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MICROWAVE TUBE OUTPUT COUPLING

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FIG. 1.

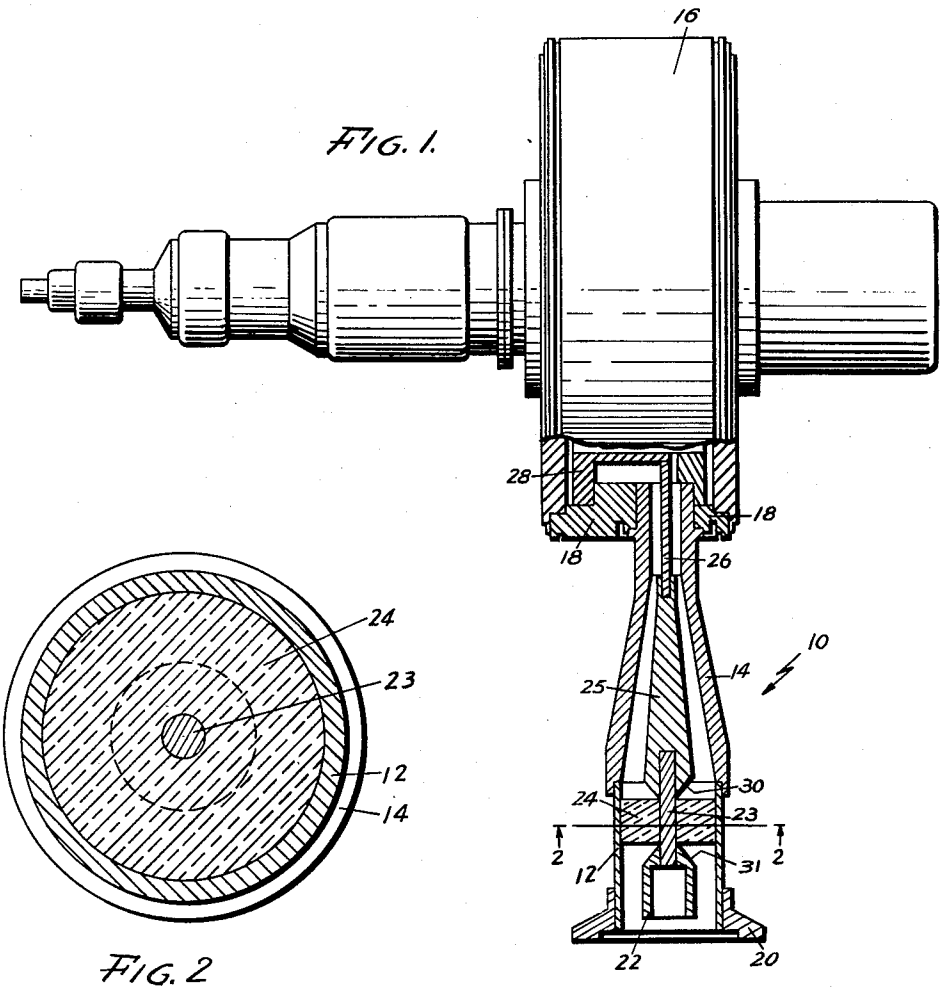


FIG. 2

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This invention relates to high frequency transmission lines, and, more particularly, to an improved energy coupling means adapted to be used in any part of a high frequency transmission line where a bead of dielectric material is employed for spacing or sealing the energy path enclosed by said transmission line.

In concentric conductor lines for the transmission of high frequency electromagnetic energy, the center conductor is usually supported clear of the outer conductor by dielectric beads, preferably of a ceramic material, which are spaced along the line at discrete intervals. As is known, the presence of a dielectric bead in an electrical coaxial line or wave guide presents an impedance discontinuity which will cause, unless special precautions are taken, partial reflection of an incident, electromagnetic wave and, consequently, standing waves are produced. Efforts to minimize or prevent reflections of this type by undercutting or overcutting the adjacent metallic conductors omit compensating for discontinuity susceptances introduced by the sharp corners or shoulders cut into the conductors. Furthermore, spacing the beads at intervals along the line solely in an attempt to cancel reflections from one bead to another results in a frequency-sensitive system, the degree of sensitivity, in part, depending on the thickness of the individual beads. In addition, tapering of the bead or supporting member, which usually is composed of dielectric material is, in many instances, impractical or difficult to produce and assemble, and the tapered end portions thereof are generally subject to cracking under shock or strain. This tendency toward cracking is more readily understood when a ceramic bead is used as a vacuum seal or window in the energy output coupling means for microwave electron tubes. This is because the high power which must be transmitted by these devices at high frequencies produces thermal heating of the vacuum seal, which must withstand a high degree of thermal shock. It is, therefore, an object of the invention to provide a vacuum-tight ceramic window, or coaxial line coupling seal, which produces a low standing wave ratio in the order of 1.2 to 1.0 from one thousand to three thousand megacycles, for example, and which is capable of transmitting substantial amounts of microwave energy while withstanding relatively high temperatures and thermal shock.

In accordance with this invention, reflection losses due to discontinuity susceptances at the surface of a typical dielectric support or bead which is mounted on the inner conductor of a line or waveguide may be overcome by providing a nontapered insulating support, the thickness of which, preferably, is adjusted to a value in which the impedance discontinuity at one transverse surface tends to cancel that of the opposite surface, and then, conically tapering the approach of the metallic center conductor to each side of the support.

The foregoing and other objects of the invention will be best understood from the following description of exemplifications thereof, reference being had to the accompanying drawing, wherein:

Fig. 1 is a sectional view of a coupling device made according to this invention associated with an electron discharge device having a metal envelope and a broken-away section showing the method of coupling; and

Fig. 2 is an enlarged cross-sectional view of Fig. 1 taken along line 2—2.

Referring now to Figs. 1 and 2, the coupling device of this invention is shown connected as a coaxial output seal and coupling for energy produced within a typical evacuated traveling wave tube. While this coupling device is particularly suited for use in connection with a traveling wave tube, it will be understood that the invention is not limited to such usage but may be connected to other sources of electromagnetic energy such as magnetrons and oscillators. The coupling device **10** in this embodiment is comprised of a coaxial line, the outer conductor **12** having one end thereof connected to a tapered union **14**, the smaller diameter end of said union being sealed to the traveling wave envelope **16** and extending within the opening provided in the outer wall **18** of the traveling wave tube. The other end of the outer conductor **12** is provided with a metallic lip or flange **20** which may be directly connected to the outer surface of a waveguide or the outer conductor of a coaxial line. An inner conductor **22** is spaced concentrically within outer conductor **12** by a dielectric support **24**, and comprises an undercut portion **23**, a gradually tapered inner conductor **25** concentric with tapered union **14**, and a probe-type member **26** of reduced cross-section extending outwardly past the end of the outer conductor and connected to an energy-conducting element **28** in traveling wave tube **16**. As is known, the energy produced during oscillation of the traveling wave tube **16** travels along the energy-conducting element **28** and may be extracted at the end portion thereof and fed to a load through coupling device **10**.

In accordance with a specific embodiment of the present invention, the vacuum-type ceramic window for the traveling wave tube **16** comprises a nontapered ceramic bead **24**, the thickness of which is determined by standard design procedures for coaxial beads and by using design data on pages 84 to 104 of the book "Microwave Transmission Design Data" by Moreno, published by McGraw-Hill Book Co., Inc., 1948. The standard thickness for the ceramic bead, as used here, is 0.25 inch. At this thickness, the impedance discontinuity at one transverse surface tends to cancel that of the opposite surface at the frequency of the energy passing therethrough, which in the present instance is in the region of 3,000 megacycles. It should be noted that the capacitance introduced into the transmission line by the ceramic bead **24** is partially compensated for by the inductance of the undercut inner conductor **23**. However, discontinuity susceptances, caused by the sharp corners normally cut into the inner conductor at the region of the dielectric junction, have been substantially eliminated by concically tapered surfaces **30** and **31**, which, in the particular embodiment shown, have been tapered at an angle of approximately 45 degrees in relation to the undercut surface of the inner conductor. While rounding, instead of tapering, the corners formed in the inner conductor will decrease the discontinuity susceptances at the dielectric junction, which acts as an impedance matching section and which produces a substantially complete reduction of dicontinuity susceptances, it was discovered that the conical taper yielded a flatter voltage-standing-wave-ratio-curve. In fact, in operation, the vacuum ceramic seal is capable of transmitting at least 1400 watts of microwave power at approximately 2500 megacycles and will cause the center conductor temperature to rise to only 90° C., a relatively low value. While it is possible to use the principles of this invention in the range of free

space wavelengths of 1 to 100 centimeters, preferably, the device is used to operate from 1,000 to 3,000 megacycles, as shown. It should be understood that a conically tapered surface may include any smooth continuous surface, as of a solid figure whose bottom is a circle and whose sides taper evenly and continuously up to a point or apex.

Also, it will be understood that, while the dielectric seal in the instant invention is preferably made of a ceramic material, any energy-permeable material may be employed. It has been found that use of ceramic material in the construction of the insulating seal permits closer control of electrical characteristics and higher bakeout and brazing temperatures of the aforementioned microwave tube than does a glass seal. For this reason, a ceramic bead, as noted, is particularly useful as the coaxial output seal for high frequency energy devices, such as amplifiers, oscillators, and other evacuated devices. In addition, tapering or gradually reducing the diameter in the metallic conductor instead of in the ceramic provides additional tensile strength in the insulator structure, while substantially eliminating reflections due to discontinuities at the dielectric junction. It should be noted that the inner conductor **22** is recessed to receive the inner conductor of a coaxial transmission line, and that the individual sections of the inner conductor are assembled by inserting the end of each member into the appropriate aperture of the adjacent member, and by connecting them together in a conventional manner with gold or eutectic silver solder.

It should be understood that various modifications of this invention will be apparent to those skilled in the art within the scope of the invention. Also, the materials, contours and dimensions specified for the particular form of the invention being described may be varied to obtain the desired results when selecting various sizes of conductors for energy propagation at selected operating frequencies. Accordingly, it is desired that this invention be not limited by the embodiments described herein except as defined in the appended claims.

What is claimed is:

1. A high frequency transmission line comprising an outer cylindrical conductor and an inner conductor passing through the inside of said cylindrical conductor parallel to the axis thereof, said inner conductor having a region of reduced diameter, means for supporting said inner conductor in fixed relationship with said outer conductor comprising an insulating support of dielectric material having parallel surfaces transverse to the axis of said outer conductor and of sufficient thickness to cancel impedance discontinuity at each transverse surface, said insulating support mounted on said inner conductor along the region of reduced diameter and having an outer diameter extending to the inner surface of said outer conductor sufficient to support said inner conductor coaxially therein, said inner conductor having progressively conically tapering surfaces extending inwardly to said region of reduced diameter at an angle of substantially 45 degrees to the axis of said inner conductor.

2. A high frequency transmission line comprising an outer cylindrical conductor and an inner conductor passing through the inside of said cylindrical conductor parallel to the axis thereof, said inner conductor having a region of reduced diameter, means for supporting said inner conductor in fixed relationship with said outer conductor comprising a supporting member composed of dielectric material having parallel surfaces transverse to the axis of said outer conductor and mounted on said inner conductor along the region of reduced diameter, said supporting member having an outer diameter in contact with the inner surface of said outer conductor sufficient to support said inner conductor coaxial therein and having sufficient thickness to cancel impedance discontinuity at the opposite transverse surfaces over a broad band at the frequency of the energy passing therethrough, and said inner conductor having smooth continuous surfaces of gradually reduced diameter extending inwardly to said supporting member.

3. A coaxial microwave transmission line comprising in combination, an outer cylindrical conductor, an inner cylindrical conductor extending through said outer conductor, a ceramic insulating bead having parallel transverse surfaces of sufficient thickness to cancel impedance discontinuity at each surface supporting said inner conductor within said outer conductor, said inner conductor having a cylindrical region of reduced diameter in the region of said bead and conically tapered portions progressively extending inwardly to said region of reduced diameter.

4. A high frequency transmission line comprising in combination, an outer cylindrical conductor and an inner cylindrical conductor having a region of reduced diameter, dielectric insulating means surrounding said inner conductor at the reduced portion thereof and having parallel surfaces transverse to the axis of said conductor, said insulating means having sufficient thickness to enable the impedance matching discontinuity formed at one parallel surface substantially to cancel that of the opposite surface, said inner conductor having conically tapered portions extending inwardly to said regions of reduced diameter at an angle of substantially 45 degrees to the axis of said inner conductor.

5. A transmission line energy coupling seal for an evacuated electron discharge device including a coaxial line having an outer cylindrical conductor communicating with the interior of said evacuated electron discharge device, an inner conductor coaxial with said outer conductor extending outwardly past one end of said outer conductor and connected to an energy conducting element of said discharge device, said inner conductor having a region of reduced diameter and conically tapered portions extending inwardly toward said region of reduced diameter, and a dielectric vacuum seal having parallel surfaces surrounding said inner conductor at the reduced portion thereof and having a diameter sufficient to contact said outer conductor and a thickness sufficient to cancel impedance discontinuity at each of said parallel surfaces, thereby to provide a vacuum-type seal for said electron discharge device.

6. The apparatus as in claim 5 wherein the vacuum-type seal of ceramic material has sufficient thickness to cancel the impedance discontinuities introduced at opposite surfaces of said seal.

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