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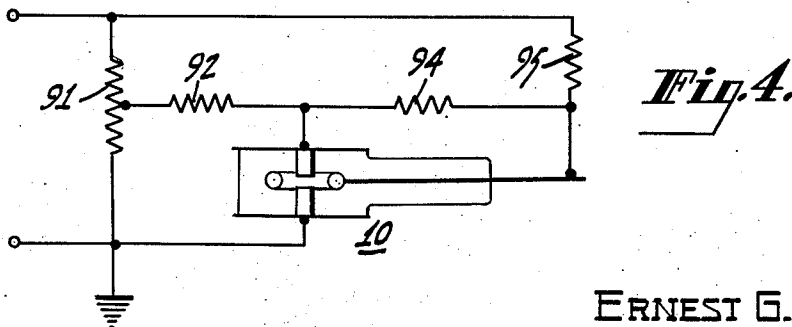
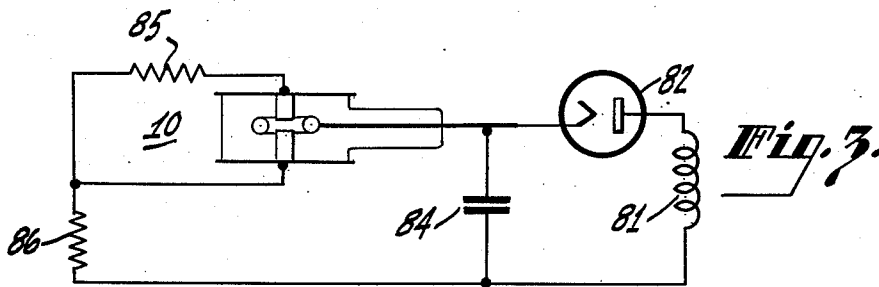
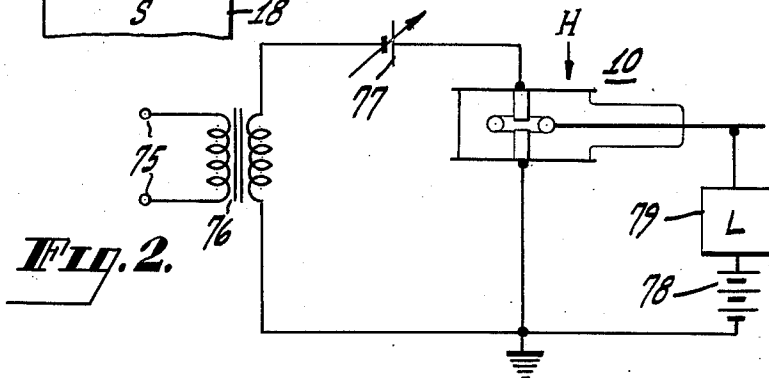
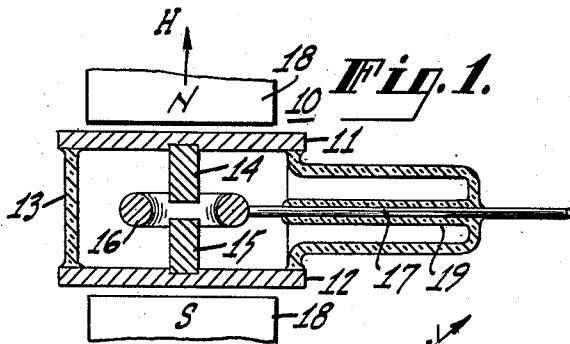
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2,813,992

GAS DISCHARGE DEVICE UTILIZING CONTROLLED ELECTRON TRAPPING

Filed Nov. 29, 1952

2 Sheets-Sheet 1



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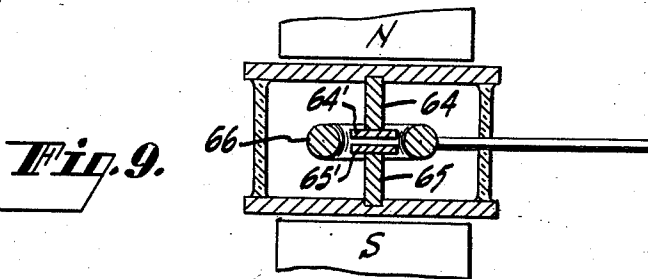
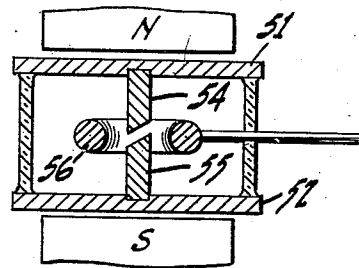
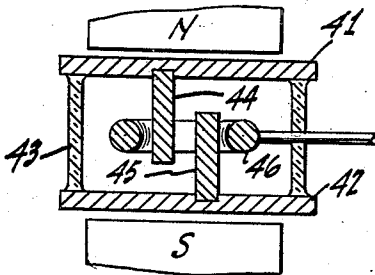
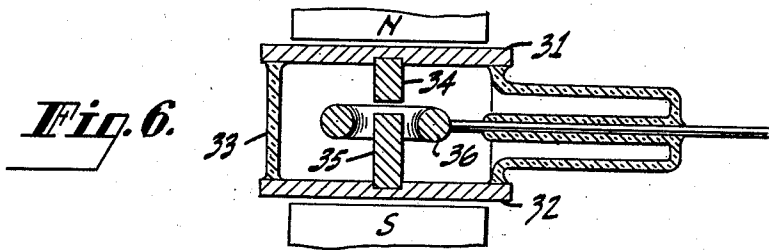
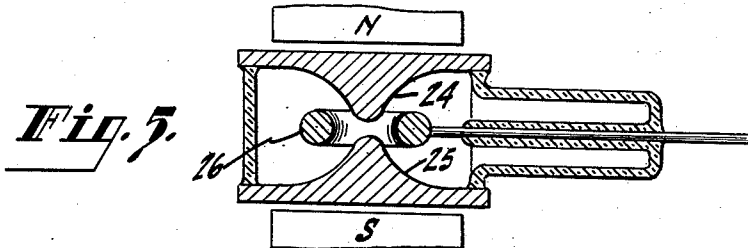
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GAS DISCHARGE DEVICE UTILIZING CONTROLLED ELECTRON TRAPPING

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2 Sheets-Sheet 2



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GAS DISCHARGE DEVICE UTILIZING CONTROLLED ELECTRON TRAPPING**Ernest G. Linder, Princeton, N. J., assignor to Radio Corporation of America, a corporation of Delaware****Application November 29, 1952, Serial No. 323,216****The terminal fifteen years of the term of the patent to be granted has been disclaimed****8 Claims. (Cl. 313-161)**

This invention relates to gas discharge devices and particularly to such devices which utilize electron trapping in a magnetic field.

Prior to this time there have been certain types of gas discharge devices that have utilized the beneficial effects of electron trapping in a low pressure gas discharge device. However, these devices have not provided a simple means for controlling the trapped electrons so that the output of the device could be modulated.

It is therefore an object of this invention to provide a new and novel gas discharge device having means to control electron trapping in the device.

It is a further object of this invention to provide a new and novel means for controlling trapped electrons in a gas discharge device.

It is another object of this invention to provide a new and improved gas discharge device utilizing control of trapped electrons within the device to develop a range of break down voltages and output currents.

These and other objects and advantages are accomplished in accordance with the general aspects of this invention by providing a gas discharge device having a gas filled envelope and a pair of elongated cathode members that extend toward each other within the envelope but are spaced apart. A hollow anode is spaced around at least one of the elongated cathode members. During operation of the device a magnetic field is established extending through the envelope and transverse to an electric field between the cathode assembly and the anode. Due to the two fields electrons are trapped in the device and by varying the electric field the trapped electrons are controlled in such a manner as to modulate the output of the device.

The novel features which are believed to be characteristic of this invention, are set forth with particularity in the appended claims. The invention itself will best be understood by referring to the following descriptions when read in connection with the accompanying two sheets of drawings in which:

Figure 1 is a sectional view of a gas discharge device constructed in accordance with this invention;

Figures 2 through 4 are schematic diagrams of some of the methods of operation of this invention; and

Figures 5 through 9 are sectional views of other devices constructed in accordance with this invention.

Referring now to Figure 1 in detail, gas discharge device 10 comprises a sealed enclosure which includes a pair of cathode plates 11 and 12 sealed to opposite ends of a tubular member 13 and closing the same. The cathode plates 11 and 12 are sealed to the insulating member 13 by conventional means that may include some type of sealing material if desired. A pair of elongated rod like members 14 and 15 are each connected to one of the cathode plates 11 and 12 and extend toward each other in such a manner that the free ends of rod like members 14 and 15 are in opposed spaced apart relation and adjacent to one another. Members 14 and

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15 are coaxial with tubular member 13. Spaced around the gap between rod like members 14 and 15 is an annular anode 16 that is substantially equidistant between cathode plates 11 and 12. It should be understood that other structures for anode 16 may be used such as a hollow tubular anode. The size of the gap between elongated members 14 and 15 and the gap between anode 16 and elongated members 14 and 15 is of the same order of magnitude. Supporting anode 16 is a conductor 17 that extends through a recessed portion of insulating member 13. Surrounding conductor 17 is an insulating sleeve 19 to avoid long path discharges in accordance with Paschens law. Adjacent the cathode plates 11 and 12 are the poles of a magnet 18 which produces a magnetic field in device 10 substantially parallel to the axis of rod like members 14 and 15.

The material for the cathode plates 11 and 12 is preferably some type of electrically conductive, low reluctance material that will readily transmit a magnetic field. An example of such material is Kovar. The rod like members 14 and 15 may be any of the conventional cathode structures i. e. thermionic, cold, etc. and are preferably constructed of some non-magnetic material such as tantalum. The annular anode 16 and conductive support rod 17 are also preferably constructed of some type of non-magnetic, electrically conductive material in order that the field from the magnet 18 will not be distorted. Insulating member 13 is constructed of any of the conventional types of insulating materials such as glass.

Gas discharge device 10 is processed in the usual manner. It is exhausted and filled with a suitable ionizable medium. Any of the well known gases or vaporable material known in the gas discharge art may be utilized. In the device being described for the purpose of illustrating the invention, mercury vapor was used at a pressure within the range of 10^{-3} to 10^{-2} millimeters of mercury while operating at room temperature.

The purpose of the recessed portion in insulating member 13 is to prevent sputtering of the mercury vapor at high voltages. It should be understood that if a different type of ionizable medium is used, or if the device is to be used at low voltages, the recessed portion of insulating member need not be present.

When the proper potentials are applied to the device, primary electrons are emitted by the cathode assembly. Due to the magnetic field the primary electrons travel in a curved path which is long as compared to the direct path between the cathode assembly and anode 16. While traveling in this curved path, the primary electrons generate secondary electrons by collision with gas atoms. Due to the magnetic field the secondary electrons also travel in a curved path and generate additional secondary electrons resulting in a glow type discharge in the device.

Due to the gap between the portions of the cathode assembly, i. e. the gap between rod like members 14 and 15, the magnetic field is transverse to the electric field, and also most of the primary electrons are emitted from the edges of the free ends of rod like members 14 and 15. Due to the fact that the primary electrons are emitted inside the aperture in annular anode 16 the electrons are originally in the desired region and the device is an improved type of rectifier.

On the inverse portion of the cycle the cathode assembly is positive with respect to anode 16 and the electrons are attracted toward end plates 11, 12; traveling parallel to the magnetic field. Thus a negligible number of secondary electrons are generated on the inverse cycle and no glow type discharge occurs, thus substantially no current flows.

When it is desired to vary the output current one por-

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tion of the cathode assembly, i. e. plate 11 and rod 14 or plate 12 and rod 15, is made more positive than the other portion and electrons are attracted back to the positive portion of the cathode assembly. When electrons are attracted back to the cathode assembly fewer secondary electrons are generated and the current is reduced in a very sensitive manner.

Referring now to Figure 2, there is shown a schematic diagram and representation of a basic amplifier or modulator circuit in which a gas discharge device constructed in accordance with this invention is utilized. One of the cathode plates of device 10 is connected through transformer 76 and a biasing battery 77 to an input signal by means of input terminals 75. The anode is connected through a load 79 and a supply voltage 78 to ground. The other side of input transformer 76 is connected to the other cathode end plate and is grounded. This tube and circuit permits large current pulses to be passed through load 79 and controlled by voltages on one of the end plates of device 10 as has been described.

Figure 3 is a schematic diagram of a current limiter circuit utilizing gas discharge device 10 constructed in accordance with this invention. The anode of device 10 is connected to output transformer 81 through a rectifier tube 82 and across a filter capacitor 84 of a rectifier power supply. One side of the load 86 is connected to one of the cathode end plates and through a control resistor 85 to the other cathode end plate, while the other side of the load 86 is connected back to transformer 81. When the current through the load 86 exceeds a predetermined value, the potential drop through resistor 85 causes the cathode end plate to become sufficiently positive to stop a discharge in device 10. If the resistance sizes have been so chosen the output current may be reduced to a predetermined value depending upon the type of control that is desired.

Referring now to Figure 4, there is shown another circuit diagram of a current limiter or control circuit utilizing gas discharge device 10. In this diagram the anode of gas discharge device 10 is connected through a load resistance 95 to one side of the input terminals. The other side of the load input terminal and one of the cathode plates of device 10 is grounded, while the other cathode plate of device 10 is connected through a control resistance 94 to the anode and through a control resistance 92 to a center tap of variable resistor 91 that is across the input terminals. If the load resistance 95 is decreased, the potential across control resistance 94 increases and thus the potential of one cathode plate becomes more positive. Due to the fact that the potential on the cathode plate of device 10 becomes more positive, the current to the anode decreases. When desired, the resistance values may be so chosen that the anode current remains constant.

Referring now to Figure 5, there is shown a modification of this invention wherein protuberances 24 and 25 are provided on the cathode plates. This structure permits the use of a solid body for the cathode plate and protuberance. Here again an annular anode 26 is utilized that is spaced around the gap between protuberances 24 and 25 so that electron trapping will occur in the gap between anode 26 and protuberances 24 and 25.

Referring now to Figures 6 through 9 there are shown various structures of gas discharge devices constructed in accordance with this invention. The various structures produce different types of output characteristics but all of the structures are such that control of the electrons trapped in the magnetic field may be readily accomplished as pointed out above.

In Figure 6 there is shown an embodiment of this invention wherein the gap between elongated rod like members 34 and 35 is "off center" with respect to the space between end plates 31 and 32. In the "off center"

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structure elongated rod like member 35 extends through the opening in an annular anode 36 as shown.

In Figure 7 elongated rods 44 and 45 are shown as having portions thereof in juxtaposed relation. Both elongated rods 44 and 45 extend through an aperture in an annular anode 46 as shown. Rods 44, 45 are each supported by a cathode plate 41 and 42 respectively.

In Figure 8 the gap between elongated rod like members 54 and 55 is slanted with respect to cathode end plates 51 and 52 with the ends of members 54, 55 surrounded by anode 56.

In Figure 9 a pair of opposed spaced rod or wire like members 64 and 65 have expanded ends 64' and 65'. An annular anode 66 surrounds the expanded ends 64' and 65' as shown. The expanded ends 64' and 65' are thin metallic disk like members. The vast majority of primary electron emission occurs at the edges of the disk like members 64' and 65' and thus is in the center aperture of annular anode 66.

It is believed obvious that though there are several specific embodiments of this invention shown and described, this invention is subject to wide variations and modifications without departing from the spirit thereof. It is, therefore, intended to cover all such modifications which come within the scope of the appended claims.

I claim:

1. A gas discharge device for operation in a magnetic field comprising a gas tight enclosure having an ionizable medium therein, said enclosure comprising a pair of spaced apart cathode members and an insulating member intermediate the periphery of said cathode members and forming therewith said gas tight enclosure, cathode means within said enclosure supported by each of said cathode members and extending from each of said cathode members toward the other of said cathode members but spaced therefrom, the space between said cathode means being free of solid members, and an anode spaced around said cathode means and spaced from said cathode members within said enclosure.

2. A gas discharge device for operation in a magnetic field comprising a gas tight enclosure having an ionizable medium therein, said enclosure comprising a pair of spaced apart cathode members and insulating means intermediate the periphery of said cathode members and sealed thereto in gas tight relation, a pair of elongated cathodes within said enclosure one extending from each of said cathode members toward the other of said cathodes but spaced therefrom, the space between said cathodes including only said ionizable medium, an annular anode surrounding the space intermediate said cathodes, support means extending through said insulating means and connected to said anode, and means for applying a magnetic field to said device whereby said magnetic field passes through said anode substantially parallel to said pair of elongated cathodes.

3. A gas discharge device for operation in a magnetic field comprising a gas tight enclosure having an ionizable medium therein, said enclosure comprising a pair of spaced apart cathode members and insulating means intermediate the periphery of said cathode members and sealed thereto in gas tight relation, a pair of elongated cathodes within said enclosure one extending from each of said cathode members toward the other of said cathodes but spaced therefrom, the space between said cathodes including only said ionizable medium, an annular anode surrounding one of said cathodes, and support means extending through said insulating means to said anode.

4. A gas discharge device for operation in a magnetic field comprising a gas tight enclosure having an ionizable medium therein, said enclosure comprising a pair of spaced apart cathode plates and insulating means intermediate the periphery of said plates and sealed thereto in gas tight relation, a pair of spaced apart electron emissive rod like members one extending from each of said plates within said envelope and having their free ends

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spaced adjacent to each other, to the space between said rod like members including only said ionizable medium, an annular anode spaced intermediate said plates and spaced around said rod like members, and support means extending from said anode through said insulating means. 5

5. A gas discharge device as in claim 4 wherein said rod like members are coaxial.

6. A gas discharge device as in claim 4 wherein the axis of said rod like members are in juxtaposition.

7. A gas discharge device as in claim 4 wherein the free end surfaces of said rod like members at an angle with respect to said plates. 10

8. A gas discharge device as in claim 5 wherein said rod like members are coaxial, the free ends of each of said rod like members being expanded, and said expanded ends 15 being substantially parallel to said plates.

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