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A. R. STRNAD

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VACUUM TIGHT WINDOW FOR HIGH FREQUENCY DEVICES

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FIG. 1

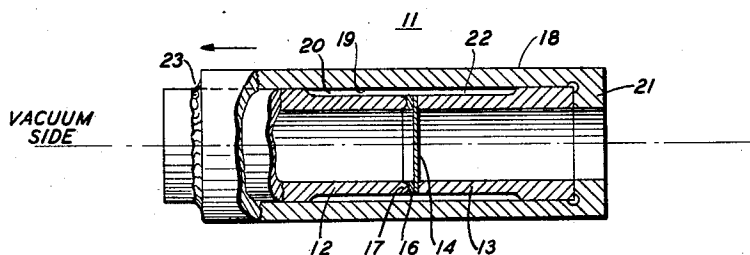


FIG. 2

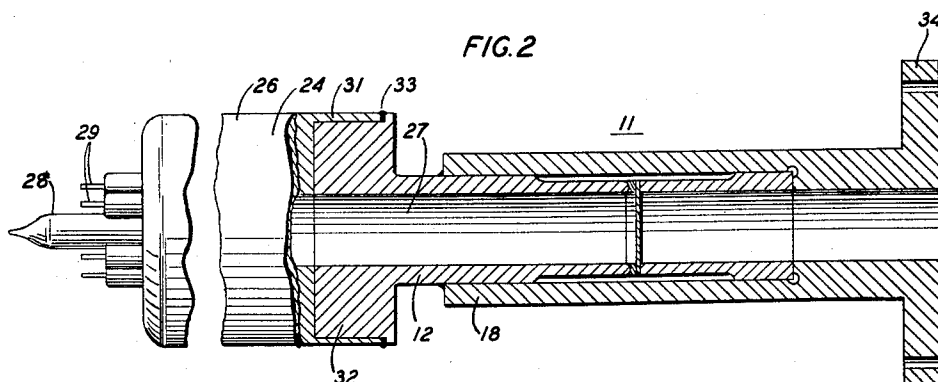
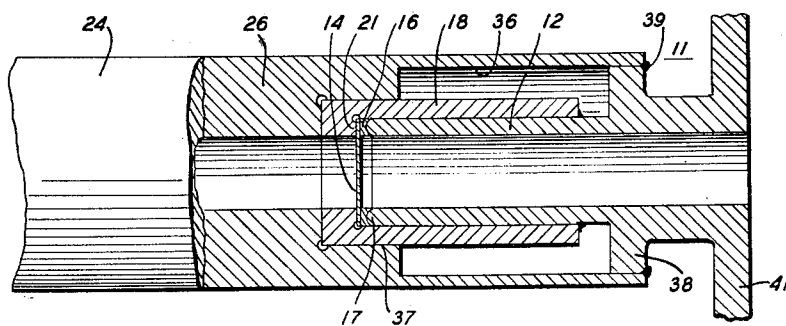


FIG. 3



INVENTOR
A. R. STRNAD

BY *David P. Kelley*
ATTORNEY

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Albert R. Strnad, Basking Ridge, N.J., assignor to Bell Telephone Laboratories, Incorporated, New York, N.Y., a corporation of New York

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10 Claims. (Cl. 315—39)

This invention relates to vacuum apparatus and more particularly to an electromagnetic wave permeable vacuum-tight window for vacuum-sealing such apparatus.

In vacuum apparatus such as, for example, high frequency traveling wave tubes, it is generally necessary to remove the energy which has been amplified or otherwise treated in the vacuum apparatus to an energy transmission circuit or a utilization circuit which is not itself under a vacuum. In order to accomplish this it is frequently necessary to have an electromagnetic wave permeable member which will permit passage of the electromagnetic wave energy from the vacuum system to the wave transmission system, or vice versa, and yet which is vacuum-tight so that the vacuum integrity of the apparatus can be maintained. Such a window ideally presents to the electromagnetic wave energy a minimum of interference so that energy will not be reflected or dissipated as it passes through the window.

One of the most satisfactory materials for achieving the above stated results is mica, which is obtainable in both synthetic and natural forms. Among the advantages of both the synthetic and the natural micas is the fact that mica has a low dielectric constant so that its impedance approximates that of air. As a consequence the electromagnetic wave energy upon encountering the mica window does not "see" any substantial impedance change and reflection of the wave energy is minimized. Another advantage of mica is that it has a lower loss tangent than comparable materials and as a consequence energy dissipation is less than it would be with the other materials. In addition to the foregoing, natural mica can be made into quite thin sheets which still possess a great deal of structural strength. This characteristic makes it possible to use a very thin sheet as the wave permeable window and thereby interference effects which occur when the thickness of the window approximates a quarter of a wavelength of the wave energy are avoided. Still other advantages of natural mica are that it is inexpensive, readily available in a great variety of sizes, and is easy to manipulate and handle.

In the manufacture of a traveling wave tube, for example, it becomes necessary, after the apparatus has been evacuated, to elevate the temperatures of the apparatus and the various electrodes therein to very high temperatures to bake out the impurities in the various components. The temperatures used are generally much higher than the operating temperature of the apparatus, and all of the components of the apparatus must be designed to withstand these elevated temperatures. Heretofore, when mica has been used, it has not been possible to elevate the temperatures during the bake-out process to as high a degree as is desirable for the reason that the glazes or solders which are used to attach the mica to the apparatus are of a low melting point and melt under the application of the very high temperatures, thereby causing failure of the vacuum seal.

Because of this temperature sensitivity of mica windows which have been used in the past, workers in the

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art have turned to other types of material such as various ceramics to accomplish the desired end of the vacuum-tight electromagnetic wave permeable window. In general such ceramic type windows are strong and not as temperature-sensitive as mica windows. However, such materials generally possess a higher loss tangent, a higher dielectric constant, and are a great deal thicker than mica and therefore do not function as an electromagnetic wave permeable window as well as mica. A synthetic mica window can withstand a higher temperature than a natural mica window because it does not require glazes or solders of such a low melting point. However, synthetic mica is quite difficult to handle, it is very difficult to split it into as thin sheets as natural mica, and it is quite difficult to obtain in sizes which are large enough for the intended function.

It is an object of this invention to provide an improved type of electromagnetic wave permeable window.

It is another object of this invention to provide a mica window which will maintain vacuum integrity of the apparatus during and after application of high bake-out temperatures.

It is still another object of this invention to provide an electromagnetic wave permeable vacuum-tight window which is simple and economical to fabricate and which is adaptable to use with a variety of types of vacuum apparatus.

These and other objects of the present invention are attained in one specific embodiment thereof wherein a mica window is mounted between two hollow metallic members in abutting relationship. The two metallic members and the mica window are surrounded by a third hollow metallic member having an internal shoulder which bears against one end of one of the inner metallic members and which is welded or brazed to the other metallic member. The entire assembly is joined, as by welding, to the wave energy source, such as to a traveling wave type tube in alignment with the wave energy transmission portion thereof, and is further provided with means for connecting to a utilization system.

In another specific embodiment of the invention, the mica window rests against the internal shoulder of the outer hollow member, and the inner member to which the outer member is brazed abuts the mica window on the side opposite the internal shoulder of the outer member.

It is one feature of the present invention that the outer metallic member has a higher thermal coefficient of expansion than either of the other two members so that upon cooling, after being welded to one of the other members, the outer member contracts to a greater degree than the inner members, which forces both of the inner members toward each other, causing them to exert a high pressure on the mica window. This pressure is maintained thereafter by virtue of the outer metallic member remaining under greater tension than the inner members.

It is another feature of the present invention that one of the inner metallic members is provided with rounded edges at the end which is adjacent the mica window. A washer of malleable material is inserted between the rounded edges and the mica. Under the pressure generated in the differential contraction of the inner and outer members the washer flows over the rounded edges of the inner member in intimate contact therewith and with the mica, forming a vacuum-tight seal between the mica and the metallic member.

These and other features of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which:

Fig. 1 is a sectional view of a mica window assembly embodying the principles of the present invention;

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Fig. 2 is a sectional view of the mica window assembly of Fig. 1 mounted in a traveling wave tube; and

Fig. 3 is a sectional view of another embodiment of the mica window assembly mounted in a traveling wave tube.

Turning now to Fig. 1, there is shown an electromagnetic wave permeable vacuum-tight window assembly 11 embodying the principles of the present invention. Window assembly 11 comprises first and second hollow metallic members 12 and 13 made of suitable material such as Kovar which are axially aligned with each other in an abutting relationship. Situated between the adjacent ends of members 12 and 13 are a window member 14 of electromagnetic wave permeable material, preferably mica, and a washer 16 of malleable material such as gold. The end of member 12 with which washer 16 is in contact is provided with shaped edges 17, the purpose of which will be explained more fully hereafter. Surrounding members 12 and 13 is a hollow metallic member 18 of a metallic material having a materially higher thermal coefficient of expansion than members 12 and 13. Thus, where members 12 and 13 are of Kovar, member 18 may advantageously be of a suitable stainless steel. Member 18 is provided with a machined inner surface 19 of a diameter which is preferably a slip fit with the outer diameters of members 12 and 13. One end of member 18 has a shoulder 21 which abuts against the end of member 13 remote from the mica window and has an internal diameter which preferably matches the internal diameter of member 13, although this is not necessary. Member 18 is of a length such that it completely surrounds member 13 and surrounds member 12 over a portion of its length. To facilitate the assembly and to minimize distortions due to heating and cooling stresses, members 12 and 13 are provided with relieved portions 20 and 22 respectively although such relieved portions are not strictly necessary.

In the manufacture of the window assembly 11 the parts as thus far enumerated are assembled as shown in Fig. 1 and then member 18 is brazed or welded at 23 to member 12. This brazing or welding operation may be a localized operation at the point 23, or may be a furnace brazing operation or any of a number of methods well known in the art which provide sufficient heat to produce a differential expansion of members 12 and 18 without damaging the other window elements. During the brazing operation the member 18 and the member 12 are both heated to a relatively high temperature causing member 18, because of its higher thermal coefficient of expansion, to move axially to the left as viewed in Fig. 1 relative to member 12. After the brazing is completed and the braze itself solidified, members 12 and 18 cool, and member 13, because of its tendency to contract more during cooling, exerts a force on member 12 to the right as viewed in Fig. 1. Inasmuch as member 13 is held against lateral movement to the right by shoulder 21, there will be a tremendous pressure exerted upon washer 16 and window 14. This pressure on washer 16 will cause it, because of its malleability, to flow and embrace the shaped edges 17 of member 12, forming a vacuum-tight seal therewith. In addition, washer 16 bears heavily against window 14 forming a vacuum-tight seal. It can be seen from the structure of Fig. 1 that the weld at 23 need not be vacuum-tight if the member 12 is on the vacuum side of the assembly. In like manner it can readily be seen that the junction of window 14 and member 13 need not be vacuum-tight. As a consequence the structure of Fig. 1 after the brazing operation constitutes a vacuum-tight electromagnetic wave permeable window provided that member 12 is mounted on the vacuum side of the window. While the arrangement of Fig. 1 utilizes a member 16 of malleable material, in certain applications member 16 may be eliminated provided member 12 is itself of sufficiently malleable material.

In Fig. 2 there is shown the window assembly 11 of Fig. 1 mounted onto a traveling wave tube 24, of the

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type such as, for example, that shown and described in the patent of A. Karp et al., No. 2,882,438, issued April 14, 1959. For simplicity, those elements in Fig. 2 which are the same as in Fig. 1 are designated by the same reference numerals. Although the invention is described hereinafter in conjunction with a traveling wave tube of this type, it is to be understood that the present invention is susceptible to use with various other types of devices such as klystrons and magnetrons, as well as other forms of vacuum apparatus.

Tube 24 comprises a metallic envelope 26 having a wave guiding passage 27 therein. At one end of tube 24 are an exhaust tubulation 28 for evacuating the tube and lead in conductors 29 for supplying the necessary voltages and currents to the various elements within the tube.

At the other end of tube 24 is mounted the vacuum-tight electromagnetic wave permeable window assembly 11 as described in Fig. 1. In order that window assembly 11 may be mounted to tube 24 in a vacuum-tight manner, the envelope 26 of tube 24 is provided with a recessed bore 31. Member 12 of window assembly 11 is provided with an enlarged portion 32 which is preferably machined to be a press fit or a slip fit in bore 31, and is welded or brazed to envelope 26 at 33 in a vacuum-tight weld. Member 18 is provided, at its end remote from where it is joined to member 12, with a suitable mounting flange 34 for connecting the utilization device or wave guides in a manner well known in the art. It is to be understood that flange 34 is only one of a number of suitable mounting arrangements, and is shown here merely by way of example.

After window assembly 11 is mounted onto tube 24, as explained in the foregoing, the tube may then be evacuated and baked out at temperatures far higher than were possible heretofore with mica windows, without any loss of vacuum, the pressure on window 14 and washer 16 being maintained sufficiently to insure vacuum integrity of the assembly.

In Fig. 3 there is shown an embodiment of the present invention wherein the window assembly utilizes only one inner metallic member instead of two as was the case with the assembly of Figs. 1 and 2. For simplicity, those elements which correspond to like elements in the embodiment of Fig. 2 have been given the same reference numerals. In Fig. 3 there is shown a traveling wave tube 24 of the type shown in Fig. 2, for example, or it may be any one of a number of types of vacuum devices known in the art. Tube 24 comprises a metallic envelope 26 having at one end thereof a first bored out portion 36 of a first diameter and a second bored out portion 37 of a second diameter. In the bored out portions 36 and 37 is mounted window assembly 11. Window assembly 11 comprises an outer member 18 of a material such as a suitable stainless steel which preferably is machined to be a loose fit in bore 37. Member 18 has an internal shoulder 21 against which rests a window 14 of mica or other suitable material. Inner member 12, having rounded edges 17, is mounted inside of member 18, and washer 16 of malleable material is positioned between member 12 and window 14. As was the case with the window assembly 11 of Figs. 1 and 2, member 13, which is welded to member 12 is under greater tension than member 12 and hence window 14 and washer 16 are under constant high pressure from shoulder 21 and member 12, forming a vacuum-tight seal.

Member 12 is provided with a flange 38 which is preferably machined to be a slip fit in bore 36, and which is welded to envelope 26 at 39 in a vacuum-tight weld. At the end of member 12 remote from the window 14 is a flange 41 for connecting the entire assembly to external apparatus. It is to be understood that flange 41 is shown here merely by way of example, and that any suitable mounting means might be used. After the window assembly 11 is mounted in tube 24, the tube may then be baked out at quite high temperature without dam-

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age to the vacuum seal. In Fig. 3, envelope 26 is depicted as having first and second bores 36 and 37. In practice, it may be feasible to eliminate bore 37 entirely to facilitate machining and assembly.

In the structure of Fig. 3, inasmuch as weld 39 is vacuum-tight, it is only necessary that the wave guiding passage have a vacuum-tight junction. Consequently, annular member 16 does not have to be on the vacuum side of the assembly.

While the principles of the present invention have been shown in connection with certain specific embodiments, it is to be understood that such embodiments are by way of demonstrating such principles and I do not intend that the present invention be restricted thereto. For example, as mentioned previously, the annular ring of malleable material need not be a separate member. It may be made integral with the hollow member, or joined thereto, or it may be the hollow member itself. The present invention is readily adaptable to uses in other types of apparatus as will be apparent to those skilled in the art, without departing from the spirit and scope of the invention.

What is claimed is:

1. A vacuum-tight electromagnetic wave permeable window comprising a first hollow member of material having a first thermal coefficient of expansion, a member of electromagnetic wave permeable material adjacent one end of said first member, and means for maintaining said first member and said wave permeable member in vacuum-tight relationship comprising a second hollow member of material having a higher thermal coefficient of expansion than said first hollow member surrounding said first member and said wave permeable member, said second hollow member being joined at one end thereof to said first hollow member and being under greater tension than said first member, whereby pressure is applied to said electromagnetic wave permeable member.

2. A vacuum-tight electromagnetic wave permeable window comprising a first hollow member of material having a first thermal coefficient of expansion, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, and means for maintaining said wave permeable member, said annular member and said hollow member in vacuum-tight relationship comprising a second hollow member of material having a higher thermal coefficient of expansion than said first hollow member surrounding said first member, said annular member, and said wave permeable member, said second member being joined at one end thereof to said first member and being under greater tension than said first member, whereby pressure is applied to said annular member.

3. A vacuum-tight electromagnetic wave permeable window comprising a first hollow member of material having a first thermal coefficient of expansion, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, and means for maintaining said wave permeable member, said annular member and said hollow member in vacuum-tight relationship, comprising a second hollow member of material having a higher thermal coefficient of expansion than said first hollow member surrounding said first member, said annular member, and said wave permeable member, said second member being joined at one end thereof to said first member and being under greater tension than said first member, and means comprising an internal shoulder in said second member for applying pressure to the side of said wave permeable member remote from said annular member.

4. A vacuum-tight electromagnetic wave permeable window comprising a first hollow member of material

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having a first thermal coefficient of expansion, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, a second hollow member of material having a low thermal coefficient of expansion abutting said wave permeable member, and means for maintaining said wave permeable member, said annular member and said first hollow member in vacuum-tight relationship, comprising a third hollow member of material having a higher thermal coefficient of expansion than said first and second hollow members surrounding said first member, said annular member, said wave permeable member, and said second hollow member, said third member being joined at one end thereof to said first member and having an internal shoulder bearing against one end of said second member, said third member being under greater tension than said first and second members, whereby pressure is applied to said annular member.

5. A vacuum-tight electromagnetic wave permeable window as claimed in claim 4 wherein said first hollow member has a rounded edge at its end adjacent said malleable member.

6. In combination a high frequency electron discharge device comprising an evacuated envelope and having an electromagnetic wave guide path within said envelope, and means for permitting passage of electromagnetic waves between said device and the exterior of said evacuated envelope comprising an electromagnetic wave permeable window, said window comprising a first hollow member of a material having a first thermal coefficient of expansion joined to said envelope in vacuum-tight relationship, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, and means for maintaining said wave permeable member, said annular member, and said hollow member under high pressure whereby a vacuum-tight joint is formed comprising a second hollow member of material having a higher thermal coefficient of expansion than said first hollow member surrounding said first member, said annular member, and said wave permeable member, said second member being joined at one end thereof to said first member and being under greater tension than said first member, whereby pressure is applied to said annular member.

7. In combination, a high frequency electron discharge device comprising an evacuated envelope and having an electromagnetic wave guide path within said envelope, and means for permitting passage of electromagnetic waves between said device and the exterior of said evacuated envelope comprising an electromagnetic wave permeable window, said window comprising a first hollow member of a material having a first thermal coefficient of expansion joined to said envelope in vacuum-tight relationship, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, and means for maintaining said wave permeable member, said annular member, and said hollow member under high pressure whereby a vacuum-tight joint is formed comprising a second hollow member of material having a higher thermal coefficient of expansion than said first hollow member surrounding said first member, said annular member, and said wave permeable member, said second member being joined at one end thereof to said first member and having an internal shoulder bearing against said wave permeable member, said second member being under greater tension than said first member.

8. In combination, a high frequency electron discharge device comprising an evacuated envelope and having an electromagnetic wave guide path within said envelope,

and means for permitting passage of electromagnetic waves between said device and the exterior of said evacuated envelope comprising an electromagnetic wave permeable window, said window comprising a first hollow member of a material having a first thermal coefficient of expansion joined to said envelope in vacuum-tight relationship, an annular member of malleable material abutting one end of said hollow member in intimate contact therewith, a member of electromagnetic wave permeable material abutting said annular member, a second hollow member of material having a low thermal coefficient of expansion abutting said wave permeable member, and means for maintaining said wave permeable member, said annular member, and said hollow members under high pressure whereby a vacuum-tight joint is formed comprising a third hollow member of material having a higher thermal coefficient of expansion than said first and second hollow members surrounding said members, said annular member, and said wave permeable member, said third member being joined at one end thereof to said first member and having an internal shoulder abutting said second hollow member, said third member being under greater tension than said first and second members.

9. A vacuum-tight electromagnetic wave permeable window comprising a member of electromagnetic wave permeable material, a first hollow member of a first

thermal coefficient of expansion to one side of said wave permeable member, a ring of malleable material between said first hollow member and said wave permeable member, and means for forcing said first hollow member against said ring to form a vacuum-tight seal between said wave permeable member, said ring, and said first hollow member, said means including a second hollow member encompassing said first hollow member, said ring, and said wave permeable member, said second hollow member having a higher thermal coefficient of expansion than said first hollow member, and means abutting the other side of said wave permeable member and connected to said second hollow member, said second member being joined to said first member and being under greater tension than said first member.

10. A vacuum-tight electromagnetic wave permeable window in accordance with claim 9 wherein said forcing means includes a shoulder on said second member to the other side of said wave permeable member.

References Cited in the file of this patent

UNITED STATES PATENTS

2,242,249	Varian et al. _____	May 20, 1941
2,422,189	Fiske _____	June 17, 1947
2,466,136	Tuller _____	Apr. 5, 1949
2,768,327	Millman _____	Oct. 23, 1956