my patent application Ser. No. 10,815 filed Feb. 24, 1960, now abandoned.

This invention relates to microwave antennas and, more particularly, to a method of manufacture of same.

Heretofore, antennas for receiving and transmitting microwave energy, for example, S-band horns for the frequency spectrum generally between 2000 to 4000 megacycles, have been constructed of solid metal walls. Such prior art horns are fabricated of welded sheet metal or made by electroforming. In both types of antennas, the thickness of the metal walls are in the order of ⅛ inch, and naturally the horn has a substantial weight.

Fabrication of metal horns by welding creates problems in maintaining the required close dimensional tolerances, particularly due to distortion of the metal during heating. Metal horns are relatively expensive in construction, and are more susceptible to corrosive elements.

Prior art antennas have proved to be generally satisfactory in normal, fixed installations. However, in mobile installations requiring the antenna to be installed on light-weight retractable masts or the like, the weight of the prior art metal horns have been found to be excessive. Furthermore, use of the metal horns in a salt-water environment is not satisfactory because of excessive corrosion of the metal surfaces, especially the smooth energy transmission surfaces.

It has been found that a suitable light-weight antenna can be constructed approximately three times lighter than a same size metal horn, and at a substantially reduced cost. Furthermore, the process of fabrication permits construction to the close tolerances that are required, and the materials are non-corrosive.

The open-ended body of the novel horn is constructed of an electrically non-conductive rigid thermal setting plastic material capable of maintaining its stability and shape. One or more layers of a thin, smooth, electrically-conductive and non-corrodible metal coating are applied to the interior horn surface. Such coating may be applied by spraying or the like after the horn body is cast, or during the casting process by a transfer method. A metal connector is applied to the supported end of the antenna body, electrical continuity being provided between the connector and the conductive coating. The free end of the horn may be sealed by a non-conductive closure member capable of passing the microwave energy without appreciable attenuation.

Principal objects of this invention is to provide a method for manufacturing an object, such as a microwave antenna horn which is substatially lighter in weight and less expensive in cost, and with equal or better operating characteristics.

Further objects are to provide a novel method of manufacturing a low-cost, high-gain, and light-weight microwave antenna.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawing wherein:

FIG. 1 is a diagrammatic circuit of a typical microwave energy system comprising transmitting and receiving systems, each component utilizing a horn antenna which can be made according to the invention device;

FIG. 2 is a longitudinal section of an S-band, exponential, microwave antenna horn made according to this invention;

FIG. 3 is a front view of the mouth of the horn having a closure member partially broken away; and

FIG. 4 is a chart of the comparative gain in decibels for a prior art metal horn and a plastic horn made according to this invention.

Referring to the drawing where like reference numerals refer to similar parts throughout the figures, FIG. 1 illustrates a typical microwave radar transmission system **10** utilizing a transmitting horn antenna **12** at one end and a receiving horn antenna **14**. The present invention can be utilized for the fabrication of either a receiving antenna or a transmitting antenna. FIG. 2 illustrates only one type of construction; namely, an S-band receiving horn antenna **14**.

Antenna **14** comprises a hollow open-ended base **16** of a rectangular configuration exponentially flaring out from a connector or neck end **18** to a flared mouth end **20**. A high electrically conductive smooth metal coating **22** is applied to the inner surfaces of the antenna. The antenna body and the conductive coating are preferably constructed according to one of the two following processes.

The initial step in both processes is to prepare a suitable male and female plaster mold assembly of the desired antenna configuration. In one method, the antenna body is composed primarily of cast plastic material, whereas in the other process the body is composed of a laminate plastic.

In the cast method, the male portion of the mold is initially coated with a plurality—i.e. four successive coats of a commercially available mold release solution. Each coat is allowed to dry for fifteen minutes in air at ambient temperature and the final coating drying for 24 hours.

Thereafter an electrically conductive gel coating is sprayed or otherwise applied to the male portion over the dried mold release. One electrically conductive gel coating that has proved satisfactory is composed as follows:

100 parts by weight diglycidyl ether of 4 hydroxy phenyl dimethyl methane
A stoichiometric quantity of primary aliphatic polyamine
540 parts by weight finely divided flake silver

The above constituents are thoroughly blended before application to the male portion. The metal used in the conductive coating should be non-corrodible, such as silver or gold, the former being preferred because of its lesser cost.

After the conductive coat has partially polymerized, the coated male mold is inserted in the mold assembly. The exterior surface of the coating may be roughened to enhance the subsequent bonding action. A sufficient quantity of a dielectric or non-conductive plastic material is then poured to fill the mold.

One suitable body material is composed of the same plastic ingredients of the coating gel described above, the metal flake, of course, being omitted.

After curing for 8 hours, the mold is disassembled. The release compound enables the antenna body to be readily removed with the conductive coating **22** being smoothly transferred from the mold to the antenna body. Thus the antenna body is integrally bonded to the electrically conductive gel coating, the exterior surface in

contact with the male mold being exceptionally smooth free of voids or any irregularities and uninterrupted. Such a smooth uninterrupted surface is of critical importance since microwave energy is conducted on the surface of the coating, and any irregularities will scatter the microwave energy and cause both a mismatch and distortion of the field.

In the laminated method of fabricating the microwave antenna body, only the male portion of the mold assembly may be employed. The male portion is first covered with one or more coatings of mold release compound, and, thereafter, the electrically conductive solution is applied such as previously described in the cast method. After the conductive coatings have dried the male portion is coated with two layers of a polyester or epoxy resin, the first coat being allowed to cure completely. While the second resin coat is in a partially cured condition, four layers of fiberglass cloth, each saturated with 20 percent by weight of resin, is draped on the cast. After the removal of all entrapped air, the fiberglass laminate is allowed to cure in air at ambient temperature. The laminated antenna is then removed from the male portion, conductive coating **22** being smoothly transferred from the cast to the body to which it strongly adheres, as in the prior cast method.

The transfer process for applying the conductive coating **22** on the interior antenna surface is the preferred method as it insures a tight bond with the plastic body and an extremely smooth outer conductive surface. However, in some microwave antenna installations where such adhesion and conductivity is not as critical, the conductive coating may be applied by spraying on either the antenna body prepared by either the cast or laminate method heretofore described.

The rough antenna is removed from the mold and the edges trimmed and smoothed in preparation for final assembly. In S-band antennas, it may be desirable to reinforce the flared end of the antenna by adding a supplemental layer of plastic to the outside surfaces.

The antenna body is then inserted into a simple fixture and metal connector flange **24** is cemented by a structural adhesive **26** to the neck of the body. A layer of conductive coating **22** is applied to the face of the flange co-extensive with the coating or inside the body to effect a fully conductive path from inside the antenna to the flange. A plastic closure plate **28**, made of polyethylene or "Teflon," is attached to the flared end of the antenna by nylon screws **30** to exclude injurious gases from damaging the smooth conductive coating within the antenna.

Evaluation tests were performed to determine the absolute gain and beam width of a plastic S-band horn manufactured by the teaching of this invention, and a conventional prior art metal S-band horn. FIG. 4 shows a comparative chart of gain in decibels (db) over a frequency range from 2250 to 4000 megacycles. A review of this chart indicates that the gain of the plastic horn is 0.5 to 1.4 db greater than the metal horn for

the operating frequencies: although these tests pertain to an S-band radar-receiving horn, similar results were found in tests of both receiving and transmitting C-band and X-band horns made according to this invention.

Thus, the novel plastic antennas provide increased gain, a weight advantage of over 3 to 1, and having other desirable features including excellent resistance to weathering in harsh marine atmosphere, dimensional stability, and inhibition of fungus growth.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claim the invention may be practiced otherwise than as specifically described.

I claim:

The method of molding a hollow microwave antenna by utilizing a male and female die assembly, such that the resulting product possesses a smooth inner surface capable of conducting microwave energy with a minimum of attenuation, said method comprising the steps of:

(1) coating the male portion of the mold with a plurality of coats of mold-release solution, each coat being allowed to dry before the application of the next succeeding coat,

(2) applying over the dried mold release an electrically-conductive gel coating consisting of a thoroughly blended mixture of

(a) 100 parts by weight of diglycidyl ether of 4-hydroxy-phenyl-dimethyl-methane

(b) 540 parts by weight of finely divided flake silver, and

(c) a stoichiometric quantity of primary aliphatic polyamine

(3) allowing the electrically-conductive gel coating to partially polymerize

(4) inserting the coated male mold into the mold assembly

(5) filling the mold assembly with an electrically non-conductive thermo-setting plastic material

(6) allowing the filled mold assembly to cure, and

(7) disassembling the mold, the electrically-conductive gel coating being integrally bonded to the plastic material which constitutes the body of the antenna, and with the surface of such electrically conductive gel coating that was in contact with the male mold portion being smooth and free from discontinuities and irregularities and hence capable of conducting microwave energy with a minimum of attenuation.

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