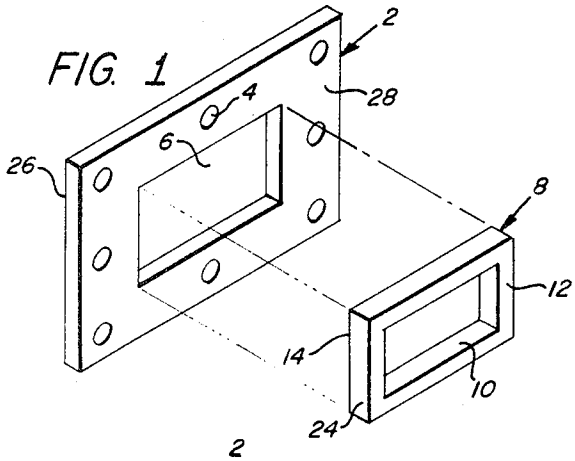
Sept. 3, 1968 A. E. BOOTH 3,400,344

HIGH POWER MICROWAVE ENERGY WAVEGUIDE COUPLING GASKET

Filed Dec. 29, 1965

FIG. 1



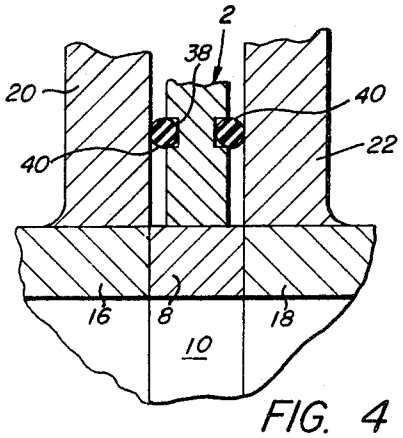


FIG. 4

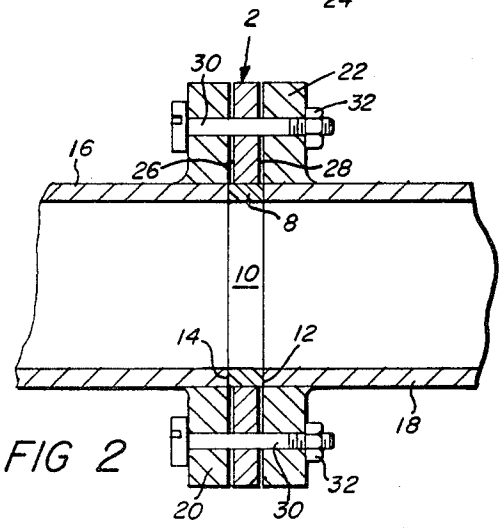


FIG 2

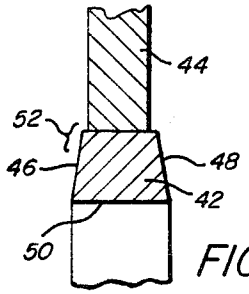


FIG. 5

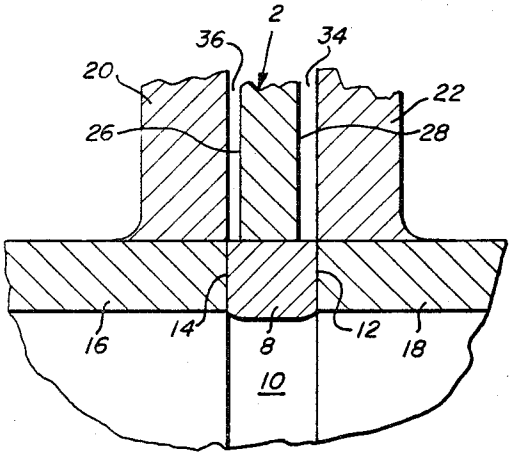


FIG. 3

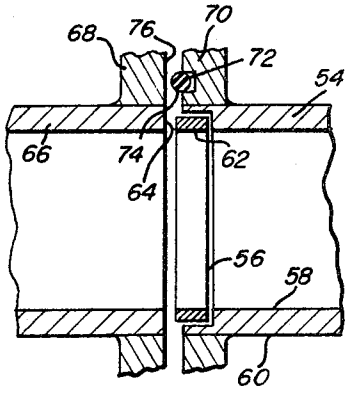


FIG. 6

INVENTOR
ALFRED E. BOOTH

BY Edgar O. Cost
ATTORNEY

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HIGH POWER MICROWAVE ENERGY WAVEGUIDE COUPLING GASKET

Alfred E. Booth, Marlboro, Mass., assignor to Raytheon Company, Lexington, Mass., a corporation of Delaware

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9 Claims. (Cl. 333—98)

ABSTRACT OF THE DISCLOSURE

A waveguide gasket for radio frequency transmission lines comprising a demountable insert having a smooth lateral surface adapted for mounting within the central aperture in the holder plate to provide continuity along the wall surfaces between opposing waveguide sections secured together under mechanical pressure. The insert is preferably of a thicker cross-sectional dimension than the holder plate.

The present invention relates to microwave waveguide plumbing and more particularly to new and novel means for providing an efficient electrical seal between adjoining mating sections of flanged waveguide adapted to propagate very high peak and average power levels of radio frequency energy without arcing or overheating at the point of contact.

In the transmission of energy at microwave frequencies hollow metallic waveguide conductors are commonly employed with mating flanges joined adjacent the ends of convenient short lengths. The mating flanges may then be mechanically coupled by conventional nut and bolt arrangements uniformly spaced on all sides to assure electrical continuity along the inner walls of the joined waveguide sections. Systems transmitting the very high power levels envisaged in the present invention must make provison for any possible arcing at the joined surfaces of the flanges and waveguide sections as well as excessive heat generated by microwave energy. It is customary, therefore, for such systems to be highly pressurized which requires the waveguide seals to be both vacuum-tight and pressure-tight in addition to the requirements for good electrical and mechanical continuity.

Numerous solutions and structures have been suggested in the art for high power microwave system applications. Included in such structures is a configuration providing a woven wire mesh gasket disposed within a suitable groove in the flange member somewhat removed from the waveguide interior walls. Such mesh gaskets have proven to be very susceptible to arcing, particularly since small particles can fall into the waveguide section during assembly. In addition, recessed rubber O ring gaskets of many designs with elaborate convolutions are available for pressure sealing alone and are also removed from the waveguide sections by being disposed solely between abutting flange member surfaces. Such sealing members do not provide good electrical continuity where it is required and are limited to very low power transmission systems.

A unique configuration resides in a plate-type member having permanent raised diamond, pin or knurled surfaces defined adjacent to the area of the waveguide opening on both of its lateral surfaces. One disadvantage of this structure is that the raised surfaces permanently deface the ends of the mating waveguide sections and cannot be reused. In addition, the raised knurled surfaces become blunted to result in a deterioration of usefulness. At the high power levels under consideration such seals are costly and inefficient.

Another gasket configuration presently employed in the microwave industry involved a sheet of plastic material impregnated with conductive metallic particles. Such

gaskets are very resilient and provide for electrical contact together with pressure sealing in an integral arrangement. Due, however, to the mechanical pressures exerted on the waveguide flanges when secured together the plastic gasket material tends to "creep" and may project within the waveguide path to present a discontinuity to the high power energy. Heating at the high power levels is also a deterrent to the use of such impregnated plastic gaskets. Additionally, some of the small metal particles may fall into the waveguide interior to create electrical arcing problems.

Deformable soft metallic gaskets adapted to mate and engage recessed tongue members in special flange members are also among the many gasket configurations presently available. Each time a waveguide section is assembled for any reason new gasket members must be inserted. Further, standard commercially available flange hardware cannot be utilized which leads to additional expense.

All existent waveguide gaskets then have a common disadvantage in that they are essentially "one shot" arrangements and cannot be reused over and over again. At high microwave power levels where good electrical continuity is required along the inner waveguide wall surfaces most of the foregoing embodiments of the prior art have proven to be unsatisfactory. Accordingly, the primary object of the present invention is the provision of a waveguide coupling gasket for uniting sections of waveguide in systems propagating high peak and average power levels of microwave energy.

Another object is the provision of a waveguide coupling means for handling high power energy transmission without electrical arcing and overheating.

Still another object is the provision of a waveguide coupling gasket which is readily reusable and inexpensive.

Another object is the provision of a waveguide coupling gasket which obviates the disadvantages of like prior art structures.

The invention broadly stated encompasses an insert member of uniform cross-sectional configuration and smooth planar lateral surfaces defining an opening having dimensions similar to the inner wall dimensions of the waveguide sections to be joined. The insert member is preferably of a highly conductive malleable material with electrical properties substantially coinciding with the waveguide section material. A holder plate for the insert may be disposed between the flange members secured at the ends of the respective waveguide sections. The insert is then lightly press-fit within an accommodating opening in the holder plate and may be simply replaced without any tools after numerous sealing operations, if desired, without replacing the holder plate itself. Consequently, the holder member may be fabricated of any inexpensive material including nonconductive plastics, since the electrical continuity is furnished entirely by the insert member.

A feature of the invention is the uniting of the waveguide sections with the insert member sandwiched therebetween in such a manner that a smooth continuous inner wall path is defined for the propagated waves. The mechanical pressure applied by means of the nut and bolt arrangement uniting the mating flanges should not exceed the elastic limit of the malleable conductive material. The smooth mating and united surfaces minimize any deforming, indentation or other mechanical damage to assure reusability. Another feature is the provision of the insert member removably mounted in the holder plate with the cross-sectional dimensions of the insert slightly thicker than the holder plate to provide a slight protrusion on each side of the holder plate.

Still another feature is the adaptability of the insert member to join waveguide sections having standardized

commercially available flanges without any modifications or alterations required.

The invention is equally applicable to any waveguide plumbing of any cross-sectional configuration and number of openings. It is also permissible to provide rubber sealing gaskets in recesses removed from the waveguide openings for additional pressure sealing where desired. Several alternate embodiments will also be described herein including structure incorporating reduced waveguide ends in the area adjacent to the interior walls in either one of both waveguide ends to be joined to thereby to define a recess accommodating the insert member when the mating flanges are in contact to obviate the use of the holder plate.

These and other objects, features and advantages will be evident after consideration of the following detailed description, together with the accompanying drawings in which:

FIG. 1 is an exploded perspective view of an illustrative embodiment of the invention;

FIG. 2 is a cross-sectional view of the illustrative embodiment in a mounted position clamped between two waveguide sections with flange members;

FIG. 3 is an enlarged fragmentary cross-sectional view of the clamped components in the area of contact;

FIG. 4 is an enlarged partial cross-sectional view of a holder plate provided with additional pressure seal gaskets;

FIG. 5 is a partial cross-sectional view of an alternative configuration of the embodiment of the invention; and

FIG. 6 is a partial cross-sectional view of an embodiment of the invention without a holder plate prior to completion of application of mechanical pressure to the mating flange members.

Referring to the drawings, particularly FIG. 1, the embodiment shown comprises a holder plate **2** defining an array of clearance holes **4** encircling a central opening **6**. In accordance with this embodiment of the invention electrical continuity is provided by the member supported by the holder plate and, therefore, it is permissible to employ any less expensive conductive or nonconductive material of a rigid or semi-rigid consistency. Conversely, since the holder plate is adapted to be reused any number of operation cycles without being discarded in the manner of certain prior art gasket structures, metals such as copper, brass or stainless steel, with any suitable durable plated finish, such as gold, rhodium or silver, may be employed. Another possible material may be provided by any molded plastic method since the mechanical forces applied to unite the waveguide sections are not applied mainly to the holder plate.

An insert member **8** of uniform cross-sectional configuration is provided with the outer peripheral wall dimensions selected for a light press-fit in the holder plate opening **6**. The material preferred for the insert member **8** is a malleable highly conductive metal. Since this is the matching electrically contiguous element disposed between the mating waveguide sections, a metal closely conforming to the thermal and electrical characteristics of the hollow waveguide members is preferred. The majority of waveguide plumbing in use today is copper or brass and hence annealed OFHC copper is preferred in most applications. The critical dimensions of the insert member **8** are the inner centrally disposed opening defined by walls **10** together with the smoothness and parallelism of the lateral planar surfaces **12** and **14** which are in engagement with the waveguide walls in a complete united assembly as shown in FIG. 2. The dimensions of the wall surfaces **10** defining the opening are selected to conform with the inner wall dimensions of hollow waveguide sections **16** and **18** bearing standard rigid flange members **20** and **22** adjacent the ends thereof. With the correct alignment thus provided, the transmitted waves are exposed to smooth continuous interior conductive wall surfaces along the propagation path. The insert member is intentionally of a slightly thicker cross-sectional dimension along the wall surfaces **24** so as to provide a slightly raised protrusion beyond opposing lateral surfaces **26** and **28** of holder plate **2**. In actual working embodiments the combined protrusion dimension from the holder plate surfaces was found to be in the range of approximately five to ten thousandths of an inch for a plate of approximately .125 inch in thickness. While a holder plate and insert member of rectangular cross-section have been shown for illustrative purposes, it is intended that the invention be equally applicable to any other cross-sectional configurations. The insert member **8** is readily positioned within the holder plate by finger pressure and hence may be simply replaced without the use of tools. The insert may also be plated with a flash of any metal such as gold for enhancing electrical conductivity properties and resistance to corrosion.

Assembly of the aforementioned components is shown in FIGS. 2 and 3. A plurality of bolts **30** are disposed in aligned holes in flange members **20** and **22** as well as holder plate holes **4**, and threaded nuts **32** are tightened to apply a closing mechanical pressure thereby bringing the contacting wall surfaces of the insert member and waveguide sections in electrically continuous engagement. The mechanical pressure provided equally by the encircling nut and bolt array is applied only to the relatively small lateral planar surfaces **12** and **14** of insert member **8** to result in very high mechanical pressures on the contact area with the respective waveguide sections. As a result a highly effective electrical bridging contact is provided between the respective waveguide sections. Referring to FIG. 3, the area of the joining seal has been illustrated enlarged many times. While to the naked eye surfaces are planar and smooth, it is believed that the malleable conductive insert assumes somewhat of a slight bowed appearance if magnified. The degree of pressure applied to couple the flange members and accompanying waveguide sections for high power applications should be limited to within the elastic limit of the insert member conductive material to ensure adequate mechanical sealing pressure at the joining surfaces.

Ideally, the complete assembled and coupled members will provide a narrow gap **34** between opposing holder plate surface **28** and flange **22** due to the protrusion of the insert member **8** when mounted in a holder plate. A similar gap **36** will be defined between surface **26** of the holder plate and flange member **20**. The conductive insert member **8** is also considered to maintain a constant volume throughout when under compression to provide for good electrical contact on all contiguous surfaces.

FIG. 4 illustrates the provision of an auxiliary resilient gasket pressure seal in opposing surfaces of the holder plate member **2** by means of a recess **38** somewhat removed from the waveguide sections and forming a closed loop. An appropriate seal such as an O ring type **40** is positioned within the recesses formed on each side of the holder plate. In this view the components have been shown before the application of the compressive force which will somewhat flatten the gasket members.

FIG. 5 shows an alternative insert member **42** disposed within holder plate **44** with tapered lateral wall surfaces **46** and **48**. The direction of the taper is away from the central opening wall **50**. The major dimension will then be at the point adjacent the inner waveguide walls which may also be referred to as the sealing edge. The tapered configuration permits a reduction in volume without altering the basic considerations of the protrusion and provision of a uniform smooth interior wall adjacent to the waveguide sections. Under compression the flow area may be generally designated **52**. A chamfered configuration may also be utilized to also reduce over-all volume.

Referring next to FIG. 6, an alternative illustrative embodiment is shown which obviates the necessity of the holder plate. Waveguide section **54** is provided with an end of reduced cross-section by notching or milling a re-

cess **56** commencing from the inner wall **58** with the outer wall surface **60** remaining unaltered. Insert member **62** will be disposed within the recess and engage the wall surface **64** of abutting waveguide section **66** when flanges **68** and **70** are securely coupled together. A recess **72** provides for resilient O ring **74** to engage surface **76** of flange **68** when the coupling is completed. While the recess **56** has been illustrated in one waveguide section **54**, both abutting ends may be similarly recessed and the insert member will be disposed in a middle position with abutting faces of flange members **68** and **70** in contiguous relationship.

Actual embodiments have been tested in all frequency bands in the microwave spectrum. Plural opening coupling gaskets for common wall hybrid structures have also been successfully employed. No excessive overheating or electric arcing was observed at power levels up to 35 megawatts.

Many modifications or alternative embodiments may be evident to skilled artisans. The detailed description and specific illustrations herein contained, therefore, are intended as exemplary only without in any manner limiting the scope and breadth of the invention as defined in the ensuing claims.

What is claimed is:

1. Waveguide coupling apparatus comprising:

plural sections of hollow waveguide having flange members secured adjacent to the ends thereof;

means including a holder plate and insert member adapted to be united between said flanged waveguide sections;

said insert member being of a highly conductive malleable metallic material of substantially uniform cross-sectional configuration defining an opening;

the inner wall dimensions of said opening being selected to conform to the inner wall dimensions of said waveguide sections to provide a substantially smooth electrically continuous path along the inner wall surfaces of said waveguide sections and insert member when the respective components are united;

said holder plate defining an opening dimensioned to accommodate said insert member in a light press-fit manner so as to render said insert member readily removable without the aid of a tool;

and said insert member lateral surfaces when mounted in said holder plate protruding beyond at least one of said holder plate lateral surfaces to provide the sole mating surface with the end wall surfaces of said waveguide sections.

2. Waveguide coupling apparatus according to claim **1** and means for securely clamping said flange members together under a degree of mechanical force sufficient to provide firm engagement of the insert member lateral surfaces and end wall surfaces of said waveguide sections.

3. Waveguide coupling apparatus according to claim **2** wherein said degree of mechanical force is below the elasticity limit of the insert member material.

4. Waveguide coupling apparatus according to claim **1** wherein said insert member is provided with substantially smooth planar lateral surfaces adapted to mate with the waveguide end wall surfaces.

5. Waveguide coupling apparatus according to claim **1** wherein said holder plate is of a nonconductive material.

6. Waveguide coupling apparatus according to claim **1** wherein said holder plate is of a conductive material.

7. Waveguide coupling apparatus according to claim **1** wherein said insert member defines lateral surfaces of a reduced cross-section with the widest dimension at the wall surface adjacent to the opening.

8. Waveguide coupling apparatus according to claim **1** wherein said insert member is plated with a layer of flash thickness of another conductive material.

9. Waveguide coupling apparatus according to claim **1** wherein the holder plate outer peripheral wall configuration conforms to that of said flange members.

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