June 21, 1932. C. G. SMITH 1,863,702

GASEOUS CONDUCTION METHOD AND APPARATUS

Filed April 12, 1926

Fig. 1

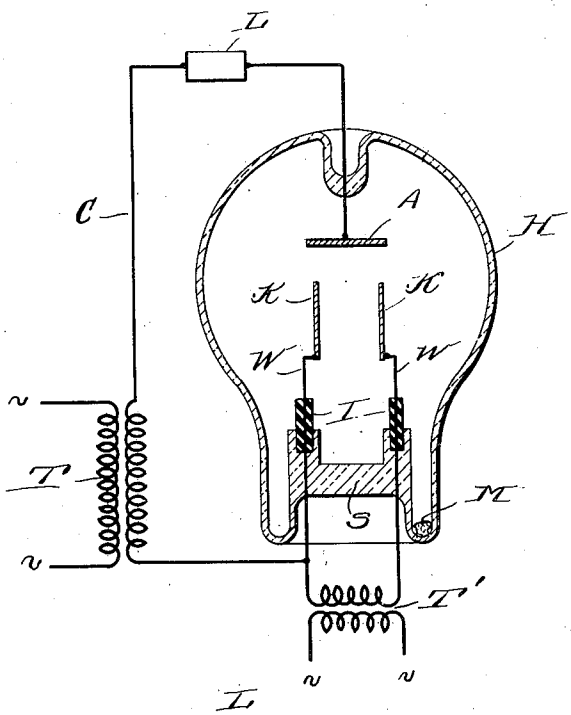
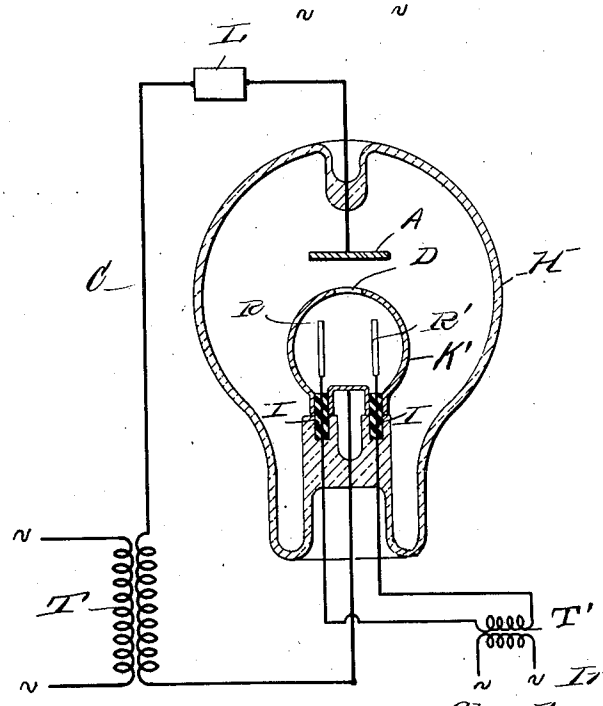


Fig. 2



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UNITED STATES PATENT OFFICE

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GASEOUS CONDUCTION METHOD AND APPARATUS

Application filed April 12, 1926. Serial No. 101,284.

In prior application Serial No. 76,794 filed December 21, 1925, is described a gaseous conduction device having means for producing a high-frequency electrodeless ring discharge, thereby to reduce the voltage drop by ionizing the gas between cathode and anode. According to this invention improved results are obtained by producing a high-frequency discharge between electrode surfaces, one or both of which may be auxiliary electrodes other than the main electrodes of the device. The period of the high-frequency discharge should be substantially confined to the time required for an electron to travel between said surfaces. The liberation of electrons at the electrode surfaces introduces complicated phenomena involving factors of mobility, mean free path, work function, etc. which ordinarily produce the so-called cathode drop, but by employing high frequencies according to this invention (e. g. 10^7 per second) the cathode drop effect is substantially eliminated, presumably because the excursions of the positive ions are small (during each half-cycle) in comparison to the mean free path of the ions. By virtue of the ionization produced by the high-frequency discharge, preferably close to the cathode surface, the cathode-anode discharge may be caused to assume arc characteristics without heating the cathode to temperatures ordinarily employed to produce an arc by thermionic emission, probably for the reason that the number of positive ions falling at any instant upon the electrode is sufficient to account in large measure for the currents flowing between cathode and anode. Consequently large current can be passed through the gaseous medium between the main electrodes with small applied voltages. The effect may be enhanced by confining the region surrounding the active surface of the cathode to restrict radiation, as by making the cathode hollow and producing the high-frequency discharge inside the hollow cathode.

For the purpose of illustrating the genus of the invention, reference may be had to the drawing in which Figure 1 is a view of one embodiment of the invention; Figure 2 is a modified form. In both figures, the invention is shown as applied to rectifiers, and being connected in a circuit in which T represents a transformer and L a suitable load in the direct or pulsating current circuit C.

The tube shown in Fig. 1 comprises a housing H of glass or other suitable material, an anode A and two cathode plates K spaced apart in front of the anode. The cathode plates are mounted on the leading-in wires W which are surrounded by cylinders of insulation I at the points where they enter the re-entrant stem S of the housing H. The gas contained in the housing is preferably one which is readily ionized and therefore for illustration a drop of mercury is shown at M to supply mercury vapor at a suitable pressure. If desired, other gases may be employed in the various embodiments of the present invention, such as caesium, etc., as disclosed in my prior applications.

In operation, the high-frequency discharge is produced between the plates K by means of high-frequency potential difference transmitted through the transformer T'. The resulting high-frequency current, which may have a magnitude of the order of one-tenth ampere or more, ionizes the gas or vapor between the electrodes K, as evidenced by a glow in the space between these electrodes, and as a result of this ionization in the region of the cathode surfaces the main discharge between the cathode surfaces and the anode A may be produced with a comparatively low potential drop between the anode and cathode surfaces.

The embodiment shown in Fig. 2 is similar to that shown in Fig. 1 and corresponding parts are correspondingly designated. However, the cathode is in the form of a hollow box K^1 which is approximately spherical. This box has a discharge opening D opposite the anode, and at the bottom it has two cylindrical protuberances fitting over the insulating sleeves I. The high-frequency transformer T' is connected to two rods R and R' spaced from each other within the hollow cathode, instead of being connected to the cathode surfaces as in Fig. 1. When a high-frequency discharge is produced between the

rods R and R′ the gas within the hollow cathode is ionized, thereby practically eliminating the cathode drop at the interior surface of the cathode, the main discharge passing between the interior surface of the cathode and the anode through the opening D by virtue of the high state of ionization inside the cathode. By confining the radiation generated inside the hollow cathode, the state of ionization may be enhanced and maintained with less loss of energy. Inasmuch as the ionized region is surrounded by the cathode K′ the latter serves to confine the radiation and the conservation of radiation may be still further effected in various ways as disclosed in my prior applications. For example, the loss of radiation through the cathode K′ may be greatly reduced by making the inside surface of the cathode brightly reflecting. As in the case of the embodiment shown in Fig. 1, the form shown in Fig. 2 may employ any suitable gas at the pressure best suited to the particular use for which the device is intended.

Obviously the invention may be applied in ways differing widely from the two embodiments chosen for the purpose of illustration, and the claims are therefore intended to be merely illustrated and not limited by the figures.

I claim:

1. The method of producing a gaseous discharge having arc characteristics between a cathode and an anode in a sealed vessel filled with gas at substantial pressure, which comprises maintaining in the gaseous body adjacent said cathode an auxiliary high frequency discharge of the order of one-tenth of an ampere and of a frequency of the order of 100,000 cycles per second or more to ionize the gas adjacent the cathode and to impart to the discharge to the anode the character of an arc.

2. The method of producing a low voltage gaseous discharge between a cathode aggregate comprising a pair of spaced electrodes and an anode in a discharge device having a sealed vessel filled with gas at substantial pressure, which comprises maintaining between said spaced electrodes an independent high frequency discharge having a period confined to the time required for an electron to travel between said spaced electrodes.

3. A unidirectional gaseous conduction device comprising a sealed vessel containing a gas filling of substantial pressure, an anode, a cathode aggregate having an extended cathode surface, said cathode aggregate having associated therewith a pair of spaced electrodes, means for maintaining between said pair of spaced electrodes a high frequency space current ionizing the gas between said electrodes to a degree at which a discharge having arc characteristics is produced between said anode and said cathode aggregate, said cathode aggregate including means constituting an enclosure around the gas adjacent the cathode surface between said spaced electrodes to conserve the energy and the ionization of the gas adjacent to the cathode surface.

4. A unidirectional gaseous conduction device comprising a sealed vessel containing a gas filling of substantial pressure, an anode, a hollow cathode having an extended interior electrode surface, and means including additional electrode means within said hollow cathode for maintaining in the gas inside thereof a high frequency discharge ionizing the gas enclosed in said hollow cathode to a degree at which a discharge having arc characteristics is maintained between said cathode and said anode.

5. A unidirectional gaseous conduction device comprising a sealed vessel containing a gas filling of substantial pressure, an anode, a cathode aggregate comprising a pair of spaced electrodes, and means for maintaining between said pair of spaced electrodes, a high frequency space current ionizing the gas between said electrodes to a degree at which a discharge having arc characteristics is produced between said anode and said cathode aggregate, the period of said high frequency space current being not larger than approximately the time necessary for an electron to travel under the applied voltage between the high frequency discharge surfaces.

6. A unidirectional space current device comprising an envelope containing a gas, a cathode and an anode spaced from each other within said envelope, means adjacent said cathode enclosing adjacent the surface of said cathode a body of ionizable gas adapted to sustain a gaseous discharge, a pair of spaced electrodes disposed in the enclosed space, and high frequency inducing means connected to said pair of spaced electrodes for producing in the enclosed gas a high frequency discharge ionizing said gas to provide electric carriers for maintaining a discharge between said cathode and said anode having arc characteristics.

Signed by me at Boston, Massachusetts, this 8th day of April 1926.

CHARLES G. SMITH.