Oct. 21, 1969 R. Z. GERLACK 3,474,360

MICROWAVE WAVEGUIDE WATERLOAD EMPLOYING
A QUARTER WAVE WINDOW TRANSFORMER
Filed June 14, 1968

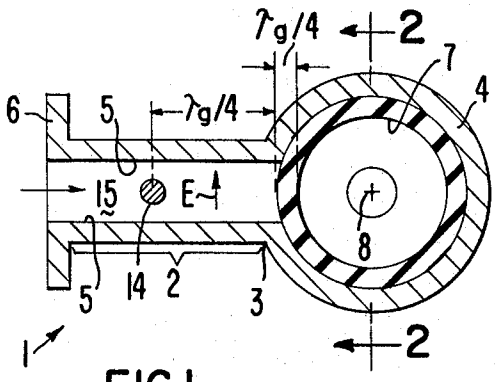


FIG. 1

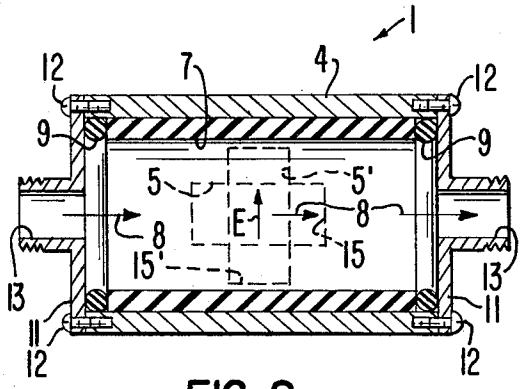


FIG. 2

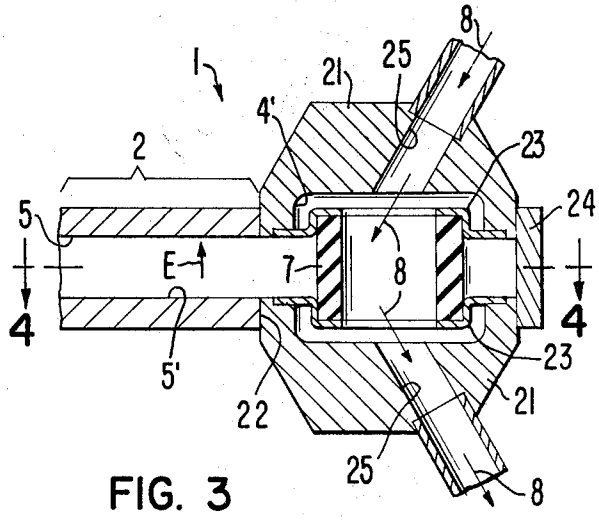


FIG. 3

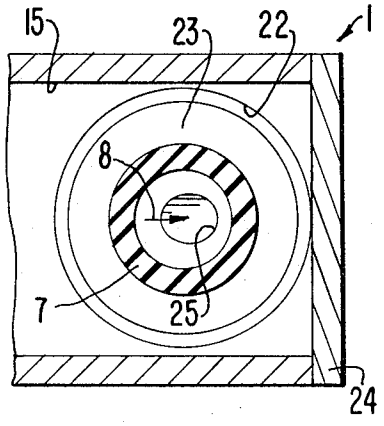


FIG. 4

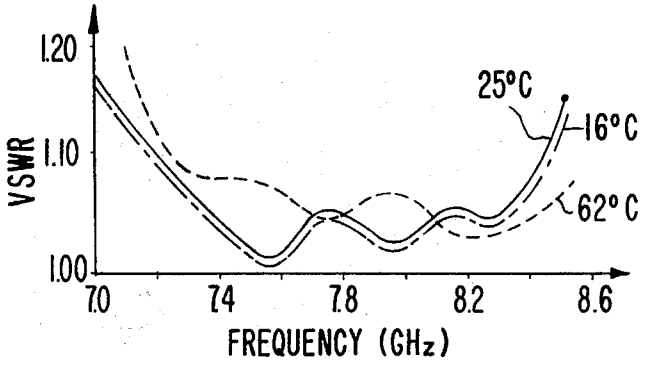


FIG. 5

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United States Patent Office 3,474,360 Patented Oct. 21, 1969

3,474,360

MICROWAVE WAVEGUIDE WATERLOAD EMPLOYING A QUARTER WAVE WINDOW TRANSFORMER

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Filed June 14, 1968, Ser. No. 737,134
Int. Cl. H01p 1/26
U.S. Cl. 333—22 7 Claims

ABSTRACT OF THE DISCLOSURE

A microwave waveguide load is disclosed. The load includes a section of hollow waveguide adapted to be connected at one end to the source of microwave energy to be absorbed. The other end of the section of waveguide "looks" into a stream of dielectric lossy coolant, such as water, contained within a dielectric tube extending across the end of the section of waveguide to form a load. The wall thickness of the dielectric tube is made an integral number of quarter wavelengths thick to form a waveguide impedance transformer between the impedance of the waveguide and the impedance of the coolant stream, whereby a broadband match is obtained to the dielectric coolant stream forming the load. The tubular dielectric window is sealed to the end of the waveguide by O rings, in one instance, or by brazing to an annular frame member, in a second instance. The tubular construction of the window facilitates fabrication of the load and reduces the manufacturing costs thereof.

DESCRIPTION OF THE PRIOR ART

Heretofore, microwave waveguide waterloads have been constructed which employ quarter wave window transformers for matching the impedance of the waveguide to the impedance of the coolant stream to obtain a wide passband high power load. However, in the prior art, the window transformer sections have comprised flat blocks of dielectric, such as alumina ceramic or Teflon. In the case of a ceramic window member it is typically a ceramic block brazed into the end of the waveguide section which looks into the coolant stream. The problem with the use of a flat block type dielectric window, as sealed into the end of a section of waveguide, is that the window must be sealed around its periphery, i.e., on all four sides of the block window typically by brazing a metallized ceramic block into a thin sheet metal frame as of copper, which in turn is brazed into the waveguide. This type of window construction is relatively expensive. Such a prior art waveguide waterload is disclosed and claimed in U.S. Patent 3,360,750, issued Dec. 26, 1967, and assigned to the same assignee as the present invention. Therefore, a need exists for a transformer window construction which is more easily sealed to the waveguide, to facilitate fabrication of the waveguide waterload.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved microwave waveguide waterload employing a quarter wave window transformer.

One feature of the present invention is the provision, in a microwave waveguide waterload of the type employing a quarter wave window transformer, of a dielectric tube for containing the stream of lossy dielectric coolant, such tube having a wall thickness of approximately an integral number of quarter wavelengths to form the window transformer, whereby fabrication of the window portion of the load is facilitated.

Another feature of the present invention is the same as the preceding feature wherein the tubular dielectric window member includes a section having axially spaced end portions which are sealed to opposite side walls of the waveguide section.

Another feature of the present invention is the same as any one or more of the preceding features wherein a pair of resilient O rings are disposed at opposite ends of the tubular dielectric window for sealing the window to the waveguide.

Other features and advantages of the present invention become apparent upon a perusal of the following specification taken in connection with the accompanying drawings wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a longitudinal sectional view of a waveguide waterload employing features of the present invention,

FIG. 2 is a sectional view of a portion of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows,

FIG. 3 is a longitudinal sectional view of an alternative waterload incorporating features of the present invention,

FIG. 4 is a sectional view of the structure of FIG. 3 taken along lines 4—4 in the direction of the arrows, and

FIG. 5 is a plot of voltage standing wave ratio versus frequency, in gigahertz, depicting the passband characteristics of the waterload of the present invention as a function of the temperature of the water.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIGS. 1 and 2, there is shown a waveguide waterload 1 incorporating features of the present invention. The waveguide waterload 1 includes a first section of rectangular waveguide 2 joined, as by brazing or welding, at 3 to a cylindrical section of waveguide 4. The cylindrical section of waveguide 4 has its longitudinal axis parallel to the broad walls 5 of the rectangular waveguide section 2. A flange 6 is affixed to the other end of the waveguide section 2 for connecting the waveguide waterload 1 to a source of microwave energy to be absorbed.

A hollow cylindrical tubular dielectric window member 7, as of alumina ceramic, is coaxially disposed within the cylindrical waveguide section 4. The outside diameter of the tubular window member 7 is substantially the same as the inside diameter of the cylindrical waveguide section 4 to prevent the formation of an air gap in the region of the strong electric fields at the junction 3 of the rectangular waveguide section 2 with the cylindrical waveguide section 4. The tubular window 7 has a wall thickness which is approximately an integral number of quarter electrical wavelengths thick at a frequency corresponding to the center of the passband of the waterload. An "electrical wavelength" is defined as that distance in the direction of power flow of wave energy in a transmission line through which the wave energy experiences 360° of phase shift.

A stream of lossy dielectric liquid coolant 8, as indicated by the arrows 8, is directed through the hollow interior of the tubular window 7 for absorbing microwave energy passing through the wall of the tubular window 7 from the waveguide section 2. For the case where the lossy dielectric liquid coolant stream 8 is water having a dielectric constant of approximately 80, the window member 7 is preferably made of alumina ceramic and is preferably an odd number of quarter electrical wavelengths thick to provide a relatively wide band quarter wave transformer section between the section of rectangular waveguide 2 and the impedance of the lossy dielectric coolant

stream 8. In case the lossy dielectric coolant is ethylene glycol or a mixture of ethylene glycol and water having a substantially lower dielectric constant than water, the tubular window member 7 preferably has a lower dielectric constant, such as that provided by Teflon (polytetrafluoroethylene resin). In case a tubular Teflon window member 7 is employed, the window member may advantageously be made an even number of quarter electrical wavelengths thick to provide a resonant half-wave window between the stream of lossy dielectric coolant 8 and the waveguide section 2.

The tubular window member 7 is sealed to the waveguide sections 4 and 2 by means of a pair of resilient O rings 9, as of rubber, neoprene or hollow metallic tubing, to provide a liquid impervious barrier across the end of the rectangular waveguide section 2. The O rings 9 are captured between the end of the tubular window member 7 and a pair of centrally apertured cover plates 11 carried from the ends of the tubular waveguide 4 via a plurality of screws 12. Threaded pipe nipples 13 are provided in the center of each of the cover plates 11 for connecting the tubular waveguide 4 to coolant pipes, not shown, for supplying the coolant and extracting the coolant from the waterload 1.

Typically, the quarter wave transformer window member 7 does not provide a perfect impedance match over a relatively wide passband between the waveguide 2 and the stream 8 of lossy dielectric coolant. Therefore, an impedance matching wave reflective discontinuity 14, such as a conductive capacitive septum, is provided in the waveguide section 2 a proper distance from the adjacent face of the window 7 to produce a wave reflection of the proper magnitude and phase to cancel the wave reflection from the mismatch between the window member 7 and the stream of lossy dielectric coolant 8. In the case of a capacitive conductive septum 14 which extends across the rectangular waveguide section 2 from one narrow wall 15 to the opposed narrow wall 15 and parallel to the broad walls 5, the septum 14 is preferably placed a quarter electrical wavelength from the adjacent face of the tubular window 7.

A waveguide waterload 1 of the type described in FIGS. 1 and 2 employing an alumina ceramic window 7 and water as the lossy dielectric coolant 8, provides a passband characteristic of the type shown in FIG. 5, where voltage standing wave ratio is plotted versus frequency for three different temperatures of the water. From the plot of FIG. 5 it is seen that the waveguide load 1 has a relatively wide passband between voltage standing wave ratios points of 1.10.

One advantage of the waveguide waterload 1 of FIGS. 1 and 2 is that the tubular dielectric window member 7 is sealed into the waveguide structure 2 and 4 by means of a pair of conventional O rings 9, thereby eliminating the necessity of a brazed joint between the waveguide 2 or 4 and the window member 7, whereby fabrication of the waterload 1 is facilitated and the manufacturing cost thereof reduced.

As an alternative to having the longitudinal axis of the cylindrical waveguide 4 parallel to the broad walls 5 of the waveguide section 2, the longitudinal axis of the cylindrical waveguide section 4 may be parallel to the narrow walls 15 of the rectangular guide 2, as indicated by the phantom lines 5' and 15' in FIG. 2. In this latter case, the O rings 9 will be located in a region of more intense electric fields than in the first embodiment, and in such a case it is preferred to employ metallic resilient O rings to prevent over-heating thereof. In both cases where O rings 9 are employed for sealing the tubular window 7 to the waveguide sections 2 and 4, it is preferred that the tubular window 7 have a length substantially longer than either the breadth or height of the waveguide section 2 to remove the resilient O rings 9 from the immediate vicinity of the strong electric fields produced at the junction 3 of the rectangular waveguide 2 with the cylindrical waveguide 4.

Referring now to FIGS. 3 and 4, there is shown an alternative embodiment of the waterload 1 of the present invention. The embodiment of FIGS. 3 and 4 is similar to the latter described alternative embodiment to waterload 1 of FIGS. 1 and 2 wherein the longitudinal axis of the cylindrical waveguide section 4 is parallel to the narrow side walls 15 of the rectangular waveguide section 2. More specifically, in the embodiment of FIGS. 3 and 4, a relatively short length of cylindrical waveguide section 4' is formed in a pair of conductive metallic blocks 21 which are in turn brazed into a circular bore 22 in the top and bottom walls 5 of the rectangular waveguide section 2. A pair of annular sheet metal frame members 23, as of copper, are brazed to the ends of the tubular window member 7 and to the top and bottom walls 5 of the waveguide 2, which are defined by the innerfaces of the conductive blocks 21. A conductive plate 22 closes off the end of the rectangular waveguide 2. A pair of coolant passageways 25 are provided by bores, in blocks 21, which intersect with the closed ends of the cylindrical waceguide sections 4'. The longitudinal axes of the passageways 25 are directed at that inside face portion of the tubular window 7, which is in registration with the center of the rectangular waveguide section 2, such that the microwave power which passes through the tubular window 7 is rapidly carried away from the window 7 for enhanced cooling and absorption of microwave power.

Although the waterload embodiment of FIGS. 3 and 4 employs a brazed window construction which is more expensive to manufacture than the O ring seals of the embodiments of FIGS. 1 and 2, the brazed assembly of FIGS. 3 and 4 is more easily fabricated than the prior art rectangular windows because the seals need only be provided at the axial ends of the window member 7, whereas the prior art rectangular window required that a seal be made entirely around the four sides of the window member. The waterload 1 of FIGS. 3 and 4 is especially useful with reduced height waveguide 2 as a resistive load termination for a severed microwave slowwave tube circuit.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter container in the above description or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. In a microwave waveguide load, means forming a hollow waveguide, means forming a microwave permeable dielectric window member sealed across said waveguide to form a liquid impervious barrier across one end of a section of said waveguide, means for connecting said waveguide to a source of microwave energy to be absorbed, means for passing a stream of lossy dielectric liquid coolant adjacent a face of said window member which is on the opposite side of said barrier from the source of energy to be absorbed for absorbing microwave energy passing into the stream of liquid coolant from the source of microwave energy, said window member having a thickness taken in the direction of power flow therethrough into the liquid stream which is approximately an integral number of quarter wavelengths at the center frequency of the passband of the load for matching the impedance of said section of waveguide to the impedance of the lossy liquid coolant, the improvement wherein said dielectric window member is a tube of dielectric material for containing the stream of lossy dielectric coolant, said dielectric tube having a wall thickness of approximately the integral number of quarter electrical wavelengths at the center frequency of the passband of the load for impedance matching, whereby fabrication of the window portion of the load is facilitated.

2. The apparatus of claim 1 wherein said section of waveguide is hollow rectangular waveguide having broad top and bottom walls and a pair of narrow side walls, and wherein the longitudinal axis of said dielectric tube is

parallel to the broad walls of said waveguide, and means forming a sealing structure sealing the end of at least a portion of said dielectric tube to said waveguide section.

3. The apparatus of claim 2 wherein said sealing structure includes a pair of resilient O rings disposed at opposite ends of said dielectric tube portion.

4. The apparatus of claim 1 wherein said section of waveguide is hollow rectangular waveguide having a broad top and bottom wall and a pair of narrow side walls, and wherein the longitudinal axis of said dielectric tube is parallel to the narrow walls of said waveguide, and means forming a sealing structure sealing the ends of at least a portion of the length of said dielectric tube to said waveguide section.

5. The apparatus of claim 1 wherein said dielectric tube is made of ceramic and the dielectric liquid is predominately water.

6. The apparatus of claim 1 wherein the wall thickness of said tubular dielectric window member is approximately one quarter electrical wavelength.

7. The apparatus of claim 5 wherein said dielectric tube is made of polytetrafluoroethylene resin and the dielectric constant of the liquid coolant is substantially less than 80.

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U.S. Cl. X.R.

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