June 1, 1954 H. C. BOOTH 2,680,207

AUXILIARY ELECTRODE FOR ULTRAHIGH-FREQUENCY GASEOUS DISCHARGE SWITCHING DEVICES

Filed July 19, 1952

2 Sheets-Sheet 1

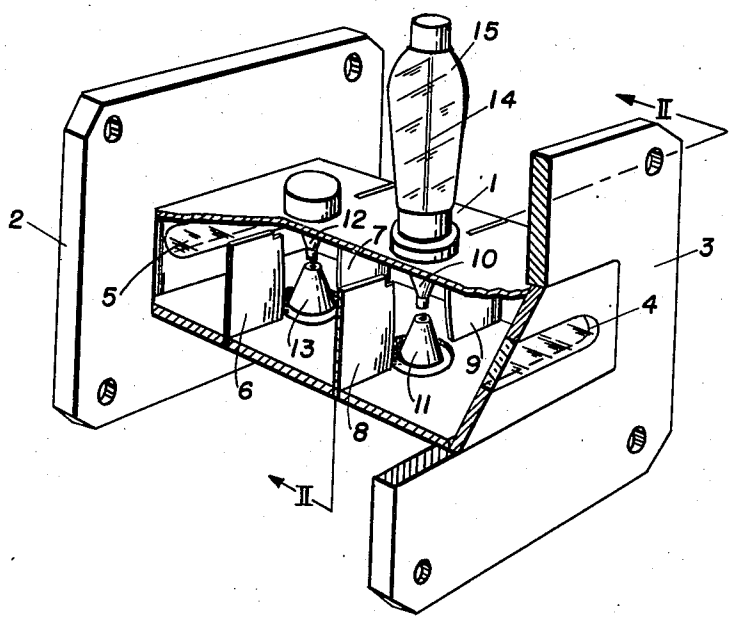


FIG. 1

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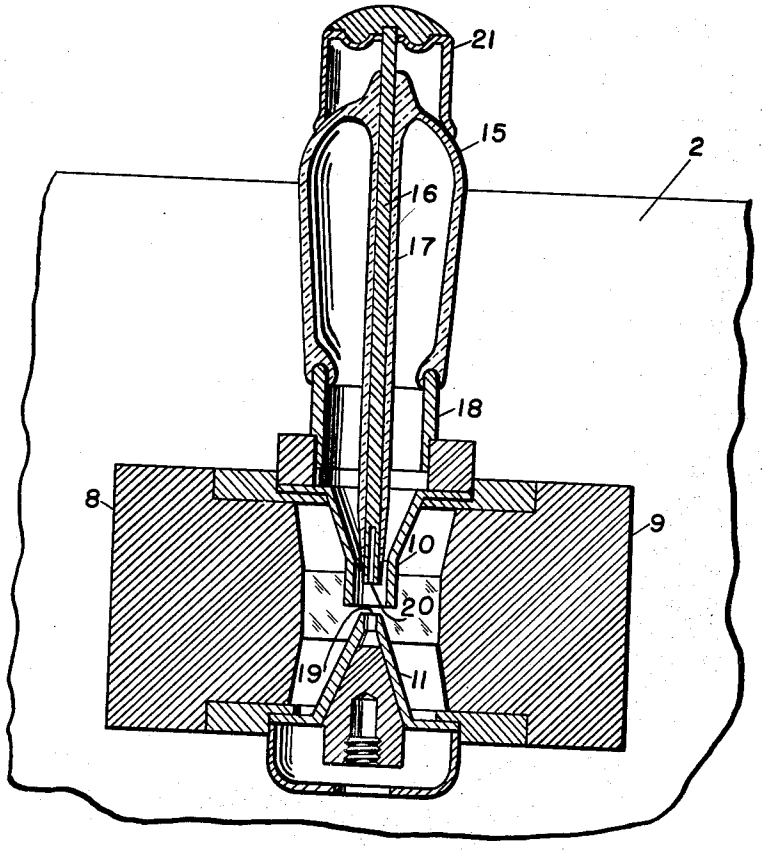


FIG. 2

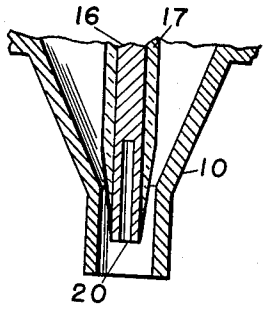


FIG. 3

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Patented June 1, 1954

2,680,207

UNITED STATES PATENT OFFICE

2,680,207

AUXILIARY ELECTRODE FOR ULTRAHIGH-FREQUENCY GASEOUS DISCHARGE SWITCHING DEVICES

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Application July 19, 1952, Serial No. 299,895

2 Claims. (Cl. 313—198)

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This invention relates to ultra high frequency gaseous discharge switching devices, and more particularly to improved auxiliary means for providing a source of electrons in the discharge gap to facilitate ionization of the gas medium employed.

In radio detection, location and range systems with a common antenna, the switching device, commonly employed to decouple the sensitive receiver during transmission of the high power pulse, is a transmit-receive electronic device. Such devices employ a gas fill under reduced pressure which ionizes when the transmitter fires, and thereby, permit essentially all of the radio frequency power to pass to the antenna. The returning signals are received by the same antenna, and will be permitted to pass through the device to the receiver without ionizing the gas fill.

Transmit-receive devices commonly employ an auxiliary electrode to supply a stream of electrons to the discharge gap to aid in the radio frequency discharge of the gas fill. This electrode is commonly referred to as the "keep-alive" electrode. The operation of such "keep-alive" electrodes, as well as a detailed description of various embodiments is noted in the text, "Microwave Duplexers," by L. D. Smullin and C. G. Montgomery, McGraw-Hill Book Co., Inc., New York 1948, pages 199–211 inclusive.

Conventionally, such electrodes are sheathed with a dielectric, such as glass or porcelain, surrounding the core and exposing only the tip. The auxiliary electrode is introduced into the device through one of the hollow conical electrodes forming a part of the resonant system. A direct current sustained glow discharge is maintained in the region surrounding the tip area by means of biasing this electrode negatively with respect to the adjacent cone electrode. Discharge currents of between 100–200 microamperes are necessary to maintain a steady flow of electrons.

In discussing the characteristics of the direct current glow discharge, I shall refer to the negatively-biased "keep-alive" electrode as the cathode, and the positively-biased adjacent conical electrode as the anode.

Generally, space limitations in the transmit-receive devices restrict the cathode area, and the resultant sustained direct current glow discharge will be in the abnormal glow region. Operation in this region will cause rapid cathode surface deterioration, as well as formation of deposits on the anode and dielectric sheathing surrounding the cathode area. These deposits further limit

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the cathode area, and momentary glow-arc transitions will result, with an accompanying sudden voltage drop. At the time of such transitions, electron emission will cease, and a larger amount of radio-frequency power will be permitted to pass before the gaseous discharge occurs. This increased power may exceed tolerable limits of the receiver, and cause burn-out of the sensitive crystal.

The gas fills employed in transmit-receive devices are determined by many considerations. Experimentally, water vapor has been found to be a necessary component of gas fills because of its electron capture characteristics. The momentary glow-arc transitions referred to, have been observed more frequently where water vapor is present in the gas fill. The elimination of glow-arc transitions is, therefore, an important problem in the art.

Accordingly, it is an object of the present invention to reduce direct current glow-arc discharge transitions in ultra high frequency gas-switching devices employing auxiliary electrodes.

It is a further object to provide an auxiliary electrode for such devices with an increased cathode surface area.

A still further object is the provision of an auxiliary electrode which will maintain a self-sustained flow discharge in the normal glow discharge region during operation at direct current potentials.

According to the teachings of the present invention, I provide an auxiliary electrode with a dielectric sheathing surrounding its circular core, exposing only the tip surface. A hole greater in length than in width is next provided in the core, extending from the tip nearest the conical electrode member. Said hole extends along the axis of the core of the auxiliary electrode for a predetermined distance. The diameter of said hole will be determined by mechanical considerations, but should provide a large enough space so that any deposits at the open end will not affect the electron emitting process. Additional cathode area will be provided by the interior surfaces of the hole. This increased cathode area will also provide a direct current glow discharge in the normal glow region, with constant current densities when the conventional direct current potentials are applied to the electrode. Operation in this region will prevent formation of deposits in the area of the tip. Sudden voltage drop, with the loss of "keep-alive" electrode effectiveness caused by glow-arc transitions, will also be eliminated.

The objects, features, and advantages of the present invention will be more clearly understood from the following detailed description of an illustrative embodiment and reference to the accompanying drawing, in which:

Figure 1 is a perspective view of an illustrative embodiment with a portion of the rectangular wave-guide removed.

Figure 2 is a transverse cross-sectional view along the lines II—II in Figure 1.

Figure 3 is an enlarged, detailed view of the component parts of the electrode of the invention.

The selected embodiment illustrating an auxiliary electrode of the present invention is an ultra high frequency gaseous discharge switching device, commonly referred to as a band pass transmit-receive tube. Such devices are known in the prior art, and have been described in detail in the text "Microwave Duplexers," by L. D. Smullin and C. G. Montgomery, McGraw-Hill Book Co., Inc., New York 1948, pages 67–114.

Devices of the character illustrated in Figure 1 comprise a predetermined length of waveguide of the hollow-pipe type 1. Secured thereto by conventional methods is an input flange 2 and output flange 3. Resonant glass-covered windows are located in each flange, as at 4 and 5. At intervals of approximately one quarter of a wavelength apart, diaphragm sections 6, 7, 8, and 9 are secured to the interior surfaces of the hollow-pipe waveguide, forming two slits of predetermined dimensions to be resonant at selected frequencies. Disposed within each resonant slit are a pair of truncated hollow cone electrodes 10, 11, 12, and 13, spaced apart a predetermined distance to form a capacitive discharge gap. An auxiliary electrode 14, embodying the features of the present invention, is positioned within glass envelope 15, with its inner end communicating with the capacitive gap through cone electrode 10.

Referring to Figures 2 and 3, the auxiliary electrode is desirably a circular core 16, of a conductive metal. Surrounding this core is an insulating sheath 17, of a dielectric, such as glass, extending to the tip of the core. The tip of the electrode is desirably spaced a short distance from the apex of cone 10. Positioning of the auxiliary electrode may be controlled by means of glass envelope 15 and metallic sleeve 18.

In the auxiliary electrode of the present invention, I provide a hole in the metallic core, as shown at 20. The dimensions of this hole are determined by mechanical considerations. In the selected embodiment, I provide a twenty-five thousandths of an inch diameter hole, in a core of forty thousandths of an inch diameter. The depth of the hole is one hundred thousandths of an inch.

The function of the auxiliary "keep-alive" electrode is to project a stream of electrons into gap 19 to aid in ionization of the gaseous medium when the radio-frequency pulse is transmitted. A direct current glow discharge is, therefore, maintained in the region of the tip of the electrode by biasing the auxiliary electrode negatively with respect to the adjacent cone electrode by means of a direct current voltage source applied to top cap 21 sealed to glass envelope 15.

It will be evident that the interior surfaces of hole 20 provide additional area for emission of electrons. Further, the construction of this holed-electrode will result in a projection of a narrow beam of electrons to the gap, thereby increasing the quantity present in said gap prior to the radio frequency discharge. The resultant direct current glow discharge will be in the normal glow region, and measurements of devices employing the improved auxiliary "keep-alive" electrode have shown an elimination of glow-arc transitions during operation.

While I have shown and described the present invention in an illustrative embodiment of an ultra high frequency gaseous discharge switching device, I wish it understood that the improved auxiliary electrode of this invention may be employed in other variations and modifications of such devices utilizing auxiliary electrodes, with similar advantages.

What I claim and desire to secure by Letters Patent is:

1. A high frequency gaseous discharge switching tube comprising a hermetically sealed enclosure with an ionizable atmosphere containing water vapor therein and discharge gap structure including a pair of spaced hollow conical electrodes, a third electrode extending co-axially into one of said pair of hollow conical electrodes, said third electrode comprising a metal rod having a reentrant axial bore at the end adjacent the hollow conical electrode and a sheath of an insulating material covering the lateral surfaces of said rod to expose only said bored end.

2. Electrode structure for a high frequency switch tube comprising a pair of hollow conical electrodes disposed in axial alignment with opposed spaced convergent ends, walls forming a chamber communicating with the large end of one of said electrodes, a third electrode comprising a metal rod extending through said chamber and co-axially into the associated one of said pair of hollow electrodes, the end of said rod terminating approximately at the apex of said hollow electrode, said rod having a reentrant axial bore at the end adjacent said apex, and a sheath of insulating material covering said rod throughout its length within said chamber and associated hollow electrode, said sheath exposing only the bored end of said rod.

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