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:
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 surfaces 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 back out 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, dimensions, and proportions 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 supporting member having an outer diameter in the region of reduced diameter, said 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 having an outer diameter extending to the inner surface of said outer conductor such 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 an insulating support of dielectric material having parallel surfaces perpendicular 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.

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 inner 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 being of sufficient thickness 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 3 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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