Sept. 28, 1965 T. E. MANWARREN ET AL **3,209,285**

FOLDED CYLINDER GASEOUS DISCHARGE DEVICE

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Fig. 1.

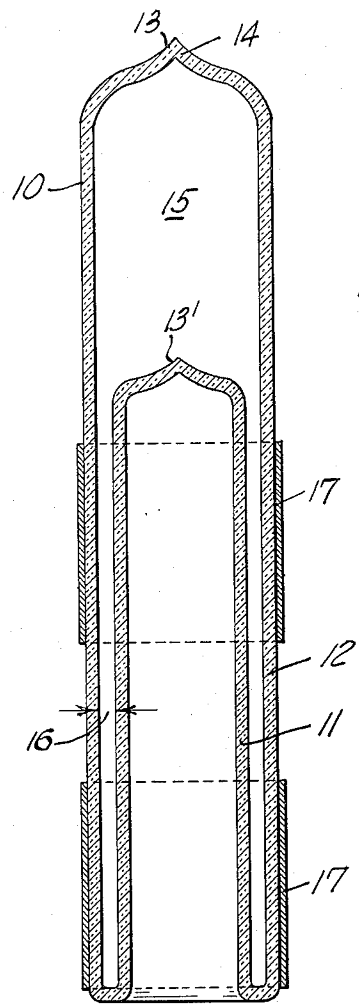

Fig. 2.

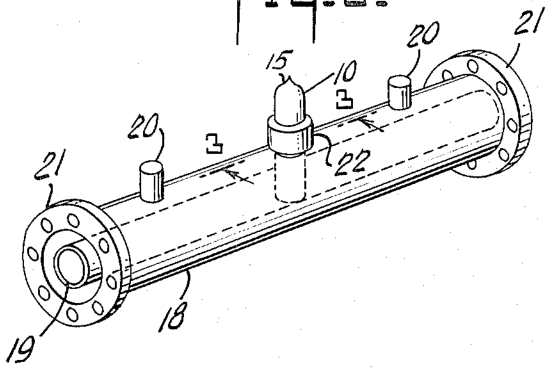

Fig. 3.

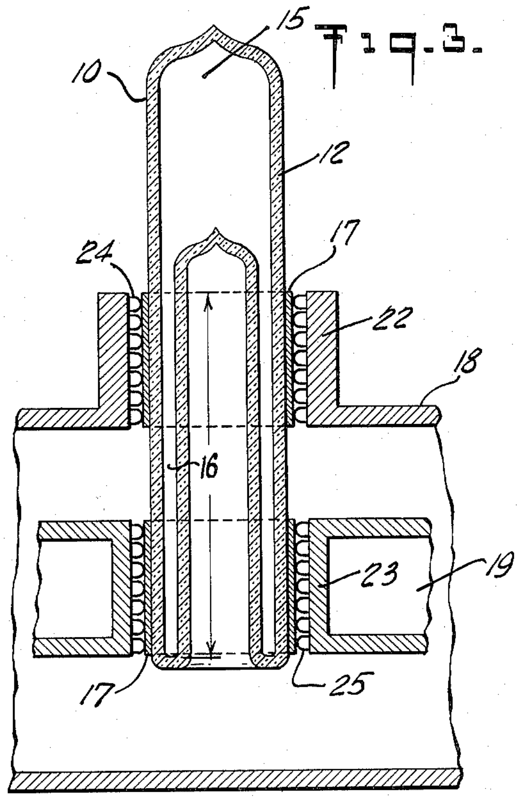

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Fig. 4.

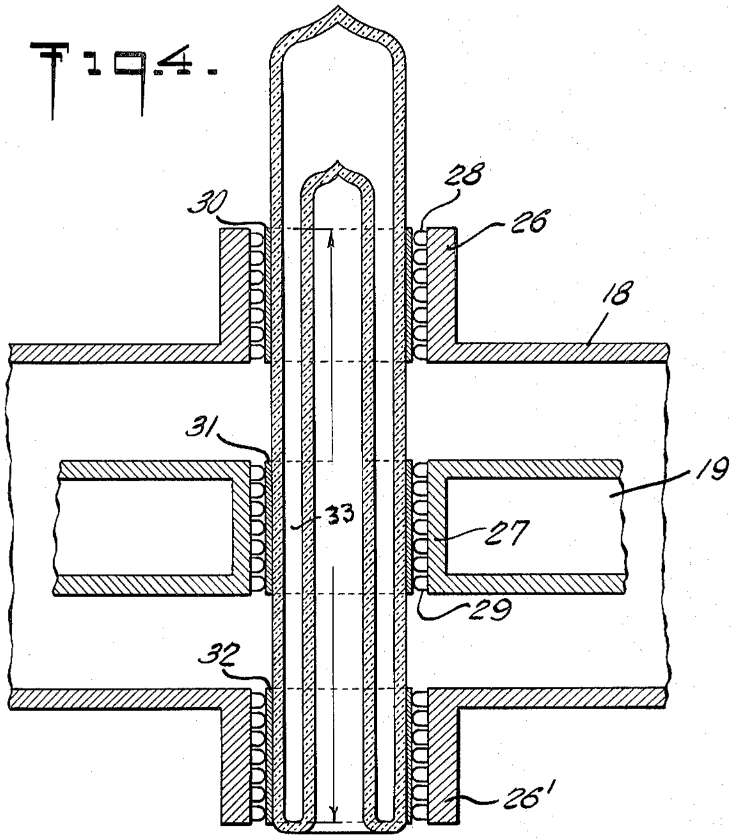

Fig. 5.

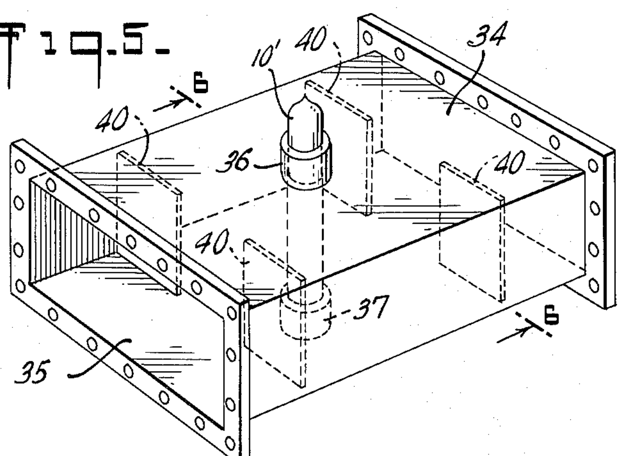

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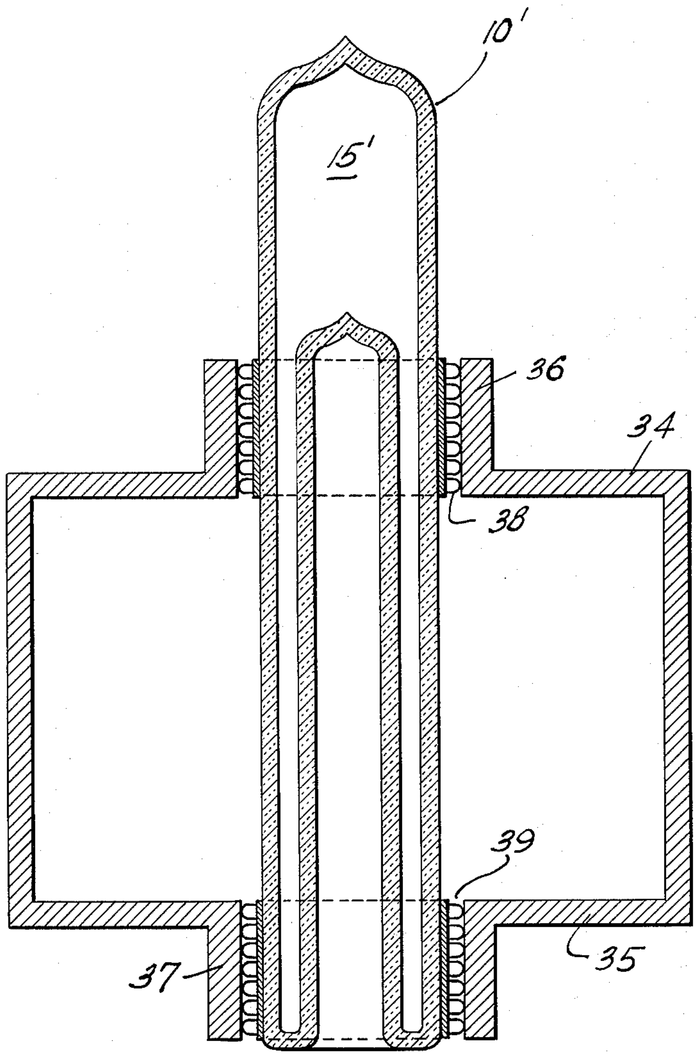
Fig. 6.



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FOLDED CYLINDER GASEOUS DISCHARGE DEVICE

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4 Claims. (Cl. 333—13)

The instant invention relates to the control of the transmission of high frequency energy and more particularly, to a novel gaseous discharge device for accomplishing the same.

By the term control in the above instance is meant the switching of energy such as in radar systems where a single antenna is employed for both transmitter and receiver and it is necessary to prevent damage to the receiver by the high energy emanating from the transmitter. Presently available devices for this purpose are limited as to their power handling capabilities, useful life, and mounting arrangements. Many modifications and suggestions have been offered in the past to extend the operating life of these gaseous discharge devices. However, all of these have introduced other drawbacks and so, by solving one problem, have created others. With a relatively short life it is clear that an equipment utilizing such discharge elements must of necessity be deactivated during the time that the replacement is made. Although these changes are made at regularly scheduled intervals in order to prevent breakdown at critical times, they are costly in both material and man-hours.

Accordingly, it is an object of this invention to provide an improved novel, gaseous discharge device whose useful operating life is considerably greater than that presently available.

Another object is to provide an inexpensive, simple, reliable, long-lived gaseous discharge device of high power capacity and which may be used in coaxial and waveguide systems among others.

Other objects and advantages will appear from the following description of an example of the invention, and the novel features will be particularly pointed out in the appended claims.

FIG. 1 is a cross-sectional view of an embodiment made in accordance with this invention,

FIG. 2 is a perspective view of the embodiment as employed in a coaxial system,

FIG. 3 is a cross-sectional view taken approximately along lines 3—3 of FIG. 2,

FIG. 4 is a modification of the embodiment of FIG. 1,

FIG. 5 is a perspective view of another embodiment as employed with a waveguide system, and

FIG. 6 is a view approximately along 6—6 of FIG. 5.

In the illustrated embodiment of the invention in FIG. 1, the tube or device **10** comprises in effect, an inner cylinder **11** and a somewhat longer outer cylinder **12** coaxial therewith and spaced therefrom. Both cylinders are closed upon themselves at one end **13** and **13'** and are joined at their opposite free ends so as to form a sealed enclosed folded cylinder. Both cylinders **11** and **12** are of any dielectric material sufficient in voltage rating to withstand the operating potentials applied thereto. Ceramics and glass are suitable for this purpose and after fabrication the exhaust stem **14** provides a means for evacuating the chamber between the cylinders and for filling this chamber with an ionizable gas generally at a reduced pressure. The chamber may be considered as consisting of two communicating volumes, one being the area of gas ionization disposed between the inner surface of the outer cylinder and the outer surface of the inner

cylinder and extending for the length of the inner cylinder. The other defined as enclosed by the upper walls of the outer cylinder and referred to as the reservoir **15**. The gap **16** or spacing between the cylinders is selectively determined in order to achieve the best possible electrical characteristics for the device.

The outer peripheral surface of cylinder **12** is provided with a plurality of spaced apart concentric ring-like metallic bands **17**. These bands are disposed along the length of the outer cylinder within the area of ionization and are in good electrical contact with the peripheral cylinder surface. In the embodiment of FIG. 1 only two such bands are shown. Bands **17** need only be of a good electrically conducting material, e.g. silver, which can make electrical contact with the cylinder wall and serve to provide an electrical terminal or contact area. These bands may also be in the form of metallic coatings, e.g. silver paint. In general, these terminals are of a sufficient size as to pass large, high frequency currents without either introducing heating losses or appreciable impedance.

FIG. 2 illustrates the physical arrangement and mounting of the tube device of FIG. 1 in a coaxial type conductor system which comprises an outer conductor **18** and a coaxial inner conductor **19** which may be in the form of a hollow cylinder and a spaced pair of inductive coupling susceptances **20**. The outer conductor is provided with end flanges **21** having apertures through which threaded bolts are passed for coupling together several such sections. Between susceptances **20** and integral with the outer conductor is a circular flange or mounting ring **22** which forms the outer wall of an opening through the conductor **18**. Below and aligned therewith is another metallic ring (not shown) between the separated ends of the inner conductor. When the device **10** is inserted into these mountings the bands **17** contact the mountings and the reservoir **15** extends outwardly of the conductor **18** while the opposite end terminates at approximately the inner conductor **19**.

FIG. 3 illustrates in cross-section the internal physical arrangement of the device in the coax of FIG. 2. The outer mounting flange **22** and the center mounting ring **23** are provided with inwardly oriented spring contact fingers **24** and **25**, respectively. These fingers are of a metallic resilient material and are carried by the mountings and so positioned as to firmly contact the bands **17** and thereby establish electrical continuity between the outer peripheral surface of the device and the inner and outer coaxial conductors. These members entoto form the tube socket. In operation, when a voltage of sufficient amplitude to ionize the gas in the gap **16** exists between the inner and outer conductors a discharge path is established between the conductors. This path includes the outer conductor **18**, flange **22**, fingers **24**, the band **17**, wall **12** of the outer conductor, the ionized gas, the fingers **25**, mount **23** and the inner conductor. In effect, this conduction path forms a short circuit between the coaxial conductors at the device **10** and thereby terminates the passage of high energy further along the coax. Considering for the moment only the tube **10**, the bands **17** on the outer cylinder, the cylinder walls and the ionized discharge along the gap **16** form a transmission whose electrical length is adjusted or selected by its physical dimensions to be such that its impedance is a minimum at the point where the current is coupled through the cylinder wall. This, in addition to the fact that there exists a large area of discharge permits this device to handle large electrical energy.

In order to provide even greater power handling capabilities the device as illustrated in FIG. 4 has been modified so as to include an additional band. In this embodiment the discharge device when mounted in the coax extends through the center conductor and completely across the coax. Outer flanges **26** and **26'**, as well as inner mount **27** carry fingers which contact silvered bands **30**, **31** and **32**. The operation of the device is identical to that of the previously described embodiment except that two discharge paths exist in the gap **33**, in that the current splits and takes two paths from the outer conductor **18** to the inner conductor **19**. One path through the flanges **26** and along upper portion of the gap **33** and the other flange **26'** and the lower portion of gap **33**. Again a low impedance is obtained by adjustment of these transmission lines and with such an arrangement almost four times the power can be carried by this device as compared to that of FIGS. 2 and 3.

FIGS. 5 and 6 illustrate an embodiment of the invention as used in a waveguide system wherein the tube **10'** passes through the guide walls **34** and **35** and is mounted as previously described in flanges **36** and **37** by the contact fingers **38** and **39**. The guide is provided with internal vanes **40** which serve as inductive coupling susceptances. The tube is located centrally thereof. In operation the tube is disposed at high voltage point in the cavity or guide and when the discharge is effected it detunes the cavity by acting as an inductive susceptance across the waveguide and a large portion of the incident energy is reflected thereby stopping the passage of this high energy through the guide. As is the case for the previous embodiments, under low level energy or power insufficient to cause ionization, the energy passes through with only minor losses. Essentially, without discharge the tube has little effect and the guide remains resonant and the only losses are those resistive losses in the guide walls and attendant dielectric losses.

Clearly the device is a TR (transmit-receive) tube and has been applied to coaxial line duplexers and waveguides. In a duplexer, the function of a TR tube is to cause a short circuit on the line at a particular point and in our case this is done by a gas discharge or ionization. Since once the tube breaks down the voltage across it remains essentially constant, the power handling ability of the tube is a function of the amount of current passing therethrough. In most conventional tubes using metal elements, the large amount of current in the tube at high power causes heating and arcing due to impurities in the gas which, in turn, causes deterioration of the metal elements. This is because most of the power is dissipated in a small area between the metal elements. With the large discharge area and lack of metallic elements exposed thereto, the device of this invention is easy to handle large amounts of power.

The reservoir **15** atop the tube serves to lengthen the overall operating life of the device in that without the reservoir the normal life expectancy of the tube is of the order of a number of hours due to the small amount of gas present between the cylinders which, itself, is rapidly absorbed by the cylinder walls. With the reservoir, tube life is extended to thousands of hours with the attendant advantage that no glow discharge takes place within the reservoir.

In addition to its increased power capabilities and extended operating life, the device of this invention possesses the following desirable characteristics:

(a) No metallic elements are in contact with the glow discharge and therefore no sputtering of metal takes place and high RF current densities can be accommodated,

(b) Low recovery time can be obtained by selectively adjusting the gap spacing between the cylinders without resort to gas clean-up agents which increase arc losses,

(c) Spectroscopically pure gases can be used with corresponding low arc losses without the expense of long recovery time.

Although some of these advantages are characteristic of particular folded cylinder type tubes, these tubes, due to their inherent limitations, are only used in resonant

waveguide iris whereas by this invention all these advantages have been incorporated into a single device not so limited and useful in both coaxial and waveguide systems where the discharge is employed to detune a resonant cavity. This operation in coax and waveguides prior to this invention, required a normal cell type tube and could not employ a folded cylinder.

It will be understood that various changes in the details, materials and arrangements of parts and steps which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

We claim:

1. In combination with a hollow rectangular waveguide structure for propagation of high frequency electromagnetic energy, a gaseous discharge device, said device comprising an outer dielectric cylinder closed at one end, an inner dielectric cylinder closed at one end, said inner cylinder being shorter than and coaxial with said outer cylinder, the free ends of said cylinders aligned and sealed to one another defining a closed chamber therebetween, said chamber filled with an ionizable gas, a pair of spaced apart electrically conductive bands in contact with and encircling the outer wall of said outer cylinder, means mounting and supporting said device in and crosswise of the direction of energy propagation in said guide and providing electrical contact between opposite walls of said waveguide and said bands.

2. The combination according to claim **1**, wherein said mounting means includes a pair of opposed aligned, ring-like flanges extending outwardly of said opposite guide walls, and resilient electrically contacting finger carried by said flanges for providing electrical continuity between said bands and said opposite guide walls.

3. In combination with coaxial conduit having an outer hollow cylindrical conductor and an inner conductor coaxial therewith, a gaseous discharge device, said device comprising an outer dielectric cylinder closed at one end, an inner dielectric cylinder closed at one end, said inner cylinder being shorter than and coaxial with said outer cylinder, the free ends of said cylinders aligned and sealed to one another defining a closed chamber therebetween, said chamber filled with an ionizable gas, a pair of spaced apart electrically conductive bands in contact with and encircling the outer wall of said outer cylinder, means mounting and supporting said device partially in and radially of said coaxial conduit with said bands in electrical contact with said outer conductor and said inner conductor.

4. The combination according to claim **3**, wherein said means includes a radially extending circular flange of an electrically conducting material carried by said outer conductor, said flange having inwardly extending contact means for establishing electrical contact between one of said bands and said outer conductor, said conductor wall having an aperture aligned with said flange.

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