Dec. 17, 1946. C. H. THOMAS 2,412,659

ELECTRON DISCHARGE DEVICE

Filed May 30, 1942

Fig. 1.

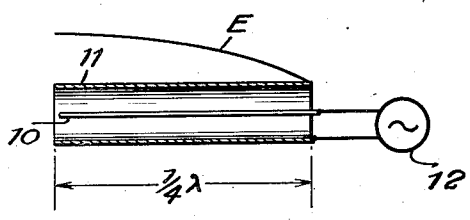


Fig. 2.

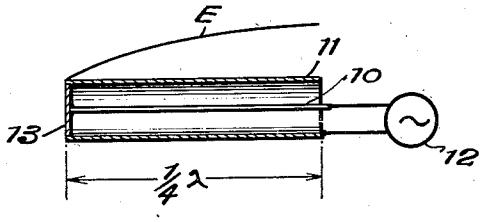


Fig. 3.

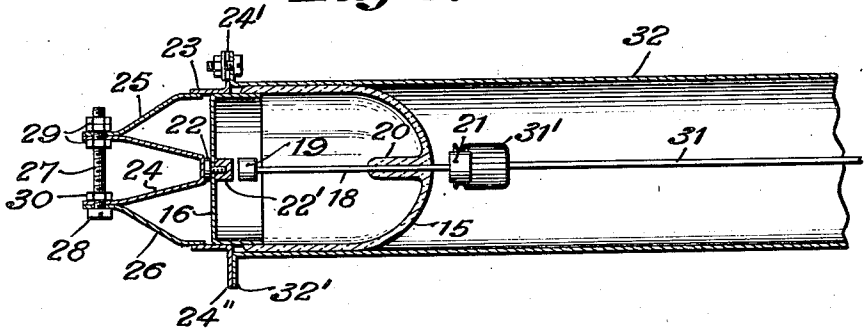
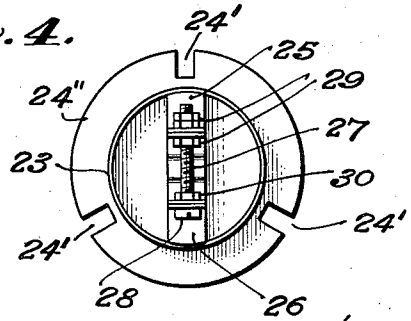


Fig. 4.



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ELECTRON DISCHARGE DEVICE

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8 Claims. (Cl. 250—27.5)

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My invention relates to electron discharge devices for use in ultra high frequency applications utilizing coaxial feed lines, the impedance of which it is desired to vary in response to predetermined voltage conditions.

One such electron discharge device includes an evacuated envelope containing a gaseous atmosphere and having a pair of electrodes spaced within the envelope to provide a gap. The device is so designed that one electrode is electrically connected to the outer line of the coaxial conductor and the other to the inner line. The device may be used with a quarter wave line, one end of which is connected to a source of radio frequency potential and the other end of which is closed by the electron discharge device. Under certain operating conditions and when no breakdown occurs between the electrodes the line acts like an open line, but when a predetermined maximum voltage is reached a discharge occurs across the electrodes shorting the open end of the coaxial line, thus causing the device to act like a shorting disc. The result is to vary the impedance at the end of the line connected to the source of radio frequency potential from a minimum to a maximum. The device may also be placed midway of a half wave length line for the purpose of varying its impedance under predetermined voltage conditions.

A device of this type must be so constructed that it can be readily attached to and detached from a coaxial line. It must also be so constructed that the high frequency impedance of the device is low. In order to be readily interchangeable with other like devices in high frequency circuits, it must be so constructed that the gap between the electrodes can be adjusted readily from the outside of the envelope, since the electrode separation governs the breakdown voltage and electrostatic capacity of the electron discharge device which factors must be held to very close limits since the capacity of the high frequency circuit apparatus with which it is used may not be variable.

In certain operations it is desirable that the electron discharge device have a low breakdown voltage and low voltage drop. However, the deionization time of the gas used must be short after the discharge ceases in order to accommodate operation at high frequencies. While a number of inert gases and mixtures have been suggested no satisfactory gas or combination of gases has been disclosed. A tube with high pressure argon has a low drop but local arcs are formed on the electrodes so that the electrodes

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sputter badly to give only a very short useful life. In some operations the breakdown of local arcs on the electrodes results in other undesirable effects so that such tubes are entirely unsatisfactory. A helium filled device with aluminum electrodes and at a pressure of 15 centimeters has a drop of about 180 volts for 100 milliamperes peak current on 60 cycles with a breakdown voltage of 250 volts. Such a tube while it will break down as desired has a deionization time which is too long for certain applications. A tube filled with hydrogen to a pressure of 10 to 15 centimeters has a breakdown voltage of about 350 volts and a drop of 280 volts for 100 milliamperes peak current on 60 cycles. Such a tube has relatively fast deionization time and will operate fairly satisfactorily for most purposes. However, the hydrogen has a higher breakdown voltage at a higher drop than does a similar tube filled with helium. Furthermore, hydrogen is further undesirable since it presents the possibility of explosion during operation when oxygen is mixed with hydrogen.

It is, therefore, an object of my invention to provide an electron discharge device which may be used at ultra high frequencies as an automatic variable impedance.

Another object of my invention is to provide such a device particularly suitable for use with coaxial transmission lines to vary the terminal impedance of the tranmission line between minimum and maximum values.

A further object of my invention is to provide an electron discharge device, the electrodes being enclosed within an evacuated envelope and having means for varying the gap from the outside of the envelope.

Another object of my invention is to provide such a device having a gas content which has a deionization time short enough to permit its use at ultra high frequencies and yet having the desired low voltage drop and voltage breakdown characteristics.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawing in which Figures 1 and 2 are schematic diagrams illustrating coaxial line circuits and the voltage distribution, Figure 3 is a longitudinal section of an electron discharge device made according to my invention associated with a coaxial transmission line cir-

cuit, and Figure 4 is an end view of the electron discharge device shown in Figure 3.

In Figure 1 is shown a longitudinal section of an open transmission line with inner conductor 10 and outer conductor 11 and a driver 12 for applying a high frequency voltage to one end of the line. The electrical length of the coaxial line is a quarter wave length of the voltage applied by source 12. The voltage distribution is indicated by the voltage curve E and it will be observed that the maximum voltage is at the end removed from the driver indicating maximum impedance at this end of the line, and minimum impedance at the driver end of the line.

In Figure 2 is shown the result of placing short circuiting disc 13 across the end of the coaxial line. This disc 13 reduces the impedance of the closed end of the line to zero and the voltage distribution curve is indicated at E. It will be seen that in this case the maximum impedance is at the open end of the line to which driver 12 is connected. To be able to change from an open to a closed line automatically in response to predetermined conditions is for certain applications highly desirable.

In Figure 3 is shown an electron discharge device made according to my invention coupled into a coaxial transmission line for accomplishing this automatic impedance change. This device has an evacuated envelope 15 closed at one end by means of cup-shaped member 16 providing a flexible diaphragm and sealed to the end of the envelope. Supported from and sealed into the envelope is the rod support 18 having fixed to its free end an electrode 19, the support and lead wire 18 being sealed into the envelope at 20 and provided at its outer end with terminal 21. Mounted on the diaphragm 16 is the terminal member 22 fixed to the diaphragm by means of the screw member extending through the diaphragm and supporting electrode 22'. A collar member 23 is brazed to the cup-shaped member 16 and is provided with a radially extending flange member 24'' provided with slots or grooves 24' permitting the device to be secured to a coaxial transmission line as indicated.

Secured to the collar member 23 are a pair of flexible supports 25 and 26 secured at their outer or free ends to the free ends of the legs of the yoke 24, which in turn has its closed end secured to the head of the member 22. Supported at the outer end or free end of the flexible supports 25 and 26 and the legs of the yoke 24 is screw member 27 having head 28 and provided with locking and adjusting nuts 29 and 30.

The outer conductor to the coaxial transmission line 32 may be provided with flange 32' which is secured to flange 24'' of the electron discharge device and the inner conductor 31 may be electrically connected to the terminal 21 by means of spring cup arrangement 31'.

The electrode 22' may be moved toward and from electrode 19 to vary the gap therebetween by flexing the diaphragm or bottom of cup-shaped member 16. By rotating the screw member 27 so that the legs of the yoke 24 are brought closer together the closed end is forced toward the right, flexing the diaphragm toward the right and shortening the gap. If the rotation of the screw is reversed the legs of the yoke are spread farther apart and the diaphragm is flexed to the left, thus increasing the spacing between the electrodes. This controls the breakdown voltage as well as the capacity between the electrodes, so that the device can be readily substituted for another and adjustment made so that the line impedance is the same after the change is made. In one application the space between the electrodes is of the order of 10 mils.

In connection with the gaseous atmosphere used I have found that a helium hydrogen mixture with approximately 20% hydrogen and 80% helium has a lower drop and lower breakdown than a tube filled with pure hydrogen. This mixture, which is non-explosive, has the advantages of rapid deionization time and low voltage drop and low voltage breakdown, and has practically the safety of helium. Such mixture filled tubes have stable operation over a long period and show very little sputtering of electrode material. I have found that the pressure may vary from several millimeters to 70 centimeters depending upon the frequency of operation and on the amount of current which passes through the tube.

While I have indicated the preferred embodiments of my invention of which I am now aware and have also indicated only one specific application for which my invention may be employed, it will be apparent that my invention is by no means limited to the exact forms illustrated or the use indicated, but that many variations may be made in the particular structure used and the purpose for which it is employed without departing from the scope of my invention as set forth in the appended claims.

What I claim as new is:

1. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a flexible diaphragm, a first electrode supported on said diaphragm within said envelope, and a second electrode supported within the envelope closely adjacent the first electrode on said diaphragm providing a gap between said electrodes, and adjustable means supported outside said envelope and secured to said diaphragm for flexing said diaphragm to vary the gap between said electrodes, and a flange on said diaphragm and a terminal connected to the second electrode, said flange and terminal being adapted to be secured to the inner and outer conductors of a coaxial transmission line.

2. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a flexible diaphragm, an electrode supported on said diaphragm within said envelope, and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, and adjustable means supported outside said envelope and secured to said diaphragm for flexing said diaphragm to vary the gap between said electrodes, and including a U-shaped member having its closed end secured to said diaphragm, and means contacting the legs of said U-shaped member for changing the spacing between the legs of said U-shaped member for flexing said diaphragm to vary the gap between said electrodes.

3. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a flexible diaphragm, an electrode supported on said diaphragm within said envelope, and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, and a collar secured to said diaphragm, a U-shaped member having its closed end secured to said diaphragm, means including a pair of support members secured to said collar

and the free ends of the legs of said U-shaped member and adjustable means at the free ends of the legs of said U-shaped member for varying the distance between the ends of said legs for flexing said diaphragm to vary the gap between said electrodes.

4. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a cup-shaped member having a flexible bottom providing a diaphragm, an electrode supported centrally on said diaphragm within said envelope and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, a collar member secured to said cup-shaped member, a pair of flexible supporting members secured to said collar member and extending away from said diaphragm, and a U-shaped member having the free ends of its legs secured to said supporting members and its closed end secured to said diaphragm, and a screw member bridging the free ends of said legs and secured thereto for varying the spacing between said legs for flexing said diaphragm to vary the gap between said electrodes.

5. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a cup-shaped member having a flexible bottom providing a diaphragm, an electrode supported centrally on said diaphragm within said envelope and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, a collar member secured to said cup-shaped member, a pair of flexible supporting members secured to said collar member and extending away from said diaphragm, and a U-shaped member having the free ends of its legs secured to said supporting members and its closed end secured to said diaphragm, and a screw member bridging the free ends of said legs and secured thereto for varying the spacing between said legs for flexing said diaphragm to vary the gap between said electrodes, the gaseous atmosphere comprising hydrogen and helium.

6. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a flexible diaphragm, an electrode supported on said diaphragm within

said envelope, and a second electrode supported within the envelope closely adjacent the electrode on said diaphraghm providing a gap between said electrodes, and adjustable means supported outside said envelope and secured to said diaphragm for flexing said diaphragm to vary the gap between said electrodes, said gaseous atmosphere comprising 20% hydrogen and 80% helium.

7. An electron discharge device having an envelope containing a gaseous atmosphere comprising hydrogen and helium and closed at one end by a flexible diaphragm, an electrode supported on said diaphragm within said envelope, and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, a collar secured to said envelope, a U-shaped member having its closed end secured to said diaphragm, and adjustable means for changing the spacing between the legs of said U-shaped member for flexing said diaphragm to vary the gap between said electrodes, said adjustable means including a pair of flexible support members secured to said collar and to the free ends of the legs of said U-shaped member and a screw member bridging the legs of said U-shaped member at the free ends of said legs for varying the distance between the ends of said legs.

8. An electron discharge device having an envelope containing a gaseous atmosphere and closed at one end by a cup-shaped member having a flexible bottom providing a diaphragm, an electrode supported centrally on said diaphragm within said envelope, and a second electrode supported within the envelope closely adjacent the electrode on said diaphragm providing a gap between said electrodes, a collar member secured to said cup-shaped member, a pair of flexible supporting members secured to said collar member and extending away from said diaphragm, and a U-shaped member having the free ends of its legs secured to said flexible supporting members and its closed end secured to said diaphragm, and a screw member bridging the free ends of said legs and secured thereto for varying the spacing between said legs for flexing said diaphragm to vary the gap between said electrodes, said gaseous atmosphere comprising approximately 20% hydrogen and 80% helium.

CHARLES H. THOMAS.