April 30, 1957 P. E. GATES 2,790,923

GASEOUS ELECTRIC DISCHARGE TUBES AND ELECTRODES

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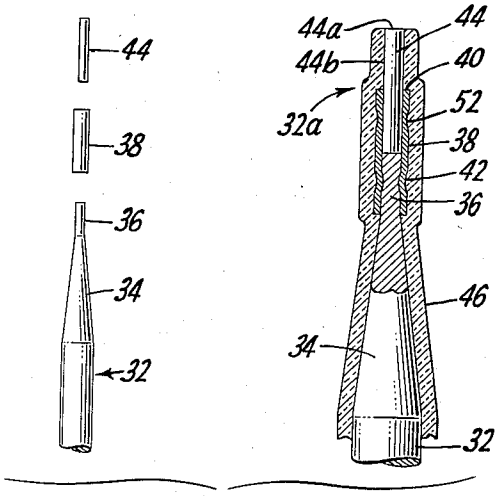


Fig. 1

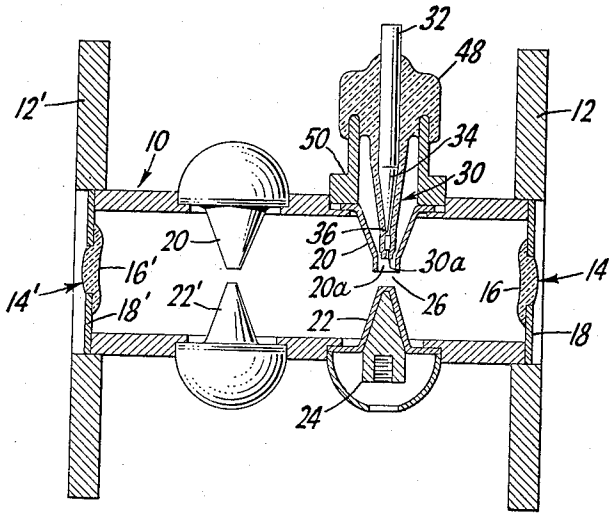


Fig. 2

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GASEOUS ELECTRIC DISCHARGE TUBES AND ELECTRODES

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5 Claims. (Cl. 313—198)

The present invention relates to improved attenuator tubes and switching devices for microwave circuits. The invention particularly contemplates provision of a novel "keep-alive" electrode for maintaining a limited volume of a gaseous fill in gaseous discharge devices in weakly ionized state, and to a simplified method of fabricating such electrodes.

The invention is disclosed as applied to a number of gaseous discharge devices, for example, attenuators, transmit-receive tubes, and anti-transmit-receive tubes. These devices depend for their performance on a glow discharge in a gaseous fill between a pair of discharge electrodes constituting a break-down discharge gap across a waveguide transmission path. In order to render transmit-receive tubes or duplexers more effective, as well as to control attenuators, it is advantageous to maintain the gaseous fill in the region of the discharge gap in a weakly ionized state. This glow discharge of a limited volume of the gaseous fill is sustained during low level signal conditions and facilitates intense ionized discharge or breakdown across the transmission path when high level energy is impressed on the waveguide. For this purpose, an additional electrode termed a "keep-alive" is arranged in close proximity to the gap. In operation, a suitable potential is applied to the "keep-alive," effective to establish the desired ionization.

In order to assure that these devices shall have a relatively quick recovery time, a gaseous fill of a mixture of an inert gas (i. e. a noble gas such as argon, whose ions combine only with each other after ionization) and a quenching gas (i. e. water) is introduced. In operation, when exposed to such gaseous atmosphere and the ionizing potential, conventional keep-alives tend to deteriorate and limit the useful life of tubes to several hundred hours, even at relatively low currents. Often, it is necessary to increase the glow discharge, further increasing the risk of progressively destroying the "keep-alive" electrode.

My co-pending application Serial No. 312,604, filed September 30, 1952, assigned to the assignee of the present invention, discloses a novel microwave device incorporating a "keep-alive" electrode suitable for maintaining the required low level ionized discharge, yet minimizing deterioration of the "keep-alive," even where an aqueous quenching mixture is used. As pointed out in my co-pending application, fabrication difficulties are encountered, due in part to the size limitations imposed on the "keep-alive" and because of the physical geometry of the environment and electrode construction, as well as the fragile character of suitable keep alive materials. Although the manufacturing methods and constructions disclosed and claimed in this application represent material advances in fabricating of microwave devices of the aforesaid character, difficulty has been encountered in attaining requisite precision and uniformity in manufacture without somewhat higher costs than anticipated.

Accordingly, it is an object of the present invention to provide a microwave gaseous discharge device having

a novel "keep-alive" electrode effective to promote long tube life, and adapted to fabrication by simplified techniques. In particular, the present invention contemplates a novel yet simple method for incorporating brittle or fragile materials such as titania, having desirable keep-alive properties, in a practical electrode construction.

It is a further object of the present invention to provide a keep-alive electrode assembly fabricated to assure uniformity from unit to unit, despite the relatively tiny components of the assembly, and in a manner compatible with minimum costs.

The above objects and further features and advantages of the present invention will become apparent from the following detailed description of an illustrative embodiment and process shown in the accompanying drawings, wherein:

Fig. 1 is a flow diagram showing the processing of an insert forming a part of a novel keep-alive electrode; and

Fig. 2 is a longitudinal cross-section of an illustrative transmit-receive tube containing a keep-alive electrode constructed in accordance with the process of Fig. 1.

Referring now to the drawings and in particular to Fig. 2, there is shown a rectangular length of waveguide 10, having flanges 12, 12' for connection to a microwave system. The ends of the waveguide 10 are provided with resonant windows 14, 14' each of which includes a center glass or ceramic body 16, 16' and a metal bezel of frame 18, 18'. One or more opposite pairs of conical discharge electrodes 20, 22, and 20', 22' afford a series of discharge gaps 26 at spaced intervals along the waveguide 10, and the gap electrodes have metallic interconnection via the waveguide wall. Electrode 22 is of closed deformable construction for critical adjustment by engagement from the exterior of the waveguide 10 through the complementary body 24 fixed in electrode 22. Associated with discharge gap 26, defined by the opposite electrodes 20 and 22, is a laterally disposed pair of plates (not shown) of conventional construction which provide an iris having a center opening for the gap electrodes. The iris and the gap electrodes constitute a resonant aperture through which microwave energy of low level can be transmitted from one window to the other. The respective discharge gaps and irises are separated from each other along the waveguide 10 by a spacing commonly being a distance equal to an effective quarter wave length at the center frequency of the band for which the device is designed.

Electrodes 20 are hollow in the preferred construction and each contains a keep-alive electrode 30 having an inner end 30*a* limited to a spacing of a few thousandths of an inch from the opening 20*a* in discharge electrode 20, both radially and end-wise. Discharge electrode 20 is accordingly closer to the other discharge electrode 22 than keep-alive electrode 30 is to discharge electrode 22 and only the relatively small inner end 30*a* of the keep-alive electrode 30 is exposed to the gaseous fill of the sealed waveguide 10 in the region of the discharge gap 26. The waveguide 10 is conventionally filled with an electron capture gas preferably a noble gas such as argon, mixed with a quenching gas such as water at a total pressure of the order of 25 millimeters of mercury.

In operation, a current is passed between the keep-alive electrode 30 and the discharge electrode 20. In such transmit-receive tubes, it is normal to apply several hundred volts between the keep-alive 30 and the gap electrodes. When the required potential is applied between the keep-alive and the waveguide structure a small volume of ionized gas is locally established in a confined region adjacent gap 26, which is somewhat effective to attenuate low level signals transmitted along the waveguide path, the attenuation being a function of the degree of ionization. Upon incidence of high level signal

bursts the limited volume of ionized gas promotes an abrupt formation of intensely ionized discharges thereby to switch the waveguide transmission path from one in which low level signals are transmitted, to one in which high level signals are almost entirely reflected. The use of such devices in radar systems and in single station receiver-transmitter units is well understood by those well skilled in the art, and requires no elaboration here.

When it is desired to increase the intensity of glow-discharge as in attenuator tubes, it is usual to greatly increase the ionizing keep-alive current. As this current increases there will be a proportionate increase in current density which might normally result in the accelerated deterioration of the keep-alive. This is of special concern in the presence of a gas fill containing water vapor where the water vapor is "cleaned up" or removed from the mixture during life of the tube. Accordingly, it is desirable to employ a keep-alive electrode having an increased current carrying capacity, and one that does not enter into the "clean-up" action.

According to a feature of the present invention, the "keep-alive" electrode 30 (Fig. 2) is formed with a rod 32, including an axial tapered or conical portion 34 and a cylindrical supporting portion or tip 36. Axially supported upon the portion 36 of the rod 32 is a thin-wall metallic sleeve 38 which cooperates with the rod 32 to form an axial passage 40 therein. The thin-walled sleeve 38 is electrically connected and permanently fixed on the rod 32 by a weld 42 or the like. As seen in Fig. 1, the welding operation causes a slight deformation of the thin-walled sleeve 38 in the region of the weld 42.

Within the bore 40 there is an insert or tip 44 of a semiconducting ceramic, specifically, partially reduced titanium oxide. The insert 44 accurately fits the passage 40 and has an end face 44*a* exposed and spaced outwardly of the sleeve 38. An insulating sheath or glass bead 46 is sealed continuously on the outer surface of the rod 32, along the sleeve 38, and along the lateral surface 44*b* of the insert. The sheath 46 confines the discharge between the "keep-alive" electrode 32 and the outer metallic structure of the hollow gap electrode 20 to the immediate region of the opening 20*a*. This "keep-alive" electrode is hermetically sealed by a glass button 48 to a sleeve or collar 50 that is brazed hermetically to the waveguide 10. Accordingly, the rod 32' is fixed concentrically of the cone 20 and critically fixed in endwise spaced relation thereto. The sleeve 50 is of a suitable glass to sealing metal alloy such as the well-known iron-nickel-cobalt aloys, commonly designated Kovar.

The titania insert 44 and the sleeve 38 are electrically and mechanically united to each other and to the conductive rod 32. Thin-walled sleeve 38 is heat-softened at 52 as by opposed resistance-welding electrodes. The joint at 52, which may be contrasted to the true weld 42, is a sound mechanical and electrical unit ion between the insert 44 and the sleeve 38. In lieu of using conventional welding tips which apply pressure to opposite sides of the sleeve 38, it may be desirable to employ an electronic torch which merely heat softens the thin wall 38, thereby causing the wall to conform to the insert, although the latter may have minute irregularities and may be slightly smaller than the passage in the sleeve 38 initially. Although the titania insert is exceptionally fragile and brittle, this type of electrical construction utilizes the physical properties of the titania for improving the life of the tube without entailing difficult assembly operations, while assuring sound mechanical and electrical connection.

The "keep-alive" electrode may be assembled in the following exemplary manner:

Initially, and as seen in Fig. 1, titanium oxide insert 44 is prepared as an extruded rod which is then fired in hydrogen at approximately 1150° centigrade for approximately three minutes, so as to render it semiconductive, and it is cut to an appropriate length. Thin wall sleeve 38 is fixed on the supporting portion 36 of the rod 32 by a true weld 42. Previously the rod 32 may be suitably cleaned of oxides, as for example, by firing in a furnace having a hydrogen atmosphere. Thereupon, the titania insert 44 is fitted into the passage 40. Heat-softening the sleeve 38 as at 52 provides a permanent reliable mechanical and electrical joint, between the insert 44 and the sleeve 38. Thereafter the assembly of the rod 32, the sleeve 38 and the projecting insert 44, is provided with the insulating sheath 46, suitably of glass, on all of the exposed surfaces of the assembly except for the end face 44' of the insert. Any glass inadvertently covering the exposed end face 44*a* of the titania insert may be ground away. The completion of the assembly of the "keep-alive" electrode 30 with the electrode construction 20 may be accomplished by following the teachings of co-pending applications, Serial No. 237,258 of July 17, 1951, and Serial No. 226,483, filed May 15, 1951, now Patent No. 2,740,186, both assigned to the assignee of the present invention.

Keep-alives constructed in substantially the aforementioned manner exhibit all the advantages of the insert material as to minimizing deterioration of the electrode and of the fill, yet have the advantages of a strong, durable structure which may be manufactured without extreme requirements for close tolerances and meticulous processing.

In broad concept, sleeve 38 might be formed integral with rod 32, by drilling accurately into the center of the end of the rod, after which the insert could be bonded in place. The illustrated embodiment is preferable for such tiny components as that used in the device of Fig. 2, where the insert may be only 0.015 inch in diameter, and 0.125 inch long, where the wall-thickness of sleeve 38 should be not much greater than 0.004 inch in this device.

Numerous modifications may occur to those skilled in the art, within the scope of the present invention, and in many instances certain features of the invention may be used without a corresponding use of other features. Accordingly, the appended claims should be broadly construed, consistent with the scope and spirit of the invention.

What is claimed is:

1. An electrical discharge device comprising an envelope containing an ionizable gas, and a pair of discharge electrodes in said envelope, one of said electrodes including a supporting rod, a sleeve axially mounted on said supporting rod and cooperating therewith to define a passage in the end thereof, an insert of titanium oxide extending into said passage, and an insulating sheath entirely covering said sleeve.

2. An electrical discharge device comprising an envelope containing an ionizable gas, a pair of electrodes in said envelope adapted to sustain a glow discharge therebetween, one of said electrodes including a body having a supporting part, a sleeve mounted on said supporting part and projecting therefrom, an insert of semiconductor extending into and projecting from said sleeve and including an end face, and an insulating sheath sealed to the assembly of said body, sleeve and insert and covering said assembly except for said end face.

3. A microwave electric discharge tube including a metal-walled envelope defining a transmission path for microwave energy and arranged to admit microwave energy to said path, an electron capture gas fill in said envelope, opposed electrodes defining a discharge gap therebetween, and a keep-alive electrode adjacent said discharge gap for maintaining a restricted volume of said gas fill in weakly ionized condition, said keep-alive electrode including a metal support, a sleeve electrically and mechanically united to said support, a semiconductive core supported in said sleeve and having a face adjacent said discharge gap, and an insulating sheath on said support, sleeve, and core covering the surfaces thereof excepting said face.

4. In a microwave electrical discharge device including an envelope containing a mixture of a noble gas and water vapor and opposed electrodes defining a discharge gap, the improvement consisting of a keep-alive electrode adjacent said discharge gap for maintaining a restricted volume of said noble gas in a weakly ionized state, said keep-alive electrode including a support having a sleeve fixed thereon axially of said support, a tip of fired titanium oxide projecting from said sleeve and electrically and mechanically united thereto, said tip having an end face exposed contiguous to said discharge gap, and a lateral film of protective insulation for said keep-alive electrode providing an insulated seal extending from said end face and through a wall of said envelope.

5. An electrical discharge device comprising an envelope containing an ionizable gas, a pair of opposed discharge elements defining a discharge gap in said envelope, and an electrode in close proximity to said gap and constituting a cathode for establishing a glow discharge during operation, said electrode including a bore-defining member having a metal wall, a core of titanium oxide fixed within said bore-defining member by deforming said bounding wall, and an insulating sheath externally of said electrode and covering said electrode except for a confined region exposing said core adjacent said discharge gap.

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