July 7, 1964 H. A. SLEEPER 3,140,416

GASEOUS DISCHARGE DEVICE

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FIG.1

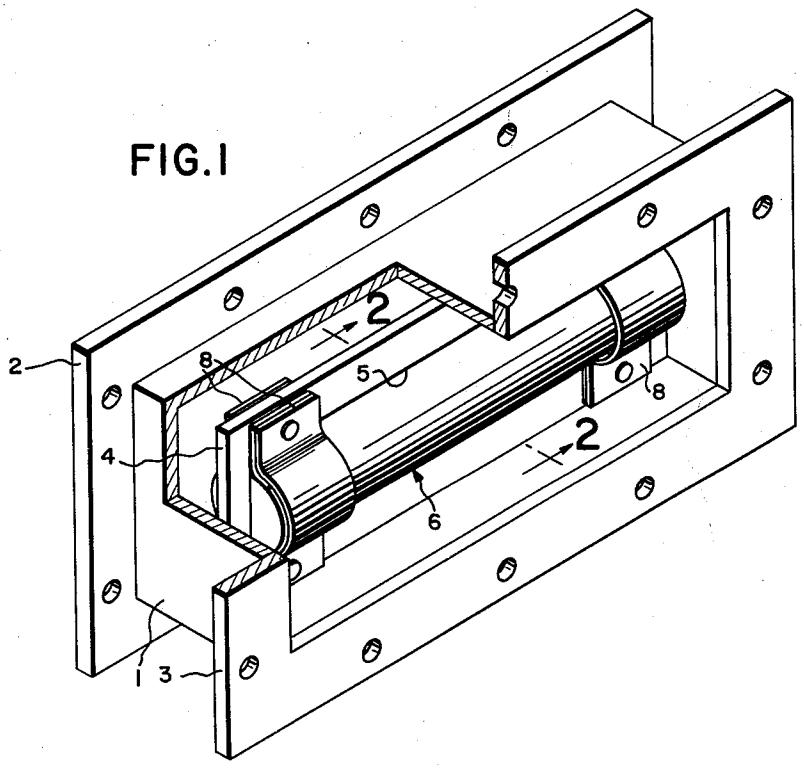
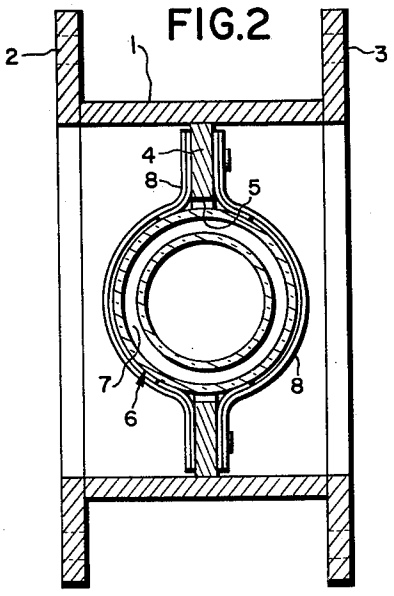


FIG.2



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GASEOUS DISCHARGE DEVICE

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The present invention relates in general to gaseous discharge devices and more particularly to such gaseous discharge devices having improved deionization characteristics useful, for example, in microwave switching tubes such as TR, pre-TR and ATR tubes for radar.

The present day radar systems commonly employ gaseous discharge devices to produce the rapid switching times necessary for single antenna operation. The transmit-receive or TR tube protects the sensitive receiving apparatus by means of an intense ionized discharge extending across the transmission path. Such tubes generally employ an electron capture agent or attachment gas such as water vapor, in the gaseous atmosphere to enhance the deionization or recovery time between the transmission cycles.

The need for a predictable short recovery time arises from the fact that low power return signals from targets must pass through the switching element without serious attenuation, at a time represented by the system minimum design range. In systems capable of operating down to short ranges the absolute recovery time must be in the order of a few microseconds.

The majority of the TR tubes made in past years, as well as the majority of tubes still used in low power equipments, use a mixture of a pure noble gas, such as argon, in combination with a controlled amount of an attachment gas, such as water vapor, to produce a rapid recovery or deionization time. Historically, the argon-water vapor system has been the most widely used.

Water vapor as an attachment gas has serious limitations for many high power TR tube applications. More specifically, its use is generally prohibited in high power applications. For example, the probable upper limit, in X-band for example, for the water vapor attachment mechanism is about 500 kilowatts peak power and 500 watts average power. The limit occurs because the deionization occurs during the transmitter pulse, as well as after the pulse, it follows that an increased amount of energy must be supplied to sustain the ionization during transmission. This additional energy, called arc loss, is translated almost entirely into thermal energy. Even though the arc loss is only a small percentage of the total transmitted power, in very high power systems, this added heat can cause rapid, catastrophic failure of the switching element.

Another difficulty encountered with the use of water vapor as an attachment gas is that for extremely low temperature operation such as, for example, at −55° C. the partial pressure of the water vapor drops to only a fraction of a millimeter due to condensation thereby losing any benefit obtained from the attachment gas in reducing the deionization time, such that, until such time as the tube is sufficiently heated, the radar will lose its short range capability.

In the present invention boron trifluoride is utilized as an attachment gas in combination with a noble gas to form the ionizable atmosphere. The boron trifluoride attachment gas readily permits relatively short recovery times useful for short range radar applications while retaining its proper operating characteristics down to temperatures well below −55° C. and also serving to permit extremely high power operation. For example, recovery times of 25 microseconds to 3 db points have been obtained at 10 megawatts peak power and 20 kilowatts

average power at L-band frequencies of 1300 megacycles. It has been found that typically the deionization time is approximately halved by the use of boron trifluoride attachment gas as compared to a pure argon or noble gas ionizable atmosphere in the same envelope and at the same power levels.

The principal object of the present invention is to provide improved deionization characteristics for gaseous discharge devices.

One feature of the present invention is the provision of a quantity of boron trifluoride gas added to the ionizable atmosphere of a gaseous discharge device for decreasing the deionization time and permitting extremely low temperature operation.

Another feature of the present invention is the provision of a microwave gaseous discharge switching tube containing a mixture of noble gas and boron trifluoride gas whereby the recovery time of the switch tube is minimized and low temperature operation and high power operation characteristics enhanced.

Another feature of the present invention is the same as the preceding feature wherein the noble gas is argon and a preponderance of the mixture by partial pressure is boron trifluoride, whereby stable recovery time characteristics are obtained over prolonged operating lifetimes.

Other features and advantages of the present invention will become apparent upon a perusal of the specification taken in connection with the accompanying drawings wherein:

FIG. 1 is a perspective view of an illustrative pre-transmit-receive tube embodiment, and

FIG. 2 is an enlarged cross-sectional view of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows.

Referring to the drawings, FIGS. 1 and 2 illustrate a pre-transmit-receive microwave switching gaseous discharge device of the broadband type suitable for operation over a relatively wide range of microwave frequencies. This class of pre-TR tube characteristically has a length of rectangular waveguide **1** with mounting flanges **2** and **3** disposed adjacent to the ends thereof. Flange **2** is considered as the input flange, and is coupled to the transmitter, while the receiving apparatus, not shown, is coupled to the output flange **3** typically via the intermediary of a separate transmit-receive gaseous discharge device, not shown.

A metallic frame **4** having a centrally located resonant aperture **5** is preferably fabricated from an electrically and thermally conductive metal such as aluminum, steel or brass.

A tubular gaseous discharge member **6** is disposed substantially closing off the central aperture **5** in the plate **4**. Gaseous discharge member **6** is of the folded cylinder type, that is, it comprises an annular gaseous discharge chamber formed by the space defined between two concentric cylinders sealed together at their ends. The cylindrical walls of the discharge member **6** are made of a suitable dielectric material such as, for example, glass or quartz, the latter being utilized when high power operation is anticipated. The annular chamber **7** defined by the annulus between the two concentric cylinders is evacuated and filled to a reduced pressure with a suitable gaseous mixture forming an ionizable atmosphere, the constituent components of which and the characteristics of which will be more fully described below.

A pair of metallic straps **8** are disposed at each end of the tubular gaseous discharge element **6** and serve to clamp the element **6** into the opening **5**.

In operation, high input power entering the waveguide **1** via flange assembly **2** upon intercepting the annular ionizable atmosphere within the chamber **7** thereby ionizes the atmosphere rendering it conductive and serving to

reflect all but a small fraction of the energy back out the input port, thereby protecting the receiver circuitry, not shown from the high input power levels.

The constituent components of the ionizable gaseous atmosphere, employed in the annular gas chamber 7 of the present invention, are any noble gas, preferably argon, at reduced pressure of approximately 2 millimeters of mercury intermixed with boron trifluoride gas at a partial pressure of approximately 20 millimeters of mercury. The noble gas reduces the firing power level necessary to produce ionization of the gaseous atmosphere. The boron trifluoride gas serves to reduce the deionization time and readily permits the gaseous discharge device to operate down to extremely low temperatures such as, for example, those below —55° C. A preponderance of boron trifluoride gas facilitates stable long life operation because of the clean up of boron trifluoride with operating life time and high power levels.

Other proportions of noble gas with boron trifluoride have been found operable. For example 7 millimeters argon with 1 millimeter of boron trifluoride was operable but turned out to have an increasing deionization time with operating life due to boron trifluoride clean up, such that the advantage over argon was lost with appreciable operating time. Therefore where operating time at high power is a major consideration a preponderance of boron trifluoride is preferred.

A folded cylinder pre-TR tube having an ionizable gas atmosphere, with 2 millimeters argon and 20 millimeters of boron trifluoride, satisfactorily operated at L-band frequency of 1300 megacycles with peak power of 10 megawatts and average power of 20 kilowatts with recovery times of approximately 25 microseconds to the 3 db point. An identical structure utilizing an ionizable gas atmosphere consisting only of argon at a pressure of a few millimeters of mercury and operable to the same power levels exhibited a deionization time of approximately 120 microseconds.

Although the novel ionizable gas atmosphere embodiment of the present invention has been described as utilized in a folded cylinder pre-TR tube it is equally applicable to other gaseous discharge devices such as, for

example, standard resonant element TR tubes of the type shown in U.S. Patent No. 2,965,787 and to ATR tubes and like where it is desired to reduce the deionization time and to improve the low temperature operating characteristics and high power handling capabilities of the gaseous discharge device.

Since many changes could be made in the above construction and many apparently widely different embodiments of this invention could be made without departing from the scope thereof, it is intended that all matter contained in the above construction or shown in the accompanying drawings shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. A gaseous discharge device comprising a hermetically sealed envelope containing an ionizable atmosphere, and a quantity of boron trifluoride gas contained within said envelope to provide means for decreasing the deionization time of the gaseous discharge device during operation thereof.

2. The apparatus according to claim 1 wherein said hermetically sealed envelope is made of a dielectric material and said ionizable atmosphere contains a quantity of a noble gas for decreasing the minimum power required for firing of said gaseous discharge device in operation.

3. The apparatus according to claim 2 wherein said ionizable atmosphere contains a preponderance by partial pressure of said boron trifluoride.

4. The apparatus according to claim 3 wherein said noble gas is argon.

5. A microwave transmit-receive switching tube comprising, a hermetically sealed envelope containing an ionizable atmosphere, and said atmosphere including a partial pressure of noble gas and boron trifluoride gas at pressures substantially less than atmospheric pressure.

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