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POLYTETRAFLUOROETHYLENE WAVEGUIDE WINDOW CONSTRUCTION

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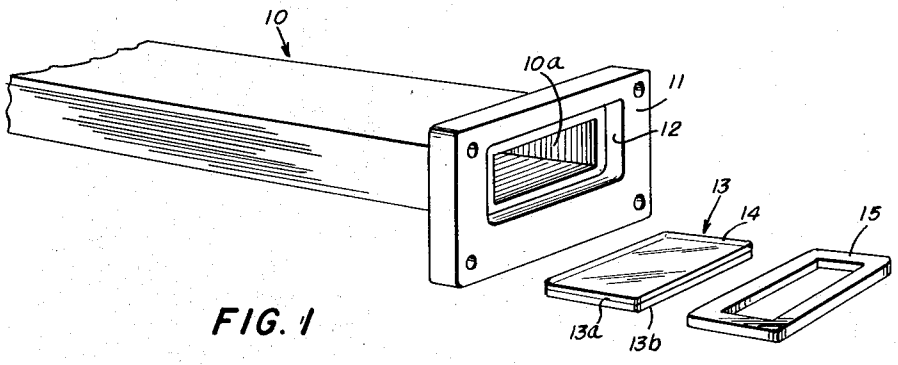


FIG. 1

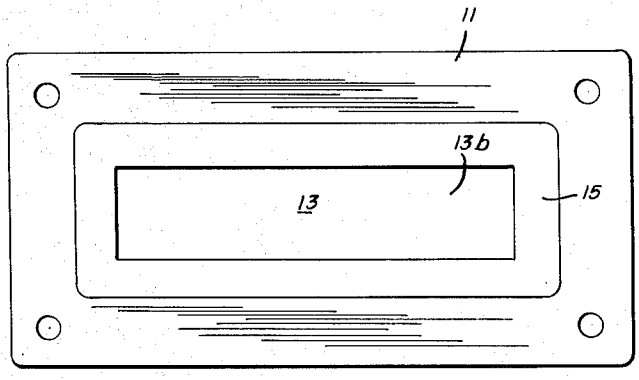


FIG. 2

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POLYTETRAFLUOROETHYLENE WAVEGUIDE WINDOW CONSTRUCTION

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1 Claim. (Cl. 333—98)
(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government for governmental purposes without the payment to us of any royalty thereon.

This invention relates to a polytetrafluoroethylene waveguide window and to an epoxy adhesive which is used to bond the polytetrafluoroethylene window to a metal waveguide section.

In a variety of applications it is necessary to close or seal a microwave system to retain air pressure within it and to prevent the entry of water, water vapor, dust or other extraneous matter. A sealed or pressure-resistant window is generally mounted across a section of waveguide and must be essentially transparent to microwave energy over desired frequency and temperature ranges.

Commercial waveguide pressure-resistant windows are currently constructed of electrical grade glass fused to a metal frame, or of mica sealed to a metal frame with a low-melting glass or solder. Apart from their substantial cost, these windows present the difficut problem of soldering or attachment to aluminum or brass waveguides, and also offer some risk of corrosion due to the proximity of dissimilar metals.

One of the objects of this invention, therefore, is to provide an inexpensive waveguide window which is essentially transparent to microwave energy, which is capable of operating at high temperatures, and which is able to withstand severe shock and vibration.

Another object is to provide a waveguide window which can be easily bonded across a waveguide section and which will not corrode when so bonded.

Another object of this invention is to provide an improved non-corrosive and high tensile strength adhesive for bonding a film of polytetrafluoroethylene to the flange of a metallic waveguide section.

According to this invention, a polytetrafluoroethylene film is treated in a sodium-naphthalene bath to render it cementable and is then bonded to aluminum or brass waveguide flanges with a high-temperature-resistant adhesive containing epoxy resin and solvent. The film so bonded provides a waveguide window. Windows so assembled have successfully withstood pressures of about 20 p.s.i.g. at a temperature of 125° C. (257° F.) for 15 minutes and have provided a voltage standing wave ratio (VSWR) no greater than 1.08 when measured within a particular test-frequency band.

The specific nature of the invention, as well as other objects, uses and advantages thereof, will clearly appear from the following description and from the accompanying drawing, in which:

FIGURE 1 shows the waveguide window of this invention prior to assembly.

FIGURE 2 shows the assembled waveguide window.

As shown in FIGURE 1, waveguide section **10** is provided with the conventional flange **11** and a rectangular recess **12** formed in flange **11**. The waveguide section **10** has the usual rectangular bore **10***a* extending longitudinally therethrough which is used to guide the microwave signals. The rectangular polytetrafluoroethylene window **13** is cemented by means of an epoxy adhesive **14** in recess **12**. Rectangular insert **15** is insertable in recess **12** and is cemented to the edges of window **13** by epoxy-

solvent adhesive **14**. Flange **11** and insert **15** are preferably composed of brass or aluminum.

Polytetrafluoroethylene window **13** can be between 0.005–0.010 inch in thickness and should be devoid of pinholes. Windows having a thickness of 0.005 inch are preferred. Before window **13** is ready for bonding in recess **12** it is immersed for 15 minutes in a bath containing a one molar complex of sodium-naphthalene in tetrahydrofuran. The window is removed from the bath, rinsed first with acetone and then with water and gently wiped dry with a soft tissue. It is then ready to receive the epoxy adhesive **14** compounded from the following ingredients:

Constituent:	Parts by weight
Epoxy resin (viscosity 5–9 poises)	25
Chlorendic anyhydride	25
Acetone	30
Methyl ethyl ketone	20

An epoxy resin which has been found to be very satisfactory is Epon 815. Epon 815 is a reaction product of epichlorohydrinbisphenol-A variety, with ten percent of butyl glycidyl ether diluent. Epon 815 has a viscosity of between 6–9 poises and an epoxy equivalent of approximately 175.

Adhesive **14** is of sufficiently low viscosity to allow extremely thin layers, less than 0.0005 inch in thickness, to be painted on the window **13**. Because of the water-like consistency of the adhesive layer it has no significant effect on the electrical behavior of the window. Therefore, when the entire window is painted with adhesive it is not necessary to mask the transmission area of the window. In addition, this thin layer provides a strong high-temperature bond for bonding the window **13** to the recess **12** as well as for bonding the brass or aluminum insert **15** to the brass or aluminum flange **11**.

In assembling a typical waveguide window in accordance with this invention, a thin layer of adhesive **14** of approximately 0.0005 inch in thickness is painted over the entire side **13***a* of window **13**. Window **13** consists of a rectangular film of polytetrafluoroethylene 0.005 inch in thickness. Window **13** is dropped in place in the brass or aluminum recess **12**, adhesive side facing rectangular bore **10***a*. Additional adhesive **14** is applied to the edges of the aluminum or brass insert **15** and to the face of the insert **15** which is to be pressed against side **13***b* of window **13**. Thus insert **15** will bond to side **13***b* of window **13** and to recess **12**.

If desired, the window and insert which are coated with adhesive **14** can be dried at room temperature for 15 minutes and then at 65 degrees centigrade in a forced-draft oven for one hour. The parts will then be dry to touch and can be stored for many days prior to the assembly and final cure.

After the window **13** is placed in recess **12** and insert **15** placed against the face **13***b* of the window, 15 to 20 p.s.i. pressure is applied to the insert **15** by a spring or other suitable means which can be devised by those skilled in the art. Curing of the adhesive **14** under pressure of 15 to 20 p.s.i. is effected at a temperature of 180 degrees centigrade in a forced-draft oven for 3 hours.

A cured assembly such as the one described above will confine an air pressure of 20 p.s.i.g. in rectangular bore **10***a* when the section **10** is heated to a temperature of 125 degrees centigrade for 15 minutes. The insertion of the 0.005 inch-thick polytetrafluoroethylene window across the rectangular bore **10***a* does not increase the voltage standing wave ratio (VSWR) beyond 1.08 when measured within a band consisting of 200 megacycles on either side of a particular microwave frequency. Tests indicate that the VSWR varies insignificantly between frequencies

of 8,000 and 10,000 megacycles. The value of 1.08 can be compared with values of VSWR in excess of 1.10 which are typical of the substantially more expensive commercial glass or mica windows.

In light of the foregoing it will be evident to those in the art that waveguide windows composed of polytetrafluoroethylene and constructed as described have advantages not attainable by known windows. In addition, an epoxy-solvent adhesive is disclosed which has an extremely low viscosity and which is resistant to high temperatures resulting from heat developed by the flight of the missile in which the waveguides are incorporated.

It will be apparent that the embodiments shown are only exemplary and that various modifications can be made in construction and arrangement within the scope of the invention as defined in the appended claim.

We claim as our invention:

In a waveguide assembly comprising a metallic section, a bore through said section substantially coaxial to the longitudinal axis of said section, a flange formed on one end of said section, a recess formed in said flange, the improvement comprising: a waveguide window in said recess, said window consisting of a film of polytetrafluoroethylene, said film having a bondable surface portion on all planar surfaces thereof, and an adhesive covering substantially the entire area of that planar surface of said film which is in contact with said waveguide and

bonding said film in said recess, said adhesive comprising epichlorhydrin bis-(4-hydroxyphenyl)-2,2-propane and an acid anhydride.

References Cited in the file of this patent

UNITED STATES PATENTS

2,637,776	Edson	May 5, 1953
2,786,794	Gams et al.	Mar. 26, 1957
2,788,306	Cox	Apr. 9, 1957
2,839,495	Carey	June 17, 1958
2,882,502	Freundlich	Apr. 14, 1959
2,883,308	Yamada	Apr. 21, 1959
2,932,806	Burr	Apr. 12, 1960
2,947,325	McFarland	Aug. 2, 1960
3,001,160	Trousdale	Sept. 19, 1961

FOREIGN PATENTS

209,032	Australia	June 19, 1957

OTHER REFERENCES

Lee et al.: Epoxy Resins, page 142, McGraw-Hill Book Co., Inc., New York. Copyright 1957.

Lee et al.: Epoxy Resins, page 198, McGraw-Hill Book Co., Inc., New York. Copyright 1957, TP986.E6.

Publication, "Epoxies—No Wonder," published in Modern Plastics. October 1952. Pages 89–94.