343-872 CROSS REFERENCE SEARCH ROOM

Aug. 8, 1967 C. W. WYBLE ET AL 3,335,419

WAVEGUIDE WINDOW

Filed Jan. 22, 1965

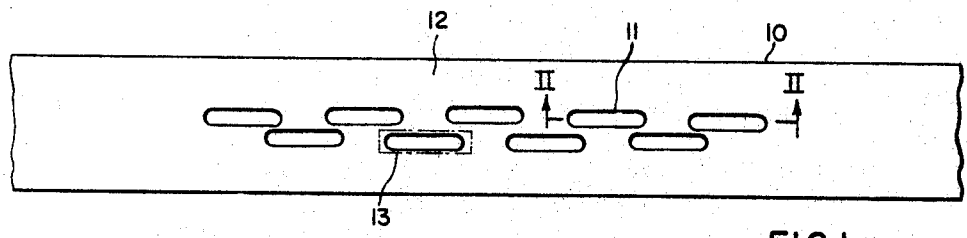


FIG. 1.

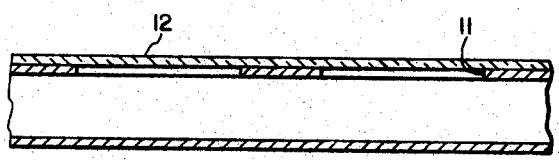


FIG. 2.

WITNESSES

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United States Patent Office 3,335,419
Patented Aug. 8, 1967

3,335,419

WAVEGUIDE WINDOW

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Filed Jan. 22, 1965, Ser. No. 427,310
5 Claims. (Cl. 343—771)

This invention relates to improvements in antennas and, more particularly, to an improved window for slotted waveguide antennas.

Waveguides are commonly pressurized in order to raise their operating voltage without danger of arcover. The slotted antennas are basically waveguides provided with slots in the broad faces which are transparent to the frequencies to be transmitted. Frequently, waveguides must be pressurized. It is obvious that it is necessary to provide windows, usually made of dielectric material, for the slots in the waveguide which are transparent to the frequencies being transmitted but are capable of retaining substantial pressure. A very urgent requirement of these windows is that they do not distort the radiation pattern.

Pressurized waveguides are normally sealed against loss of pressure by bonding or sealing a low loss dielectric material over the slots or openings in the waveguide. Under operating environmental conditions this produces a substantial problem even for low temperature operations due to the stringent electrical and mechanical requirements for the dielectric sheet material and for the bonding material which is used to hold the dielectric sheet onto the waveguide. These problems become greatly magnified as the operating temperatures are increased. The problems are further complicated by the wide range of temperatures and pressures which are encountered under environmental conditions.

In antennas designed to operate on high speed aircraft and missiles or projectiles, it is necessary that the slotted guide windows withstand an air pressure differential of 25 p.s.i. under ambient temperature environment where the temperature may range at least from —85° F. to 550° F. for extended periods of time at each extreme. To meet military and space requirements, it is required that the life of this seal be a minimum of 200 hours. While these materials are subjected to this variation in environment parameters, it is a rigid requirement that no distortion of the radiation pattern take place.

In the cumulative list, volume No. 2 of the National Inventor's Council, a publication of the United States Department of Commerce, dated November 1962, it is indicated that there is an urgent need for dielectric covers for slotted waveguides. Item 3169 of that cumulative list is entitled "Dielectric Covers For Slotted Waveguides And Adhesives For" is a general specification of requirements for the solution of a problem to which the present invention is directed. This item indicates that such dielectric covers of windows must withstand an internal pressure much greater than the pressure differential due to ambient pressure found at the high altitudes. This pressure, incidentally, is of the general order of 25 p.s.i. as previously mentioned. In addition to this, this item specifies that a sealing material is desired which is capable of forming a hermetic seal to stainless steel. In the present instance, the waveguide is usually a nickel alloy which is of the same general character as stainless steel. That item also indicates that the value of the dielectric must be low and there must be a variation of less than 20% during production. The window material must be of the order of 0.010 inch to 0.040 inch in thickness with the thermal expansion coefficient within 20% of that of stainless steel. Furthermore, the window material must have a loss tangent of .001 or less at microwave frequencies.

That same item presents as background, a statement that the known solid waveguide covers are made of Teflon impregnated fiberglass and are held in place by adhesives which provide the hermetic seal. The item points out that this material is not suitable for use at the high altitudes and temperatures and that new materials must be found. It points out that Pyroceram has most of the desired properties but is too brittle and its dielectric value is too high. As the waveguide is pressurized, the low external pressure at the high altitudes develops too great a pressure differential and the prior art covers tend to pop off.

It is considered that Item 3169 of the National Inventor's Council list is an accurate summation of a problem to which the present invention is directed. Accordingly, it is a primary object of this invention to provide a solution to that problem. The present invention stems from research and development work on this project over a substantial period of time. The solution to this problem in accordance with the present invention has far exceeded the requirements stated in the Government list of inventions required for the Armed Forces and other governmental agencies and has provided a slotted waveguide window having the desired properties and having a lifetime under the rigid environmental conditions to be encountered in excess of 500 hours with indications that the 1000 hour goal may be achieved.

The above object, stated in terms of the solution of the problem described, together with a better understanding of the invention as well as additional objects and advantages will best be understood from the following description when taken in connection with the accompanying drawing, in which:

FIGURE 1 is a top view of a slotted waveguide antenna in which the present invention is embodied; and

FIG. 2 is a partial section elevational view of FIG. 1 on line II—II looking in the direction of the arrows.

Briefly stated, the present invention provides a slotted waveguide antenna in which the slots are covered by windows made of an aromatic polyimide-coated glass fabric which is sealed to the metal waveguide by a polymeric diphenyl oxide adhesive. The invention represents the solution to a problem which requires a leak-proof pressure seal of material having the proper dielectric properties capable of withstanding the wide range of temperatures, including very high temperatures, and the fabrication of the device in such a way that the characteristics of the radiation pattern from the slotted antenna is not disturbed in any manner. Since the polymeric diphenyl oxide adhesive has a dielectric constant different from that of air and from that of the polyimide-coated fabric it is required that a method of assembly be provided whereby there is absolutely no adhesive extending over the edges into the slots of the waveguide.

Referring to the embodiment of the invention illustrated in FIG. 1, there is illustrated a microwaveguide section **10** having a plurality of openings **11**, the arrangement of which is critical to the operation of the microwaveguide, but is immaterial as far as this invention is concerned, except that the configuration of the arrangement of the slots introduces a rigid requirement in the fabrication of the device. As an example, it is to be noted that the spacing between some of the slots is very small, which means that there is a very narrow strip of the metal between the slots to which the window material may be adhered. It might be remarked in passing that the waveguide is made of a very thin wall nickel alloy material which has coefficient of expansion characteristics very similar to that of stainless steel.

In carrying out this invention, a mandrel, preferably made of a phenolic condensation product, or some similar material which is rigid, but will not scratch the internal waveguide surfaces, is inserted into the waveguide section **10** for the purpose of preventing entry of the abrasives subsequently described. The outside of the section **10** is then vapor blasted to remove all foreign particles and oxide from the surface to facilitate the bonding of the window material to the waveguide surfaces. The waveguide is then rinsed and baked to dry residual moisture and cooled to room temperature, after which, the waveguide section is tapped lightly to remove gross residue and ultrasonically cleaned to remove any residual sand resulting from the vapor blast operation.

Next, a sheet **12** of aromatic polyimide-coated glass fabric, from which the window is formed, is roughened by lightly abrading one side of the fabric with very fine grit abrasive paper, or its equivalent, to facilitate adhesion to the surfaces of the waveguide. Thereafter, both the waveguide section **10** and the piece of glass fabric which has been roughened on one side is subjected to ultrasonic cleaning treatment for from 2 to 2½ minutes in clean trichloroethylene.

In assembling the window material over the slots it is extremely important that the openings of the slots remain clean and sharp with no foreign matter remaining thereon in order not to adversely affect the radiation pattern of the antenna. To this end, the individual slots or openings **11** are carefully and individually masked by tape, care being taken to keep the tape as close to the edges of the slots as possible and not to let the tape come in contact with the waveguide surface except at the very edge of the slots. It will be readily apparent that other suitable steps might be performed which would provide a suitable mask for each of the individual slots. The masking of the slots is for the purpose of preventing any of the adhesive from adhering to the inner surfaces of the slots during the subsequent fabrication steps.

The polymeric diphenyl oxide adhesive is applied to both surfaces to be bonded by spray application. The diphenyl oxide polymer is dissolved in toluene and the solution is adjusted to a suitable viscosity for spray application and is applied to the masked waveguide section. Application to the glass fabric composition structure is also accomplished by employing a mesh. However, in this case the mesh is supported by a fine mesh screen which also serves to maintain the window material in a flat configuration during the spraying operation. The spray gun is adjusted to deliver a fine spray and a light deposit at a pressure of 20 to 25 p.s.i. and is manipulated across the areas to be bonded with three or four passes on each adhesion face to minimize pin holes or voids in the built-up film.

The deposited films are then subjected to incremental drying steps to volatilize the solvent without blister formation. A 20 to 30 minute air drying step is followed by a heat drying step of 1¼ to 1½ hours at 100° C., plus or minus 5° C. A precure step of 1¼ to 1½ hours at 150° C. which volatilizes the residual solvent is then applied to advance the state of cure and minimize flow during the bonding operation.

Because the walls of the microwaveguide are very thin and substantial pressure must be applied during the final fixing and bonding of the glass coated fabric to the waveguide surfaces, a suitable stainless steel mandrel, which has been finished to very close tolerances, and has been coated with a Teflon lubricant, or its equivalent, is inserted into the waveguide. The stainless steel mandrel, or its equivalent, is used because of the high temperatures involved in the final bonding operation. The stainless steel mandrel must be completely free of contamination and care must be taken to not force the mandrel into

the waveguide. Then, using suitable fixtures for holding the waveguide section, the adhesive coated surface of the glass fabric is brought together in careful alignment with the adhesive coated surface of the waveguide with the corresponding masked portions of each very carefully aligned. The fixture need constitute nothing more than a rigid structure having a channel-like groove to receive the waveguide with suitable means being provided for holding a rigid plate against the upper surfaces of the fixture. In order not to damage the waveguide and the glass fiber a strip of suitable material, such as Teflon tape, is placed on the top surface of the glass fabric to serve as a mold-release agent. Then, in order to evenly distribute the pressure uniformly over the entire length of the waveguide, a suitable resilient strip, such as a strip of silicone sponge rubber, is placed over the Teflon strip and the cover of the mold is brought into tight engagement with the upper edges of the mold. The assembly is then cured for a minimum of 2 hours at 200 plus or minus 5° C.

After this curing operation, the assembly is removed from the oven and while the assembly is still hot the waveguide is removed from the fixture and the mandrel is removed from the inside of the waveguide. The waveguide section and the glass fabric window are then again inserted in the oven and heated for a further minimum of 3 hours at 300 to 315° C. Then, after the last curing step the product is finished and the polyimide glass fabric will be securely bonded to the waveguide section **10**.

The invention is not limited to the use of aromatic polyimide-coated glass fabric for the window. If desired, the window may be made of glass fabric impregnated or coated with a linear polymeric imide-containing resin, such as a polymeric amide-imide resin.

We claim as our invention:

1. A slotted microwave antenna adapted to be pressurized comprising, a section of waveguide having a plurality of slots covered with aromatic polyimide-coated glass fabric, said fabric being secured to said waveguide by a polymeric diphenyl oxide.

2. A microwave-transparent pressure retaining closure for a metal waveguide structure having an opening therein, said closure being capable of withstanding high temperatures without having its electrical and mechanical characteristics altered, said retaining closure comprising an aromatic polyimide-coated glass fabric adhered to said structure by a polymeric diphenyl oxide.

3. A microwave slotted antenna adapted to be pressurized comprising a closed waveguide structure made of gas pressure retaining material opaque to microwaves, openings in said structure to permit emission of radiant energy, a sheet of aromatic polyimide-coated glass fabric extending across said opening and being bonded to said structure by a polymeric diphenyl oxide.

4. A slotted microwave antenna adapted to be pressurized comprising a section of waveguide having a plurality of slots covered with a glass fabric impregnated with an aromatic polymeric imide-containing resin, said fabric being secured to said waveguide by a polymeric diphenyl oxide.

5. Method of adhering a transparent window of glass fabric coated with an aromatic polymeric imide-containing resin to a slotted metal waveguide comprising the steps of: cleaning the metal waveguide; applying a film of polymeric diphenyl oxide on said metal waveguide; applying a film of polymeric diphenyl oxide on said coated glass fabric; bringing said diphenyl oxide coated surfaces together; and, applying pressure and heat to cure the polymeric diphenyl oxide.

No references cited.

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