June 9, 1964 E. L. STREET 3,136,919

GASEOUS DISCHARGE CONTROL DEVICE

Filed April 3, 1961

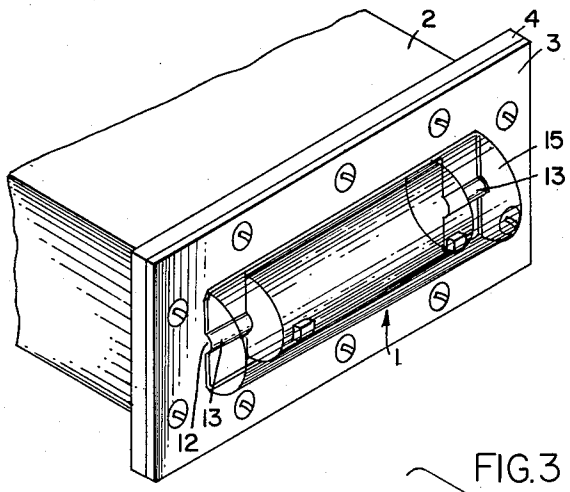


FIG. 1

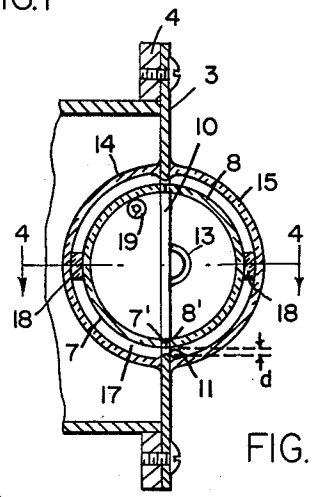
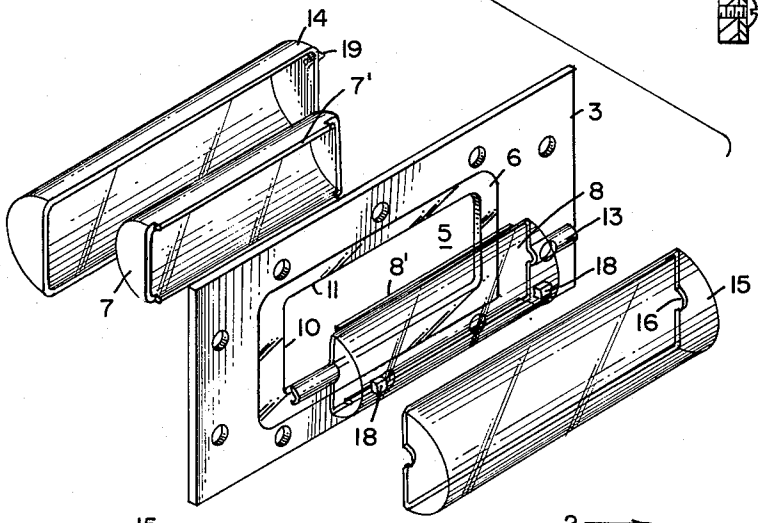


FIG. 2

FIG. 3



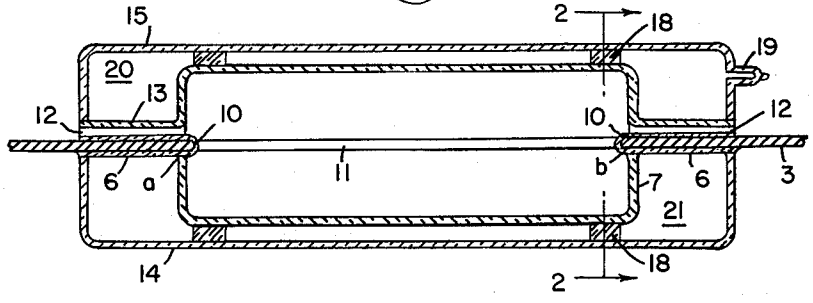


FIG. 4

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GASEOUS DISCHARGE CONTROL DEVICE

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The present invention relates to microwave transmission control devices and, more specifically, to an improved gaseous discharge tube of the folded cylinder type.

Control of transmission of microwave energy has resulted in present day systems employing a single antenna. Intense gaseous discharges within an evacuated envelope upon exposure to high power energy will effectively prevent passage to sensitive receiver elements.

A new concept prevalent in the control art, particularly for use in high power systems over 1,000,000 watts, is the electrodeless folded cylinder device shown and described in U.S. Patents 2,922,124 and 2,922,131 issued January 19, 1960, to Ray S. Braden. This device comprises a tubular member formed by two concentric cylinders of a dielectric material such as glass or quartz, hermetically sealed together at their ends and containing a noble gaseous atmosphere of high purity. The spacing between the cylinders is critical and is generally equal to the mean free path of the gas molecule. As a result of the closely spaced cylindrical configuration, a thin sheath of ionized gas is present during the discharge and due to the short diffusion path plus high plasma density the mechanism of deionization or recovery time is considerably enhanced. In the conventional configuration an area between the mounting structure and the annular discharge gap has a condenser-like effect which results in higher power level thresholds of initiation of the discharge thereby increasing the leakage power. Further, life of the conventional tube is an important factor since the relatively narrow annular gap between the concentric cylinders provides for a limited volume of a gaseous atmosphere.

Accordingly, a primary object of the present invention is the provision of a new and improved gaseous discharge control tube of folded cylinder configuration.

The principal feature of the invention resides in the novel assembling of semi-cylindrical sections on opposing sides of a mounting plate to facilitate exposure of a limited area of metal coplanar to the cylinder axis within the discharge area. The exposed metal aids considerably in the ionization of the gaseous atmosphere thereby lowering the voltage gradient at which a discharge will be initiated. Ancillary to the advantages in performance will be the provision of additional gas storage facilities by reduction in the overall length of the inner cylinder member with regard to the outer member of the disclosed structure.

Further objects, features and advantages will become apparent after consideration of the following detailed description and appended drawing, in which:

FIG. 1 is a perspective view of the illustrative embodiment appended to a section of rectangular waveguide;

FIG. 2 is a detailed vertical cross sectional view of the embodiment taken along the line 2—2 in FIG. 4;

FIG. 3 is an exploded view illustrating the method of assembly; and

FIG. 4 is a cross sectional view taken along the line 4—4 in FIG. 2.

Referring now to FIG. 1 the discharge tube 1 of the invention is mounted at one end of a rectangular waveguide section 2 by securing the metallic iris plate member 3 to mounting flange 4. A typical example of the use of the embodiment of the invention may be as the first element in a high power duplexer to be exposed to the high

level microwave energy transmitted in the circuit. It may be similarly useful as a resonant window assembly in a complete transmit-receive (TR) tube preceding the receiver apparatus or as an antitransmit-receive (ATR) stub mounted in the circuit leading from the transmitter to the antenna.

In accordance with the practice of the invention a plurality of semi-cylindrical elongated members with end enclosures to each define a trough-like structure are provided. A metallic plate 3 defining an iris opening 5 provides the supporting member and forms an integral part of the overall folded cylinder discharge tube. The opening dimensions may be selected to be resonant at a predetermined frequency or may conform to the internal dimensions of associated waveguide for broadband operation.

The area 6 adjacent to the opening 5 is coated with a thin layer of glass as by glazing of a dielectric frit material in the manner well-known in the art. The area along the longer dimensions of the opening are relatively narrow and both sides of the plate member are similarly coated with the coating extending over the opening edges designated 10 and 11. Inner semi-cylindrical member 7 and 8 are sealed to the plate member 3 along the surface parallel to edges 10 with the joint designated "*a*" and "*b*" in FIG. 4. A suitable notch in each member is provided in order that the edges 7′ and 8′ may abut and be joined to form a continuous cylinder as shown in FIG. 2. It is necessary that the outer wall of the cylinder clear edges 11 of the opening for the successful operation of the tube. The clearance space is indicated by letter "*d*." Inner member 8 may be provided with semi-cylindrical tubulations 13 joined at the ends thereof to provide passages 12 for a coolant such as air or a liquid to facilitate removal of heat generated by the intense gas discharge within the tube.

Outer semi-cylindrical members 14 and 15 may then be joined to the respective sides of plate member 3 with member 15 suitably notched as at 16 to accommodate tubulations 13. In this instance the members are joined to the surfaces adjoining edges 10 as well as those adjoining edges 11. In the case of the joint adjacent to edges 11 it is desirable to permit said edges to protrude into the annular gap 17 between the inner and outer cylinders. Hence, a portion of the longer glazed metallic edge will be exposed coplanar to the longitudinal axis of the outer cylinder and extend within the area of the discharge. By exposing the extended edges 11 of the plate member 3 within the annular discharge gap, it is possible to lower the voltage gradient required to initiate the gaseous discharge thereby reducing the excessive leakage power occurring when high power microwave energy is transmitted through tube 1.

The spacing of the annular gap 17, in accordance with the teaching of the aforementioned patents, may be uniformly controlled by means of a plurality of quartz tape spacers 18 secured to the outer walls of the inner cylinder members. Exhaust tubulation 19 provides for evacuation of the overall folded cylinder tube and filling with an ionizable atmosphere such as spectroscopically pure argon at a pressure of from 4 to 10 millimeters of mercury.

Adjustment of the longitudinal dimension of outer members 14 and 15 with respect of the inner members will provide for additional reservoir chambers 20 and 21 for increased operational life of the discharge tube.

The embodiment described will thus provide for a relatively narrow sheath of ionized gas upon incidence of the high power energy upon the outer surface of member 15 as disposed in FIGS. 1 and 2. In addition the protruding metallic surface within the annular gap has improved operating characteristics particularly at exceedingly high

powers where fast ionization is desirable to prevent damage to sensitive receiver components.

While an illustrative embodiment has been shown herein, many different embodiments may be made without departing from the scope of the invention. It is intended, therefore, that all matter appearing in the foregoing description and accompanying drawing be interpreted in a broad sense consonant with the definition of the invention in the appended claims.

What is claimed is:

1. A gaseous discharge tube for control of transmission of microwave frequency energy comprising a metallic plate member defining a central rectangular opening with a coating of dielectric material bonded to a portion of the surfaces adjacent to said opening, an inner cylindrical member of a dielectric material disposed within said opening with its axis lying within the plane of the plate member, a pair of semi-cylindrical members of a dielectric material sealed to said coating along all sides of said opening and spaced from said inner cylinder a critically short distance to define an annular gap, said semi-cylindrical members being sealed along the longer oppositely disposed sides of said opening in a manner to provide for the protrusion of an adjacent metallic edge at two relatively widely separated locations within the annular gap, said inner cylinder and semi-cylindrical members defining a vacuum tight envelope and a filling of an ionizable atmosphere contained therein.

2. A gaseous discharge tube for control of transmission of microwave frequency energy comprising a metallic plate member defining a central rectangular opening with a coating of a dielectric material bonded to a portion of the surfaces adjacent to said opening, a first pair of semi-cylindrical dielectric members sealed to said coating along the narrow dimension of said opening and joined to each other along abutting edges lying with the plane of the plate member to define an inner cylinder, a second pair of semi-cylindrical dielectric members sealed to said coating all sides of said opening and spaced from said inner cylinder a critically short distance to define an annular gap, said second pair of dielectric members being sealed along the longer sides of said opening a short distance away from the edge to provide for the disposition of a metallic surface within the annular gap, said first and second pairs of dielectric members defining a vacuum tight envelope and a filling of a spectroscopically pure inert gaseous atmosphere within said envelope under reduced pressure.

3. A gaseous discharge tube for control of the transmission of high power microwave frequency energy comprising an outer and inner pair of semi-cylindrical dielectric members spaced apart a very short distance defining an annular discharge gap therebetween and forming a hermetically sealed concentric chamber, an apertured metallic plate having a pair of oppositely disposed metallic members extending between said outer semi-cylindrical members into said annular discharge gap each of said pair of oppositely disposed metallic members being separated apart a distance larger than said very short distance between said outer and inner pair of dielectric members, and a gaseous atmosphere within said chamber under reduced pressure.

4. An apparatus according to claim 3 wherein said metallic members are coated with a dielectric material along the sides thereof and said outer semi-cylindrical members are joined to said plate member along all sides of said aperture.

5. A gaseous discharge tube for control of the transmission of high power electromagnetic energy, said assembly comprising a metallic plate member defining a central aperture and hollow dielectric material enclosing substantially all of said aperture, said dielectric material forming a hermetically sealed chamber containing an atmosphere of gaseous molecules under reduced pressure therewithin, said chamber comprising at least two walls disposed apart a narrow distance equal approximately to the mean free path of said gaseous molecules and forming a discharge gap therebetween and said plate member having at least one inner aperture edge extending into said hermetically sealed chamber for reducing the microwave leakage power occurring when microwave energy is transmitted therethrough.

6. An apparatus according to claim 5 wherein said at least one inner aperture edge is coated with an insulating material and said chamber is double-walled having an outer wall structure joined to said plate member along all sides of said aperture.

7. A gaseous discharge tube for control of the transmission of high power microwave frequency energy comprising an outer and inner pair of semicyclindrical dielectric members spaced apart a very short gap distance defining an annular discharge gap therebetween and forming a hermetically sealed concentric chamber, said outer pair of semicylindrical dielectric members each having a first and second lateral edge, said first lateral edges being disposed adjacent each other, and said second lateral edges being disposed adjacent each other; an apertured metallic plate having a first metallic member passing between said first lateral edges into a first interaction region of said annular discharge gap and a second metallic member passing between said second lateral edges into a second interaction region of said annular discharge gap, said first and second interaction regions being disposed apart one from the other a distance larger than said very short gap distance and adjacent oppositely disposed sides of said annular discharge gap, whereby said gaseous discharge initiates at substantially lower threshold energy levels and power leakage losses during transmission of said high power microwave frequency energy are substantially reduced.

8. An apparatus according to claim 7 wherein said outer semicylindrical members are joined to said plate member along all sides of said aperture.

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