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DIELECTRIC COVER FOR SLOTTED WAVEGUIDES

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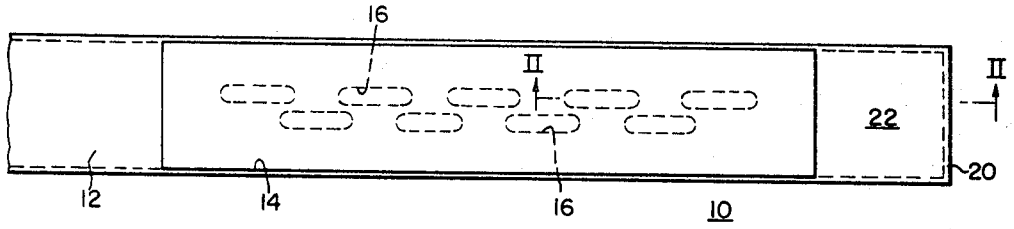


FIG.1.

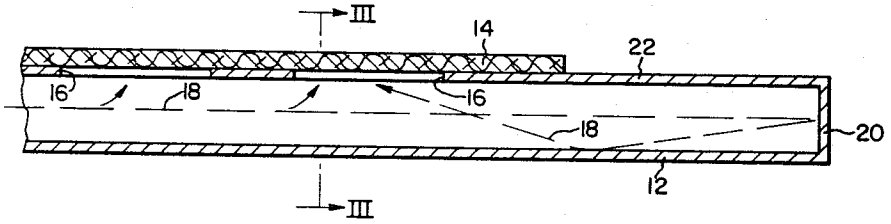


FIG.2.

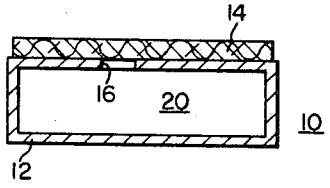


FIG.3.

WITNESSES

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DIELECTRIC COVER FOR SLOTTED WAVEGUIDES

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ABSTRACT OF THE DISCLOSURE

A slotted microwave metal antenna adapted to be pressurized with gas and comprises a section of waveguide having a plurality of spaced slots. An imperforate layer of glass-fabric on the waveguide extends over and covers the slots. The glass fabric is impregnated with an aromatic polyimide or aromatic polyamide-imide resin and the coated fabric is highly adherent to the surface of the waveguide so as to prevent the pressurizing gas from escaping. The fabric is applied to the metal antenna surfaces which have been preliminarily chemically etched, rinsed and oven-dried, after which an adhesive coating of an imide or aromatic amide-imide polymer is applied and baked at about 300° C. before the glass fabric is applied and baked in place.

This invention relates to antennas and more particularly it pertains to waveguide antennas having slotted openings for radar radiation.

Generally, waveguides are elongated tubes composed of metal that act as conduits or guides for energy beams of one sort or another, such as light beams, electromagnetic radiation of various frequencies, X-rays, ionized radiation, and high frequency radar. Openings or "windows" are provided in the metal to enable transmission of the beams to the exterior of the waveguides.

Inasmuch as the interior of the waveguides are sometimes pressurized and/or provided with special atmospheres, the openings must be sealed to prevent the loss of gas pressure and to maintain these conditions. For that reason the openings are covered or sealed with a dielectric material which then serves as "windows" which are transparent to the frequencies being transmitted and which retain the gas atmosphere at a given pressure within the waveguides.

Pressurized waveguides must be sealed against loss of pressure by bonding the dielectric material to the metal waveguide to provide an imperforate film or layer over the openings without seriously detracting from the dielectric properties, such as dielectric constant and dissipation factor, of the dielectric material in order to avoid attenuation or dissipation of the energy beams being transmitted or passing therethrough. For that purpose very thin films of dielectric material are used which possess the desired mechanical and electrical properties. However, there has been a persistent problem of bonding or adhering the dielectric material to the outer surface of the waveguide and over the openings. Mechanical bonds give imperfect seals and often lead to crack propagation.

On the other hand, when adhesives are used to seal the dielectric material to the waveguide, the adhesives frequently fail upon aging or they possess undesirable electrical properties so that great care must be exercised to keep them out of the openings during the sealing process. Hence, the problem of assembly with any such materials is tedious and difficult because of the nature of the diverse materials and the problem of achieving acceptable bonds between them.

Associated with the foregoing is the problem of employing waveguides having dielectric materials as windows for

sealing the openings which must operate for up to 1,000 hours at temperatures of up to about 550° F. or as low as −50° F. Through these windows microwave frequencies must be transmitted without distortion or attenuation and the windows must maintain a positive pressure seal at two or more atmospheres in an environment of air or vacuum or a gas such as nitrogen, carbon dioxide, or sulfur hexafluoride within the waveguide. Moreover, such waveguide antennas must operate on high speed aircraft, missiles, or projectiles and withstand air pressure differentials of the order of 25 p.s.i. under ambient temperature environments ranging from at least −50° F. to 550° F.

Prior procedures for preparing the metal surface of the waveguide for bonding of the dielectric material have frequently included the step of sandblasting the metal surface to obtain a roughened but clean metal surface. The resulting surface is uneven with high and low areas which require the application of exceedingly high pressures of the order of several thousand p.s.i. to obtain a satisfactory bond between metal and dielectric material in the absence of an added or separate adhesive material.

Moreover, the presence of a separate adhesive layer is undesirable since the adhesive agents generally used do not possess the requisite electrical properties at a temperature and, therefore, interfere with the propagation of microwave energy in the amount and patterns desired. Many adhesive agents also tend to soften badly and lose bond strength when subjected to operating temperatures above 400° F. For example, slotted waveguide covers have been made of polytetrafluoroethylene impregnated glass fibers and were held in position by an adhesive which provided the hermetic seal. This adhesive material was not suitable for use at high altitudes and temperatures. As the waveguide was pressurized the low external pressure at high altitudes developed too great a pressure differential and such resinous covers tend to "pop off."

Alternatively, sheets of inorganic materials such as recrystallized glass, as disclosed in U.S. Patent No. 2,920,971, also have many of the desired properties but were too brittle and the dielectric constants were too high. Thus, prior attempts to obtain a seal to satisfy all of the electrical, mechanical and thermal requirements of the system have not been satisfactory.

In accordance with the present invention, it has been found that the sandblasting procedure for cleaning the metal surface may be eliminated and replaced by a chemical cleaning procedure which results in a smooth, rather than a rough, surface as provided by sandblasting. Cleanliness of surface is of prime importance in preparing the metal surface of the waveguide for bonding of the dielectric material for covering the waveguide slots or windows.

It has also been found that the use of a selected aromatic polyimide or aromatic polyamide-imide resin impregnated on a suitable fabric such as glass fiber cloth is capable of forming a high strength bond directly to the metal substrate without requiring the use of any intermediate adhesive composition. It is further noteworthy that the use of such polymers is possible even after the said polymers have been fully heat cured, and that the ability to form strong bonds to metal does not depend upon the careful retention of some degree of residual chemical reactivity, but only upon the application of suitable heat and pressure during formation of the bond line.

The resistance of this family of aromatic imide and polyamide-imide polymers to oxidation and thermal aging is now well known. The good electrical properties and relative insensitivity of the electrical properties over a wide range of temperatures which makes these materials of interest as dielectric windows or seals in applications such as disclosed herein are shown in Table I.

TABLE I.—ELECTRICAL PROPERTIES OF AROMATIC POLYMERS VERSUS FREQUENCY AND TEMPERATURE

Polymer	Temp., ° C.	Dielectric Constant ε				Dissipation Factor Tan δ			
		10^2 c.p.s.*	10^3 c.p.s.	10^5 c.p.s.	10^{10} c.p.s.	10^2 c.p.s.	10^3 c.p.s.	10^5 c.p.s.	10^{10} c.p.s.
Aromatic Polyimide K Film	25	3.2	3.2	3.3	----	.005	.001	.007	----
	250	3.1	3.1	3.0	----	.001	.001	.002	----
	325	3.0	3.0	----	----	.028	.004	----	----
Aromatic Polyimide Glass	25	6.4	6.4	----	----	.001	.002	.005	----
	250	6.4	6.3	----	----	.009	.004	----	----
	325	6.5	6.3	----	----	.076	.013	----	----
Aromatic Polyamide-imide Film	25	4.5	4.5	4.2	----	.005	.008	.015	----
	200	4.5	4.5	----	----	.021	.009	----	----
	250	5.7	4.6	----	----	.122	.025	----	----
I-6/Glass Aromatic Polyimide Film	25	4.5	4.5	4.5	4.1	.003	.002	.002	.007
	250	4.4	4.4	4.4	4.1	.005	.002	.002	.005
	315	4.5	4.3	4.3	4.1	.040	.008	.003	.006
I-8/Glass Aromatic Polyimide Film	25	3.7	3.7	----	4.2	.003	.003	----	.009
	250	3.6	3.5	----	4.1	.009	.007	.008	.006
	325	3.7	3.6	3.5	4.1	.055	.016	.012	.005

* Cycles per second.

The chemistry of the polymers is set forth hereinafter.

Accordingly, it is a general object of this invention to provide a dielectric layer for a slotted waveguide having very good adhesion between the metal surface of the waveguide cover and providing imperforate windows at the slots characterized by good stability and dielectric properties.

It is another object of this invention to provide a dielectric layer for a slotted waveguide which dielectric layer comprises aromatic imide and amide-imide polymers which are highly stable and have good dielectric properties at high temperatures.

It is another object of this invention to provide a method for obtaining a highly adhesive bond between an aromatic imide or aromatic polyimide-imide resin coated glass cloth and a nickel or like metal surface.

Finally, it is an object of this invention to overcome the foregoing problems and desiderata in a simple and effective manner.

Briefly, the invention includes a slotted microwave antenna adapted to be pressurized and comprising a section of waveguide having a plurality of slots, an imperforate layer of glass fabric-resin on the waveguide and extending over and covering the slots, the glass fabric being impregnated with an aromatic polymide or aromatic polyamide-imide resin, and the coated fabric layer being highly adherent to the surface of the waveguide so as to prevent gas escaping therefrom.

The invention also includes a method for bonding a layer of glass fabric with the applied aromatic polyimide or polyamide-imide resin to a waveguide composed of metal such as metal comprising the steps of (1) chemically etching the metal surface in an acid solution to remove oxides and to expose clean metal and rinsing, (2) drying the waveguides in an oven, (3) applying to the surfaces of the waveguides a coating comprising imide or aromatic amide-imide polymer, (4) baking the coated waveguide at a temperature of about 300° C., (5) preparing a glass cloth coated with at least one imperforate layer of a polyimide or polyamide-imide resin solution and baking the resulting coated cloth to cure the resin and remove the solvent and reaction products, and (6) bonding the coated glass cloth to the prepared metal surface of the waveguide by the application of pressure at an elevated temperature.

For the better understanding of the nature and objects of the invention, reference is made to the following detailed description and drawings, in which:

FIGURE 1 is a plan view of a portion of a slotted waveguide antenna;

FIG. 2 is an enlarged vertical sectional view taken on the line II—II of FIG. 1; and

FIG. 3 is a transverse sectional view taken on the line III—III of FIG. 2.

In the drawings a waveguide is generally indicated at **10**. It includes an elongated tubular member **12** and a cover or layer **14** of dielectric material. The tubular member **12** is composed of a metal such as nickel, nickel base alloys such as Monel metal, stainless steel, silver gold, titanium, aluminum, copper, and alloys thereof, and plated metals and alloys such as nickel plated copper or steel, chromium plated steel, tin plated steel, zinc plated steel, and brass. It frequently has a rectangular cross-section as best shown in FIG. 3. The waveguide **10** is an elongated member having a plurality of spaced slots **16** on one side thereof to enable the passage and transmission of beams shown in dashed lines **18** of microwave energy such as radar. One end of the tubular member **12** is closed hermetically by an end cap **20**. The other end is open to receive the beams **18** of microwaves from a generating or other source.

The layer **14** is a dielectric material such as an elongated strip of resin impregnated cloth or fabric and in particular resin coated glass cloth which is secured to the surface **22** of the tubular member **12** for the purpose of covering the several slots or openings **16** to prevent the escape of pressurized gas such as air, nitrogen, carbon dioxide, fluorinated hydrocarbons, argon, or sulfur hexafluoride which is contained within the tubular member **12** to facilitate its operation, which in some cases may be at a lower pressure than the ambient material. The cover **14** is a dielectric and serves as a window through which the beams **18** pass and are transmitted via the slots **16** for desired broadcast or transmission.

The layer **14** is preferably composed of a resin impregnated cloth of fibrous material such as glass fibers and has no effect upon the beams **18** which pass through it, but serves primarily to cooperate with the applied resin to retain the pressurized condition within the tubular system. In some cases, the layer **14** may be comprised of the pure polymer material in film form such as aromatic polyimide or polyamide-imide film and the joining methods of this invention will also be applicable thereto. However, presence of the glass fiber reinforcing fabric is ordinarily preferred in order to improve resistance of the dielectric material to tearing or splitting, particularly when heat aged, and also to withstand gas pressures.

The tubular member **12** has a dimension of about 12 inches long by 1 inch wide by ¼ inch. It may be composed of stainless steel or other metal as indicated above. It is preferably composed of nickel. One method of producing the metal waveguide is by electrodepositing metal on a destructible form, such as wax, by known techniques to obtain a desired thickness of metal wall, for example 0.010 to 0.025 inch. Where the member **12** is composed of another metal such as stainless steel or steel, the slotted surface is preferably coated with a layer of nickel.

To obtain satisfactory adherence of the layer **14** to the metal **12** it is necessary that the surface be cleaned of dirt, grease, oxides, and foreign matter. The highest degree of cleanliness and surface smoothness is critical to the success of satisfactory adherence. A combination of cleanliness and a smooth metal surface is especially

needed when attempting to bond cured aromatic polyimide materials.

It has been found that the prior practice of cleaning the metal surface by sandblasting with a material such as aluminum oxide is inadequate and, in fact, undesirable because it leaves a roughened surface consisting of minute high and low areas. Sandblasted surfaces require an excessively large pressure of the order of several thousand p.s.i. for satisfactory adherence of the aromatic polyimide cover to the metal tubular member. In the practice of this invention the cleaning of the metal surface is carried out so as to obtain a smooth surface which cooperates with the aromatic polyimide to require a much smaller amount of pressure and less extreme temperatures to produce a highly adherent resinous cover on the member **12**.

Where the member **12** is composed of nickel or a nickel containing alloy such as stainless steel, the surface may be prepared by using the following steps:

(1) Degrease, for example with trichloroethylene,

(2) Scrub with pumice and distilled water,

(3) Rinse in tap water for 15 minutes, then force dry in an oven for 5 minutes at 120° C., for example.

(4) Dip surface for 30 seconds in nickel etch solution at about 82° C., the solution containing by volume, about 1 part nitric acid, 1 part acetic acid, 2 parts distilled water.

(5) Rinse in tap water, then place in strong hydrochloric acid, 20% hydrochloric acid, 5 minutes.

(6) Rinse 5 minutes in tap water followed by a distilled water rinse,

(7) Force dry at about 80 to 90° C. for 15 minutes and then store in a desiccator until ready to hot bond.

If the layer **14** is applied immediately following the foregoing treatment, a satisfactory adherence of the layer to the metal surface may be obtained. However, more consistently satisfactory results are obtained when the treated surface is provided with a coating of an aromatic polyimide or polyamide-imide resin after step No. 7 and is then baked as follows: one hour at 100° C., ½ hour at 150° C., ½ hour at 200° C., ½ hour at 250° C., and ¼ hour at 300° C. The resin coated surface is then ready for high temperature bonding with the cover **14**.

Where the member **12** is not coated immediately with the resin and is required to stand for an indefinite period of time before the cover **14** is applied, the member **12** (after the step No. 7) should be placed in a desiccator to protect the metal surface from oxidation, gas absorption, moisture, and airborne contaminants such as dust.

The layer **14** is composed of a glass fiber cloth or fabric material and of the aromatic imide or amide-imide resin impregnating the fabric to form an imperforate sheet. The glass fiber cloth or fabric material preferably has a thickness of from about 0.001 to 0.020 inch.

The resin with which the cloth is coated and impregnated is a soluble aromatic polyamic acid intermediate which on curing is converted to an aromatic imide or amide - imide polymer whose preparation is disclosed in any of U.S. Patent Nos. 3,179,614; 3,179,630; 3,179,633; 3,179,634; and 3,179,635. Two variations of the resins therein disclosed are identified as AI-131 and AI–13 for reference purposes in the several tables hereinbelow. Table II identifies the components of the several resins employed herein.

TABLE II.—COMPOSITION OF POLYMERS

Polymer	Reacted Components	Code Name	Chemical Name
M	DAPE, PMDA	DAPE	4,4'-diaminophenyl Ether
		PMDA	Pyromellitic Dianhydride.
K	DAPE, PMDA	DAPS	4,4'-diaminophenyl Sulfide.
		MPD	m-Phenylenediamine.
I-1	DAPE, PMDA	BTDA	3,4,3',4'-benzophenonetetracarboxylic Dianhydride.
I-6	DAPS, PMDA	PAA	p-Aminoacetanilide.
		PA	Phthalic Anhydride.
I-8	MPD, BTDA	MAB-PPD	3,4'-diaminobenzanilide.
		IP	Isophthalic Acid.
I-40	MPD, PAA, BTDA, PA	TP	Terephthalic Acid.
AI-110	MAB-PPD, PAA, PMDA		
AI-115	MAB-PPD, PAA, BTDA		
AI-131	MPD, MAB-PPD, BTDA		
AI-133	MPD, MAB-PPD, PAA, BTDA		
AI-7	MPD, IP, TP, PMDA		

One or more coats of either or both resins AI–131 and AI–133 are applied to glass cloth normally identified as No. 116, 60 by 58 taffeta weave, A1100E glass cloth to produce a pore free sheet. After each coat of resin is applied to the cloth, it is dried in a curing tower and after the final coat is applied the coated glass cloth is cured under conditions described in examples as follows:

Example I

The polymers employed herein were in the form of viscous resinous solutions [12–15% in solvents such as dimethylacetamide (DMAC) or N - methylpyrrolidone NMP]. They were impregnated into a carrier fabric, usually type 116, E glass cloth (60 x 58 taffeta) with either A1100E or heat clean (112) finish. The impregnation was accomplished by continuously passing the cloth through a dip pan containing the resin solution, then through a forced hot air oven to cure the resin and remove solvent. The coating process was then repeated to build up additional thickness of resin on the fabric. Thickness increased about one mil for each repeat pass after the first one. Usually a total of five coats were applied. Care was exercised to avoid formation of even minute bubbles in the resin coating. The treated hot zone was maintained at 150° to 195° C. over its length and residence time of the cloth was ten minutes on each pass.

After coating was completed the material was given an additional cure of 10–15 minutes at 205° C. It was then storable indefinitely if protected from moisture. When desired for bonding experiments the treated cloth was cut to size and then precured in an oven for 30 to 60 minutes at 300° to 260° C. before being placed into the bonding press.

In some cases, a top coating of the same or another similar resin solution was applied to either the cloth or the metal surface just prior to bonding. This coating served to seal any pores in the cloth or to fill out slight imperfections in the metal surface and protect it from contamination as well as to provide a lower bonding temperature pressure relationship than the initial polymer alone would have required. In such cases the freshly applied resin coating was baked out on a schedule of one hour at 100°, one half hour at 150°, 200°, 250° and one-fourth hour at 300° C. prior to placing in the press.

When the coated glass cloth to be used for cover **14** is fully cured it is ready for attachment to the member **12**.

In order to bond the strips of resin coated glass cloth to the slotted surfaces of the waveguides, a steel mandrel is inserted into the prepared waveguide member **12** and the reinsulated cloth is placed over the face of the member. The assembly is placed in a hot press to bond the cloth in place. The hot pressure bonding of the aromatic amide, amide-imide, and imide polymers to the

waveguide members utilizes their properties above the glass transition temperature (T_g) thereof. The polymers change from a glassy to a rubbery state at T_g and flow slightly under pressure to bond to themselves or to metal. The glass transition T_g is defined as the temperature range below which the thermal motion of the molecules become so slow that they are unable to respond within a reasonable time to the action of an applied force.

Where the member **12** has been provided with a protective coating of resin after cleaning, the resin may be composed of I–40, AI–7, AI–131 or AI–133 and the material forming a layer **14** is applied under temperature pressure and time conditions as shown in Tables III and IV as follows:

Table III serves to demonstrate the versatility of the invention by bonding a wide variety of aromatic imide and amide-imide polymers to a number of metals. Table IV shows the preparation of actual waveguide components using glass cloth impregnated with several polymers of choice.

surfaces, by degreasing with trichloroethylene, scrubbing with pumice and distilled water, rinsing with tap water for 15 minutes, then force drying in an oven for 5 minutes, dipping the waveguide in an etch solution consisting of one part nitric acid, one part acetic acid and 2 parts distilled water for 30 seconds at 82° C., rinsing in tap water and then placing in 20% hydrochloric acid for 5 minutes, rinsing for 5 minutes in tap water with a subsequent distilled water rinse, force drying at about 82° C. for 15 minutes, then storing in a desiccator prior to the step of bonding.

The etched surface is then coated with AI–131 resin and given a stepwise cure to a temperature of 300° C. The resin glass for the cover is composed of No. 116, 60 by 58 taffeta, with either heat cleaned or an A1100 finish E glass cloth which is coated with AI–131 resin and cured at approximately 200° C. The glass cloth impregnated with the resin is then bonded to the nickel surface by the application of a pressure slightly in excess of 200 p.s.i. for a period of not more than 1 hour and with the application of a temperature of about 300 to 360° C. The waveguide was then tested at operating conditions for 16 hours by subjecting it to an internal pressure of 30 p.s.i.g. nitrogen pressure at 288° C. (550° F.). The lack of blisters and leaks after 16 hours indicated a satisfactory bond was obtained.

When the waveguides are constructed in the foregoing manner, an appreciable life expectancy under actual conditions of internal pressure up to 30 p.s.i. and temperatures up to 550° F. may be expected with a high degree of confidence. Any faults due to imperfections in the metal surface will generally result in early failure caused by localized debonding and can be screened by an initial short term test under combined temperature and pressure. Results of actual thermal aging, thermal cycling and pressure cycling tests performed on various waveguide specimens appear in Table V.

TABLE III.—BONDING OF AROMATIC POLYMERS TO METAL SURFACES

Resin film or resin on glass cloth	Mold conditions					
	Temp., ° C.	Pressure, p.s.i.	Time, min.	No. samples	Bond obtained [1]	Metal adherends
ML/glass	440	6,000	5	3	Yes	NPS, Gold, Ni.
H film	415	10,000	1	4	Yes	NPS, CPS, CS, Copper.
H film	380	10,000	5	2	No	NPS.
I–1/glass	400	200	5	7	Yes	SS.
I–6/glass	410	200	1	3	No	NPS.
I–6/glass	415	400–800	1	3	Yes	NPS.
I–6/glass / AI–7 Topcoat	275	2–6,000	60	2	Yes	NPS.
I–8/glass	405	200	1	9	No	NPS.
I–8/glass	410	200	1–5	125	Yes	NPS, SS, Ti.
I–8 film	400	200	4	2	Yes	Ti.
I–40/glass	415	200	5	3	Yes	NPS, SS, Ti.
I–40/glass	410	200	1	1	No	NPS.
AI–131/glass	325	200	15–60	3	Yes	NPS.
AI–131/glass	400	200	5	1	Yes	Ni.
AI–133/glass	400	200	5	2	Yes	Ni, SS.
AI–133/glass	380	200	5–30	4	Yes	Ni.
AI–133/glass	325	200	30	1	Yes	NPS.
I–8/glass / AI–133 Topcoat	320	200	60	1	Yes	NPS.
I–6/glass / AI–131 Topcoat	325/380	200/100	60/30	2	Yes	NPS.
ML/glass / AI–131 Topcoat	325	200	30	1	Yes	NPS.
AI–110/glass	400	200	5	3	Yes	SS.
AI–115/glass	350	100	5	3	Yes	SS.

[1] Yes indicates peel strength in excess of 2 lbs./in. width.
Fluorocarbon release material used on mold surfaces.

NOTE.—NPS=Nickel plated steel; CPS=Chrome plated steel; CS=Carbon steel; SS=Stainless; Ni=Nickel; Ti=Titanium; H film=Trademark KAPTON.

TABLE IV.—BONDING OF DIELECTRIC SEALS TO WAVEGUIDES

Material	Mold Conditions				
	Temp., ° C	Pressure, p.s.i.	Time, min.	No. Samples	Seal Obtained [1]
ML/glass	440	6,000	2	2	Yes.
I–6/glass	415	8,000	5	7	Yes.[2]
I–6/glass	380	3,500	1	1	No.
I–1/glass / I–40 Topcoat	375	330	2	1	Yes.[2]
AI–131/glass	325	250–1,000	60	3	Yes.[2]
AI–131/glass	365	200	10	1	Yes.[2]
AI–133/glass	380	300/900	10	2	Yes.[2]
AI–133/glass	320	250–1,000	60	3	Yes.[2]

[1] Yes indicates peel strength in excess of 2 pounds per inch width.
[2] Indicates also withstood 30 p.s.i.g. gas pressure inside of waveguide.

Example II

Waveguides composed of nickel prepared by electrodeposition were cleaned including chemically etching the

TABLE V.—EFFECT OF AGING ON DIELECTRIC SEALS TO NICKEL WAVEGUIDE SURFACE

Material	No. Samples	Withstood 30 p.s.i. at—		Aging			Repeated Thermal Cycles +288° to −50° C.	Comment
		Room temp.	288° C.	Time, hrs.	Temp., ° C.	Atmosphere		
ML/glass	1	Yes	N.T	170	300	Air	N.T	No failure. Peel strength 1 lb./in. at 300° after test.
I-6/glass	7	Yes	Yes	40	300	Air	N.T	No failure.
ML/glass	6	Yes	N.T	N.T.			Yes [3]	Do.
I-6/glass	6	Yes	N.T	N.T.			Yes [3]	Do.
ML/glass	[3] 6	Yes	Yes	300	288	Air	N.T	Pressure cycle 30 p.s.i. to zero p.s.i.g. temperature cycled 288° to 25° C. every 24 hrs. No failures.[2]
I-6/glass	[3] 6	Yes	Yes	300	288	Air	N.T	Do.
I-6/glass	8	Yes	N.T	250	288	SF_6	Yes	No failure at 30 p.s.i.g.
AI-131/glass	2	Yes	Yes	5	288	30 p.s.i. N_2/Air	N.T	No failure.
	1	Yes	Yes	16	288	30 p.s.i.g. N_2/Air	N.T	Pinhole leak.
	1	Yes	Yes	246	288	30 p.s.i.g. N_2/Air	N.T	No failure.
AI-133/glass	5	Yes	N.T	N.T.			N.T	
I-40/AI-131/glass	[3] 3	Yes	Yes	600	288	30 p.s.i.g. N_2/Air	Yes	Do.[3]

[1] No bond failure experienced up to 60 p.s.i.g. where metal distorted.
[2] Excessive leakage observed after 520 hrs.
[3] Tests performed in manufacturing division.

N.T.=Not tested.

Accordingly, the device and method of the present invention overcome problems inherent in prior waveguides and methods. The present invention provides for a glass impregnated with aromatic imide or amide-imide polymers which can be successfully bonded to electrically formed waveguides. The metal surface of the waveguide must be clean and is preferably coated with a similar resin which is cured prior to the application of the resin impregnated glass cloth. No other adhesive is required even though a completely reacted resin is used.

It will be understood that the disclosure be construed as illustrative of the invention and not in limitation thereof.

What is claimed is:

1. A slotted microwave antenna adapted to be pressurized comprising, a section of tubular waveguide having a plurality of slots, a resin impregnated layer of glass fabric bonded to the waveguide and extending over and covering the slots, the glass fabric being impregnated with at least one resin selected from the group consisting of aromatic imide and amide-imide polymers, and the layer being sufficiently adherent to the surface of the waveguide to withstand internal gas pressure and elevated temperatures.

2. The antenna of claim **1** in which the waveguide is composed of an element selected from a group consisting of nickel, titanium, gold, copper, silver, and base alloys thereof, stainless steel and platings of zinc, chromium, nickel and tin applied to any of the foregoing and to steel.

3. The antenna of claim **1** in which the surface of the waveguide is coated with a resin selected from a group consisting of aromatic imide and amide-imide polymers.

4. The antenna of claim **1** in which the waveguide is composed of an element selected from a group consisting of electrodeposited nickel, stainless steel, silver, gold, titanium, aluminum, copper, nickel plated copper, nickel plated steel, chromium plated steel, tin plated steel, zinc plated steel, and brass, the metal surface is coated with a polyamide-imide resin and the glass fabric layer is impregnated with a cured resin of aromatic amide and imide polymers.

5. The method for preparing slotted waveguide antennas from a section of nickel tubular material provided with slots, the step comprising cleaning the surface of the material by applying an acid etch solution, rinsing the etch solution from the surface, drying the rinsed surface, coating a glass fibrous dielectric cloth material with a resin selected from a group consisting of an aromatic imide and an amide-imide polymer, curing the resin coating, and applying the coated glass cloth material to the cleaned surface of the tubular material by the application of a pressure of about 200 p.s.i. and higher and at a temperature ranging from about 250° C. to 360° C. for up to one hour.

6. The method of claim **5** in which the cleaned surface is treated with an application of a coating of a resin selected from a group consisting of an aromatic amide-imide polymer.

7. The method of claim **5** in which the etching solution applied includes a mixture of about 1 part of nitric acid, 1 part of acetic acid, and 2 parts of distilled water and the cleaning also includes a subsequent application of a hydrochloric acid solution.

8. The method of claim **5** in which the cleaning step includes the application of a degreasing solvent and a pumice scrubbing followed by a rinse in water and an oven drying procedure.

9. The method of claim **5** in which the etched member is subsequently dried at about 82° C. for about 15 minutes.

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