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A. J. HUMPHREY ET AL

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ELECTRIC DISCHARGE DEVICE

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FIG. 1

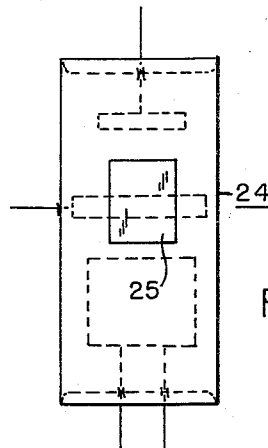
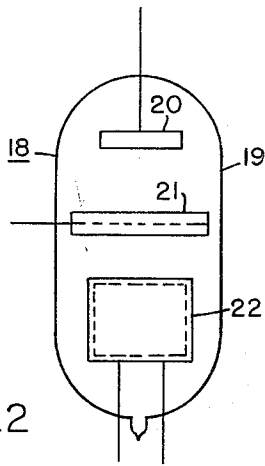
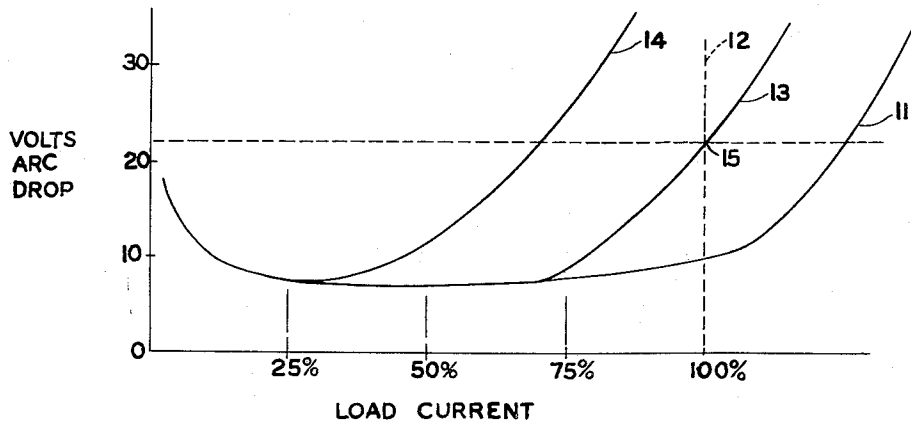


FIG. 3

INVENTORS  
ANDREW J. HUMPHREY  
WILLIAM A. MAIJALA  
BY  
*Woodling and Kroet,*  
*attys.*

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**ELECTRIC DISCHARGE DEVICE**

Andrew J. Humphrey, Cleveland, and William A. Majjala, Burton, Ohio, assignors to The Reliance Electric and Engineering Company

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4 Claims. (Cl. 313-187)

The invention relates in general to electric discharge devices and more particularly to thermionic gas or vapor electric discharge devices.

Two types of gaseous discharge devices are used as rectifiers and grid controlled rectifiers. One type employs a heated emissive surface as a cathode and another type employs an arc cathode. This invention deals primarily with the heated cathode type of device or the general class of hot cathode gas filled rectifying devices, which may also be used as converting devices, but hereinafter referred to as rectifying devices.

One characteristic of a thermionic gas discharge device is the increase in the voltage drop through the device during conduction when the effects of tube aging show up. These effects may be due to a lessening of the inert gas filling of the device, reduction in the emission of the cathode due to deterioration from ion bombardment or through the using up of the emissive coating or perhaps from physical damage due to misuse of the tube. This voltage between elements during conduction is determined by all these factors. This increased voltage drop or arc drop seriously limits the normal useful life of the device, because it increases the watts loss and heating in the device, and lowers its efficiency.

Accordingly, an object of the invention is to provide a means to indicate approaching end of life of the device.

Another object of the invention is to provide a primary medium and a supplemental medium within an electron discharge device.

Another object of the invention is to provide a supplemental gas or vapor in a device and having a higher ionization potential than the primary gas or vapor therein.

Another object of the invention is to provide a means for establishing a different radiation spectrum upon aging of an electron discharge device.

Still another object of the invention is to provide an electron discharge device with a primary gas or vapor having a definite radiation spectrum and also providing a supplemental gas or vapor of a higher ionization potential which increasingly ionizes as the arc drop within the device increases to indicate approaching end of life of the device.

Another object of the invention is to utilize, in an electric discharge device, a supplemental gas of a smaller percentage than the primary medium, and of a higher ionization potential to radiate a different spectrum upon aging, together with a more rugged cathode to withstand ion bombardment.

Other objects and a fuller understanding of this invention may be had by referring to the following description and claims, taken in conjunction with the accompanying drawing, in which:

Figure 1 is a diagram of volts versus current indicating various operational curves of the electron discharge device;

Figure 2 is a diagrammatic showing of a gas or vapor electric rectifier device incorporating the invention; and

Figure 3 is a modified rectifier device incorporating the invention.

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The prior art has known several different types of electron discharge devices and in the rectifier or converter class of gas or vapor filled devices there are at least two common types in use today. One is a device having a fillant in the envelope of xenon and the other one having a fillant of mercury plus an inert gas. This inert gas might be either argon or xenon in present day rectifier devices. This second type of thermionic device usually contains a small pool of liquid mercury to furnish the mercury vapor atmosphere and the pressure thereof is established in accordance with the physical considerations of the device and the amount of cooling. In such prior art devices the inert gas was generally included in the fillant primarily to allow operation when mercury pressure was low due to adverse temperature conditions. In the xenon filled prior art devices one method by which end of useful life could occur was by the occlusion of the fillant on the walls and in the structure of the tube. Since the fillant is an inert gas, chemical combination does not occur but the gas when ionized can, under certain conditions of operation, achieve a velocity which will drive the ion into the solid portions of the tube with such force that it is difficult for the molecule to be released. When this occurs the gas is said to "clean up." This "clean up" effect is essentially limited to ions although nonionized molecules may occasionally be driven into the walls.

Another cause of depletion of the fillant in the xenon tube is sputtering. In this action an ion having a high velocity will knock off a portion of the anode or grid or some other solid portion of the tube and this metal will be sputtered on to the surface of some other portion of the tube. When this occurs gas ions or molecules are sometimes trapped between the sputtered metal and the element upon which it is sputtered. This also results in removal of the useful gas in the tube. As a result of occlusion and sputtering, the available ionizable medium or fillant becomes less; hence, the pressure is reduced and the ionization potential necessary for satisfactory operation of the device becomes greater.

In all the gas or vapor filled thermionic cathode discharge devices, no matter what the primary fillant may be, life may be limited by other factors as well. As previously stated, the emission of electrons from the cathode may be reduced. This may occur in several ways, one of which is deterioration of the electron emissive material, which is generally merely a coating on a base metal. Any misuse of the device, accidental or otherwise, such as overcurrent, overheating, overvoltage, arc-backs and the like, all may damage the cathode emitting surface. All of these aging factors tend to raise the arc drop or voltage drop across the device. This rising arc drop is an unavoidable characteristic of aging, and is utilized in this invention as an indicator of approaching end of life.

The arc drop is the entire drop in voltage between the cathode and anode of the device, and is used to ionize the gas or vapor medium. As the electrons are accelerated from the cathode toward the anode, they ionize the molecules of the fillant, and this ionization neutralizes the space charge which otherwise would exist near the tube elements, as it does in a so-called vacuum tube or device. In operation of such gas or vapor devices, there is found in the vicinity of the electrodes a glow characteristic of the ions carrying current. While light is a secondary product in these rectifier devices, it is necessarily present.

The particular voltage and current under which a gaseous rectifier or thyatron is required to operate will determine the physical spacing between elements and the pressure of the gas fillants in the device. Ordinarily if a rectifier is filled with a gas having a high ionization potential, the addition of even trace amounts of a lower

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ionizing gas will decrease the arc drop markedly and will also decrease the voltage which the device will hold off between elements. The filling of the gas with the lower ionization potential will essentially determine the voltage which can be sustained between elements and the arc drop. Addition of a gas with a higher ionization potential will have very little effect upon the ability of the tube to withstand voltage and upon arc drop. As long as the amount of this supplemental gas is between 10% and 70% of the primary gas, its effects are negligible. Above this proportion some effect on tube operating characteristics can be noted. These effects may not be undesirable for particular types of rectifying devices hence the amount of the supplemental fillant may be considerably above that of the primary fillant.

The amount of the fillant in a discharge device determines the pressure therein. If a high voltage device is required, only a small amount of fillant, e.g. at a pressure of 20 microns of mercury, is used. The low pressure enables the device to withstand the high voltage, both forward and backward, yet the scarcity of molecules of gas limit the current carrying capacity materially, considering the physical size of the device. Conversely, if higher current capacities are required, then more gas molecules and hence higher fillant pressures must be used, which inherently lower the voltage rating of the device. The end result is a compromise of as little gas as one can get by with for a particular current rating in order to meet a desired voltage rating.

The prior art also used mixtures of inert gases or a mixture of vapor such as mercury and inert gases to achieve lower ionization potential of the fillant. This was used for three different reasons; namely, for aid in starting of the device, for improved operation, or for low temperature operation. Additionally, in gaseous discharge devices used as lamps, the mixtures of gases were used to achieve an initial desirable color of the discharge.

The present invention relates to the use of an additional or supplemental gas or vapor for the purpose of indicating approaching end of life of the device. The primary gas or vapor may still be that which has been formerly used; for example, xenon, or mercury plus an inert gas, such as xenon, argon or krypton. The supplemental gas or vapor added in accordance with this invention is one which has a higher ionization potential and an easily detectable different radiation spectrum from that of the primary fillant.

The supplemental gas of this invention is chosen as neon, because of its easily detectable red glow upon ionization, and because its ionization potential of about 22 volts is satisfactorily materially higher than the ionization potential of the commonly used primary fillants. Mercury has an ionization potential of about 10 volts, and xenon has an ionization potential of about 12 volts; therefore, a preferred mixture is the use of xenon as the primary fillant at a pressure of approximately 110 microns of mercury, and a supplemental gas of neon at a pressure of about 60 microns of mercury. Thus during normal operation of the device and during normal life of the device the arc drop or discharge through the device is sustained by the primary fillant of xenon with this arc drop being about 12 volts through the xenon. As the tube or device ages, primarily through the occlusion of the primary fillant, the arc drop tends to rise. As it approaches 22 volts in arc drop the neon supplemental gas will commence to glow. This will cause a characteristic red color of discharge which will be quite distinct from the discharge of xenon which has a violet cast. In the typical glass envelope discharge device this may readily be noticed on observation by untrained personnel, thus signifying that the tube has reached approximately the end of normal life and should be replaced. If a metal envelope discharge device is used it may be provided with a transparent window to observe the change in radiation spectrum.

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A second choice of fillant for electron discharge devices is a primary fillant of mercury plus an inert gas such as xenon, krypton or argon or a combination thereof with the inert gas having a pressure sufficient to allow a degree of operation when the mercury pressure as determined by the physical characteristics of the device and the amount of cooling would be quite low. This inert gas additive is preferably xenon at a pressure in the order of 60 microns of mercury. The supplemental gas would be neon at a pressure of 50 to 70 microns of mercury. In this mixture of fillants the device would have an arc drop of about 10 volts, as determined by the mercury or the low ionizing potential inert gases and after the ionization potential of the neon was gradually approached during life of the device the neon would gradually begin to be ionized and to radiate its characteristic red glow.

A third choice of fillants of the invention is the use of mercury as a primary fillant and neon as a supplemental gas. In this case the neon preferably has a pressure of approximately 90 microns of mercury.

A fourth choice of fillant mixture is a primary gas or vapor of mercury plus argon with the argon being at a pressure of about 60 microns of mercury. The supplemental gas is neon at a pressure of about 50 to 70 microns of mercury. The argon has an ionization potential of about 16 volts; hence, the discharge of the device is primarily through the mercury vapor at about 10 volts arc drop with the argon normally not ionizing and sustaining the discharge except at low temperature operation. Again as end of life of the device approaches the neon will increasingly ionize to radiate its characteristic red glow.

In the preferred fillant described above of xenon plus neon various mixtures have been tried and it has been found that the neon at a pressure of about 60 microns of mercury is quite satisfactory. Ten and fifteen microns of mercury pressure of the neon have been tried but have been found to be insufficient. Thirty five microns of mercury pressure of neon has been tried and the characteristic neon red glow shows up quite well to indicate approaching end of life of the device. If too much neon is included, this tends to lower the ability of the device to withstand the operating potential applied on the anode and cathode; hence, the voltage rating of the device is reduced. Also, if too little xenon is included in the device this harms the satisfactory operation of the device primarily because of lack of current carrying capacity and life.

Figure 1 shows a characteristic operational curve 11 of volts versus amperage. This is a typical arc drop within the device between cathode and anode for different load currents passed by the device. Line 12 indicates approximately the rated current of the device which is designed to utilize the device to approximately its maximum capabilities. This curve 11 shows that normally a device has approximately a 10 volt arc drop through the range of rated current and that this arc drop only increases where the rated current of the device is exceeded. Curve 13 is a curve of the operational characteristics after the tube or device has aged considerably and curve 14 is an operational curve with still further aging. These curves show that the arc drop or voltage drop in the discharge increases considerably in the higher current ranges as the tube ages. As stated above, this is caused primarily by occlusion of the gas or vapor which reduces the total amount of gas or vapor available and ionizable to carry the arc or discharge; hence, the potential required to ionize the remaining fillant increases. With the preferred mixture of xenon and neon the neon begins to glow at about point 15 on curve 13 when the ionization potential of about 22 volts has been reached on this curve 13. The device may continue to be used, of course, dependent on circuit considerations, however, the characteristic red glow of the device indicates that the arc drop within the device has in-

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creased materially and; hence, the efficiency has been likewise materially reduced. This red glow indicates that the device should be replaced for efficient operation, and to prevent further deterioration and complete breakdown.

Figure 2 shows diagrammatically a gas or vapor electric rectifier device 18 which may take any number of forms and the present drawing is only by way of illustration of one form of the invention. This rectifier device 18 includes a transparent envelope 19 to contain the primary and supplemental fillants. This envelope contains the elements necessary to make the rectifier device such as an anode 20, a grid 21 and a cathode 22.

Figure 3 shows a modified rectifier device 24 which is made of metal, and, hence, opaque. In this case a transparent window 25 is provided in a suitable location in the wall of the rectifier device 24 in order to observe the color of the radiation from the gas or vapor within the device 24.

Cathodes of thermionic tubes are subject to sputtering when bombarded with ions above a certain energy level. The cathode commonly used in a gas thyatron is the barium oxide cathode and its damage point is between 20 and 30 volts arc drop. The so-called nickelate cathode will be undamaged at arc drops below 40 to 50 volts and is preferable for the indicating tubes of this invention using neon, which must operate on the indicating gas for an appreciable length of time before the tube is replaced.

A nickelate cathode may be one wherein the electron emissive cathode has a core of one of the metals adjacent to the iron group in the atomic series of elements and on this core there is dissolved an electron emissive compound which comprises one of the metals chromium, manganese, copper and molybdenum, an alkaline earth metal and oxygen. More specifically, the electron emissive cathode may comprise a nickel core with a barium nickelate dissolved therein and having additional barium nickelate forming a spongy surface therefor.

Although this invention has been described in its preferred form with a certain degree of particularity, it is understood that the present disclosure of the preferred form has been made only by way of example and that numerous changes in the details of the circuit and the combination and arrangement of circuit elements may be

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resorted to without departing from the spirit and the scope of the invention as hereinafter claimed.

What is claimed is:

1. In a gas electric rectifier device, the provision of a primary gas of xenon at a pressure in the order of 110 microns of mercury, and a supplemental gas of neon having a higher ionization potential than that of said primary gas and at a lower pressure in the order of 60 microns of mercury.

2. In a gas electric rectifier device, the provision of a primary gas of xenon at a pressure in the order of 95 microns of mercury, a supplemental gas of neon having a higher ionization potential than that of said primary gas and at a lower pressure in the order of 60 microns of mercury, and a cathode in said device having an electron emissive surface including a nickelate compound.

3. In a gas electric rectifier device, the provision of a primary gas of xenon at a given pressure and a supplemental gas of neon having a higher ionization potential than that of said primary gas and at a lower pressure in the order of half said given pressure.

4. In an electric rectifier device, the provision of a primary medium consisting essentially of xenon sustaining the discharge therewithin throughout the normal life of said device, supplemental gas means consisting essentially of neon and in the order of 10 to 50 percent of the total fillant pressure and having a higher ionization potential than that of said primary medium, whereby during normal life the discharge is through the primary medium and as aging raises the arc drop the supplemental gas means increasingly ionizes and emits detectable radiation to indicate approaching end of life of said device, and a transparent portion in the envelope of said device.

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