Dec. 10, 1963 K. H. R. C. KREUCHEN ETAL 3,114,123

WAVE GUIDE WINDOW HAVING EDGE SEALED IN BOTTOM OF CHOKE

Filed July 17, 1961 2 Sheets-Sheet 1

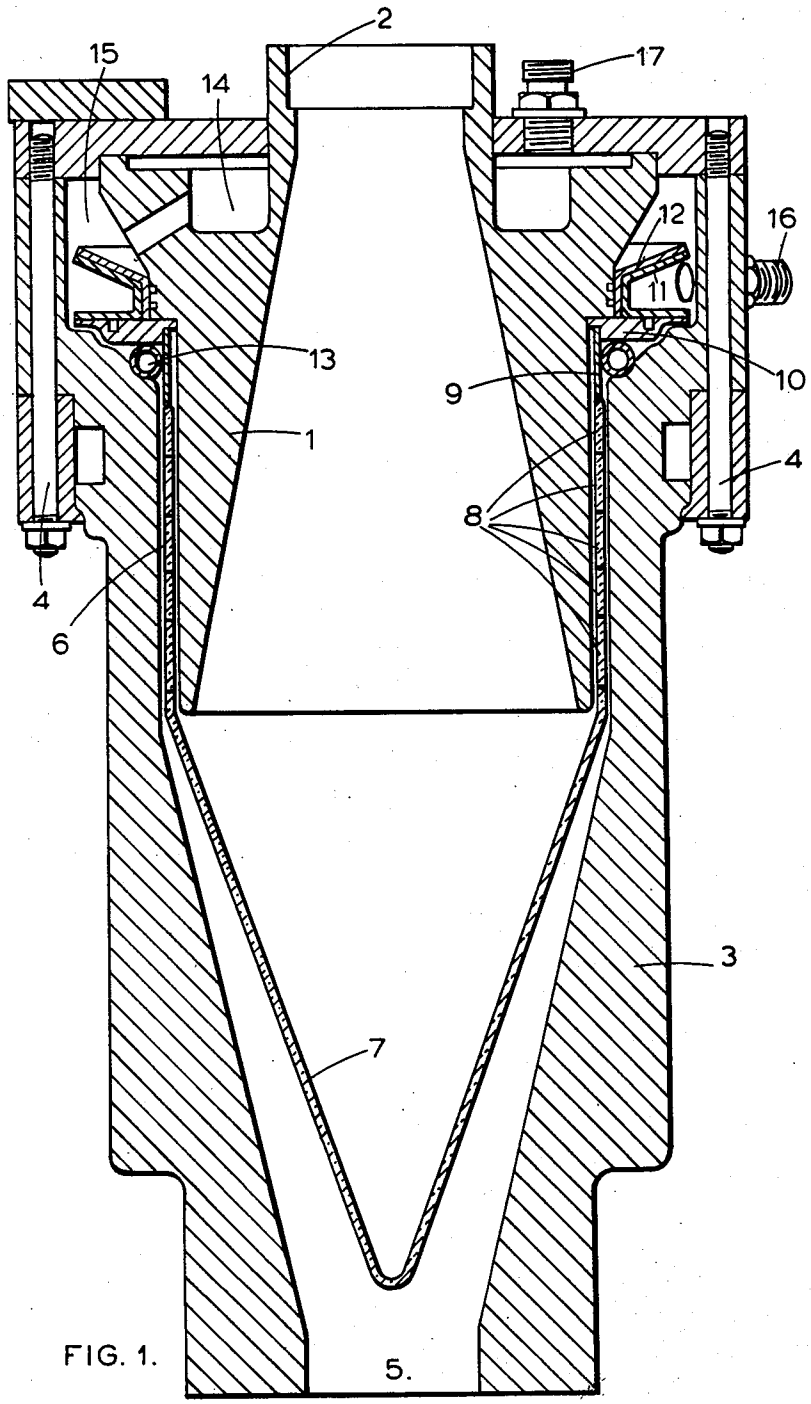


FIG. 1.

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FIG. 2.

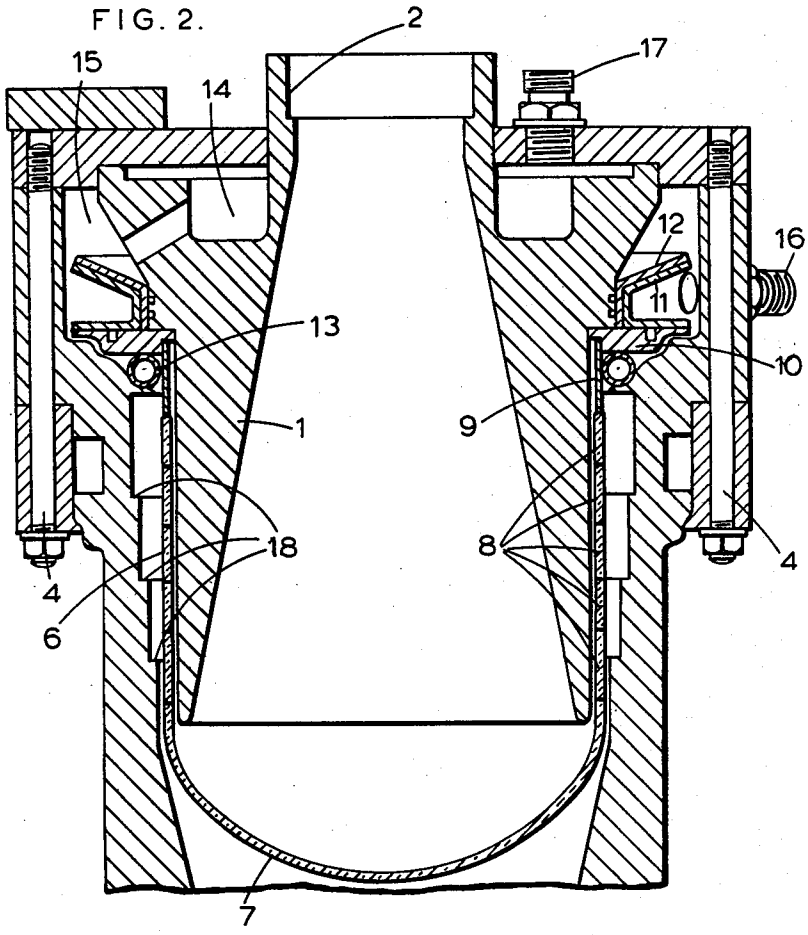
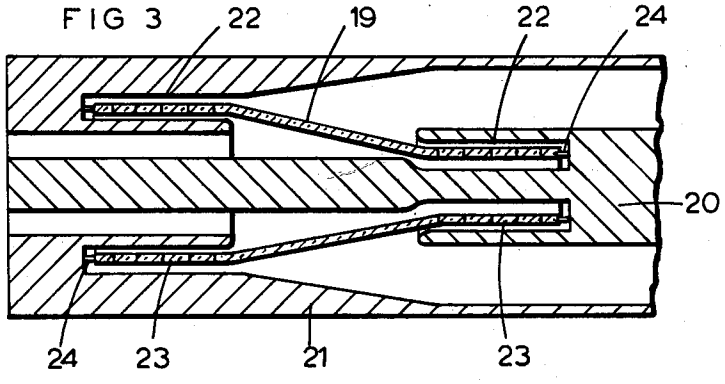


FIG 3



United States Patent Office 3,114,123 Patented Dec. 10, 1963

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WAVE GUIDE WINDOW HAVING EDGE SEALED IN BOTTOM OF CHOKE

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Filed July 17, 1961, Ser. No. 124,577
Claims priority, application Great Britain Aug. 3, 1960
10 Claims. (Cl. 333—98)

This invention relates to a device having a window for transmitting high frequency energy.

Windows formed of dielectric material such as quartz, glass or ceramic are often employed for the transmission of high frequency energy between two sections of a transmission line with the opposite surfaces of the window maintained at different pressures, the window being hermetically sealed to one of the sections. The device comprising the window and transmission line section may in turn be hermetically sealed to an electron discharge valve such as a klystron or magnetron to enable transmission of energy to be effected from said valve into said line.

For the transmission of high power over a reasonable bandwidth a matched window which is sometimes referred to as a non-resonant window has been proposed these windows usually having the shape of a dome or a cone. In the following description and claims a matched window is intended to mean a window which is distributed along a transmission line of the hollow waveguide or co-axial line types over a distance not less than one quarter wavelength at the operating frequency.

When matched windows of high dielectric strength materials such as quartz are employed difficulties arise in making an hermetic seal between the window and a metal part and it is common practice to employ an intermediary so-called graded seal comprising one or more lower dielectric strength materials between the window and the metal part of the line. The use of such graded seals is liable by dielectric losses in the materials of lower dielectric strength to cause considerable loss of energy and also the possibility of breakdown of the seal. With matched windows constructed of materials such as ceramic which can be directly sealed to metal there is the liability of arcing occurring at the position of the seal.

It is an object of the invention to provide a device having a matched window for the transmission of high frequency energy whereby one or more of the above disadvantages are eliminated or reduced.

According to the invention there is provided a device for the transmission of high frequency energy comprising a transmission line section having a matched window of dielectric material hermetically sealed thereto wherein said hermetic seal is disposed within the space formed between two adjacent conductors and which form a radio frequency choke the lengthwise dimension of which lies substantially along the direction of propagation of said high frequency energy.

Thus the choke with the dielectric loading of the dielectric material therein is dimensioned so that the radio frequency voltage at the open end of the choke is a minimum at a frequency in the frequency band to be transmitted and preferably the impedance of the choke is kept as small as possible to minimise radio frequency voltages set up in the choke.

In order that the invention may be more fully understood and readily carried into effect embodiments thereof suitable for the transmission of high power radio frequency energy will now be more fully described with reference to the accompanying drawings in which:

FIGURE 1 shows in cross section a device according to the invention having a matched window hermetically sealed to a hollow waveguide,

FIGURE 2 shows in cross section a modification of the choke and window arrangement of FIGURE 1, and

FIGURE 3 shows a cross section through a portion of a co-axial transmission line having a matched window hermetically sealed thereto in accordance with the invention.

Referring to FIGURE 1 of the drawings a transmission line in the form of a hollow waveguide section 1 formed of copper has an inner wall substantially of conical formation which is circular at its larger end and gradually tapers with a change of cross-section so that its smaller end 2 is rectangular. The outer wall of the waveguide 1 is of uniform diameter over a considerable portion of its length extending away from its circular end. The end 2 is constructed in known manner so that it can be connected to a source of high frequency energy such as the output cavity of a high power klystron amplifier valve for example, the end 2 being sealed to the valve in a vacuum tight manner. A second waveguide section 3 which is for weight considerations made of an alloy of aluminium is clamped to the waveguide 1 by a number of bolts 4, two of which are shown in the drawing. The inner wall of waveguide 3 is cylindrical over its length where it overlaps the outer wall of waveguide 1 and it then tapers to form a rectangular opening at its narrow end 5. The end 5 may be provided with any suitable means for connecting it with a further section of hollow waveguide for propagating the power. It will be noticed that because of the shape and dimensions of the waveguide sections 1 and 3 an annular gap 6 disposed in the direction of propagation of the radio frequency energy is provided at the position where these sections overlap and that this gap, as later explained, functions as a radio frequency choke.

Within the waveguide section 3 there is provided a cone shaped quartz matched window 7 having at its larger end a graded seal of cylindrical shape formed by a series of glass rings 8 and the last of said rings 8 which is of Kodial (Registered Trademark) glass is hermetically sealed to a metal ring 9 of Kovar (Registered Trademark). The ring 9 is sealed to a Kovar annulus 10 which in turn is hermetically sealed to the waveguide 1 as by brazing via annuli 11 and 12 formed of stainless steel. Between the annulus 10 and the waveguide section 3 there is provided a circular helical spring 13 which electrically short circuits these parts so that no electrical energy can pass therebeyond.

According to the invention the hermetic seal for the window 7 is provided within the annular gap 6 and taking into account the dielectric loading imposed by the graded seal 8 this gap 6 is so dimensioned that it functions as a radio frequency choke. In the present example the gap 6 is of a length such that it provides a choke of one wavelength at the mid frequency of the operating frequency band so as to ensure a smooth continuation of the R.F. circuit at the window. With this construction the radio frequency voltage across the opening of the choke at the position of the window 7 at this mid frequency is substantially zero and by suitably choosing the width of the gap 6 between waveguide sections 1 and 3 the impedance of the choke can be made small so as to minimise the radio frequency voltage set up in the choke and thereby the dielectric losses in the graded seal.

As is well known the glasses employed for making graded seals from quartz to Kovar are of lower dielectric strength than quartz and they are thus unsuitable for withstanding high frequency power. To overcome this problem it has been proposed to form an outwardly extending flange at the base of the conical quartz window so that this flange projects through the walls of the waveguide via suitable flange joints and then to make the cylindrical-graded seal at a position outside the waveguide where there is substantially no radio frequency

field. Graded seals are extremely difficult to fabricate and their length and the number of intermediate glasses required usually increases as the diameter increases.

With a construction according to the invention as illustrated, the base of the window **7** is of the same diameter as the graded seal **8** and it will thus be seen that by employing the present invention the grade seal is much smaller for the same size of window compared with the aforementioned prior arrangement in which the graded seal is provided outside of the waveguide. Furthermore, the overall dimension of the waveguide coupling is greatly reduced. By employing the invention the construction of large windows of quartz with graded seals is very considerably simplified. In a particular example the quartz window may have a diameter of 3½ inches at its base and an axial length of 6 inches, the graded seal **8** also has a diameter of 3½ inches and an axial length of 3 inches. A window of this form is suitable for the transmission over a frequency band 2700 mc./s. to 3300 mc./s. with a power of tens of megawatts peak and tens of kilowatts mean.

To provide cooling, water may be circulated through ducts **14** and **15** via suitable inlet and outlet connections **16** and **17** and also if desired conduits for the flow of cooling liquid may be provided in the wall of waveguide section **3**. Furthermore, the outer surface of the conical window **7** may be maintained at a pressure difference of about 4 atmospheres from its inner surface which faces the waveguide by directing air under pressure against the window preferably at the apical end thereof.

Matched windows are capable of operating over a relatively wide frequency band and where the device is to have a wide pass band of frequencies the choke should be constructed so that it can also operate effectively over the same band of frequencies. One way in which the pass band of the radio frequency choke can be increased is to construct it as illustrated in FIGURE 2 in which the inner wall portion of the section **3** of the waveguide is provided with a series of annular portions **18** of increasing diameter forming steps spaced at quarter wavelength intervals. The annular portions **18** can also be dimensioned so as to take into account the loading imposed thereon by the dielectric of the seal.

The component parts of the device shown in FIGURE 2 which operate in the same manner as those in FIGURE 1 have been given the same reference numerals but it will be observed that the matched window **7** has been illustrated in this example as being of dome formation. It will be understood that the present invention is concerned with the disposition of the hermetic seal of a matched window within a radio frequency choke and that the window of FIGURE 1 could be replaced by a dome shaped window or the window of FIGURE 2 could be replaced by a conical shaped window.

The invention can also be applied to other forms of transmission lines such as co-axial transmission lines as illustrated in FIGURE 3 in which a matched window **19** of quartz for example is hermetically sealed between the inner metallic conductor **20** and the outer metallic conductor **21** of the line. In such an arrangement annular gaps **22** are formed by two adjacent conductors at appropriate positions in the walls of the inner and outer conductors **20** and **21** and the quartz window **19** is provided at each of its ends with a cylindrical extension **23** disposed within the gaps **22**. The extensions **23** are formed from a number of glass rings of different compositions which are sealed together to provide a graded seal of the kind already described in respect of the arrangement of FIGURE 1 and the ends of these extensions are hermetically sealed to Kovar metal cylinders **24** brazed to the end walls of the gaps **22**.

The gaps **22** are dimensioned such that they form radio frequency chokes in respect of the frequency or the mid frequency of the band of frequencies to be transmitted by the co-axial line and these chokes can conveniently be

made to be one wavelength in depth. Each of the gaps **22** may be formed of two cylindrical parts and in this event the inner wall of the outer cylindrical part may be provided with annular steps in the manner already described in connection with FIGURE 2.

Although the invention has been described applied to a window construction of quartz other vitreous dielectric material such as low loss glass may be employed.

Furthermore, the invention can also be applied to dielectric windows such as ceramic which can be sealed directly to a metal member without the interposition of a graded seal so that the hermetic seal is disposed within a choke to minimise arcing at the position of the seal. In such a construction the choke may be of smaller dimensions say ½ wavelength at the operating frequency.

What we claim is:

1. A device for the transmission of high frequency electro-magnetic energy, comprising a transmission line section having metal portions including a first wall portion and a second wall portion surrounding the first wall portion and spaced radially from it to form an annular radio frequency choke the lengthwise dimension of which lies wholly along the direction of propagation in said section of said energy, a matched window of dielectric material comprising a hollow portion through which energy in said line section is propagated, and an extension from said hollow portion, which extension is hermetically sealed to another of said metal portions of said section, said extension having a diameter which is no larger than the maximum diameter of said hollow portion in said line section and said extension lying substantially wholly within the space forming said choke.

2. A device according to claim 1 in which the spacing of said first and second wall portions is stepped so that said choke is stepped along its length.

3. A device according to claim 1 in which said window is formed of vitreous material.

4. A device according to claim 1 in which said window is formed of ceramic material.

5. A device according to claim 1 wherein said choke is dimensioned to be an integral number of half wavelengths long at the operating frequency of the device.

6. A device according to claim 1 coupled to an electron discharge valve, said device serving to output electromagnetic energy from said valve.

7. A device for the transmission of high frequency electro-magnetic energy, comprising a transmission line section having metal portions including a first wall portion and a second wall portion surrounding the first wall portion and spaced radially from it to form an annular radio frequency choke the lengthwise dimension of which lies wholly along the direction of propagation in said section of said energy, a matched window of dielectric material comprising a hollow portion of relatively high dielectric strength through which energy in said line section is propagated and an extension from said hollow portion incorporating at least one ring portion of lower dielectric strength, said window portions being hermetically sealed in succession one to another and to another of said metal portions of said section, said extension having a diameter which is no larger than the maximum diameter of said hollow portion in said line section and said extension lying substantially wholly within the space forming said choke.

8. A device for the transmission of high frequency electromagnetic energy comprising a transmission line section having metal portions including a first cylindrical wall portion and a second cylindrical wall portion surrounding the first cylindrical wall portion and spaced radially from it to form a radio frequency choke the lengthwise dimension of which lies wholly along the direction of propagation in said section of said energy, said metal portions further including a third cylindrical portion projecting into the space forming said choke, a matched window of dielectric material comprising a hollow portion through

which energy in said line section is propagated and an extension from said hollow portion, which extension is hermetically sealed to said metal portion projecting into the space forming said choke, said extension having a diameter which is no larger than the maximum diameter of said hollow portion in said line section and said extension lying substantially wholly in said space.

9. A device according to claim 8 in which said first and second cylindrical wall portions together constitute part of one conductor of a co-axial transmission line.

10. A device for the transmission of high frequency electro-magnetic energy comprising a transmission line section having metal portions including a first cylindrical wall portion and a second cylindrical wall portion surrounding the first cylindrical wall portion and spaced radially from it to form a radio frequency choke the lengthwise dimension of which lies wholly along the direction of propagation in said section of said energy, said metal portions further including a third cylindrical portion projecting into the space forming said choke, a matched window of vitreous dielectric material comprising a central hollow portion of relatively high dielectric strength

through which energy in said line section is propagated and an extension from said hollow portion incorporating at least one ring portion of lower dielectric strength, said window portions being hermetically sealed in succession one to another and to said metal portion projecting into the space forming said choke, said extension having a diameter which is no larger than the maximum diameter of said hollow portion in said line section, and said extension lying substantially wholly within said space.

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