May 21, 1929. C. G. SMITH 1,714,403

ELECTRICAL APPARATUS

Filed July 30, 1923

Fig. 1

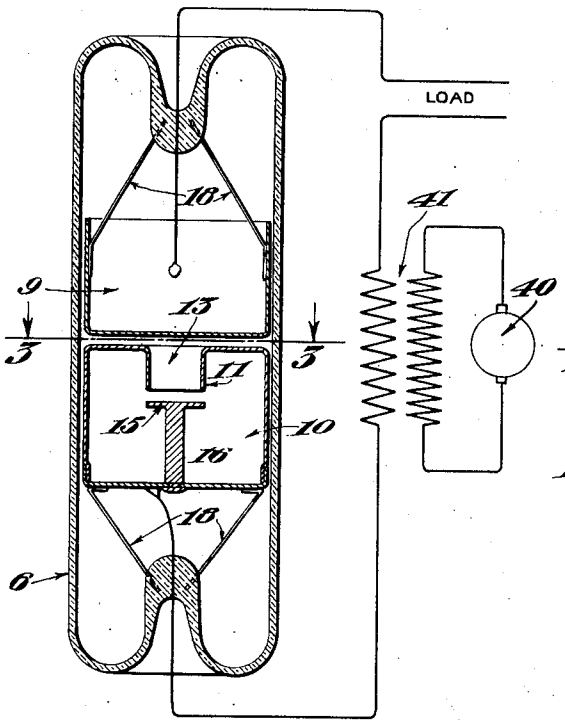


Fig. 2

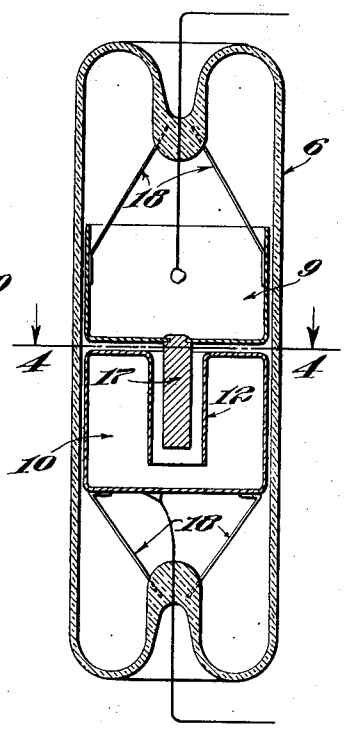


Fig. 3

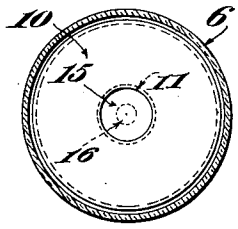
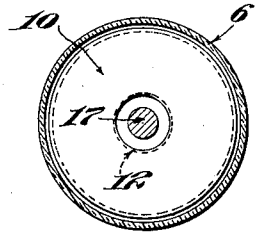


Fig. 4



Witness

M. G. Orgain

Inventor

Charles G. Smith

by his Attorneys

Van Everen Fish Hitchcock & Cary

Patented May 21, 1929. 1,714,403

UNITED STATES PATENT OFFICE.

CHARLES G. SMITH, OF MEDFORD, MASSACHUSETTS, ASSIGNOR, BY MESNE ASSIGNMENTS, TO RAYTHEON INC., OF CAMBRIDGE, MASSACHUSETTS, A CORPORATION OF MASSACHUSETTS.

ELECTRICAL APPARATUS.

Application filed July 30, 1923. Serial No. 654,642.

The present invention relates to electrical apparatus and more particularly to the type of electrical apparatus disclosed in the patent to Smith 1,617,179 granted Feb. 8, 1927.

The patent referred to above discloses a novel type of electrical rectifying apparatus which operates to control the lengths of electron paths between electrodes in a gaseous medium by the formation of a space charge of positive ions. In its simplest and best known form the invention comprises a hollow cathode provided in one face with an opening, which is spaced from the surface of a cooperating anode by a distance which is short and comparable to the mean free path of electrons in the gas in which the electrodes are immersed. By means of the opening in the hollow cathode, electrons passing from the interior of the hollow cathode to the anode are enabled to take sufficiently long paths to initiate gaseous conduction. This conduction, however, forms within the hollow cathode a space charge of relatively immobile positive ions, which remain therein for a considerable length of time. Upon a reversal of potential, electrons leaving the region adjacent the anode are blocked from entering the cathode and are thus restricted to short paths, thereby rendering conduction impossible, as explained more particularly in a patent to Smith 1,545,207 granted July 7, 1925. Devices of this type have a fairly low voltage drop and may be used as rectifiers with high efficiency.

The object of the present invention is to provide improvements in apparatus of this general type in order to extend the range of operation and to allow the use of higher voltages.

With this object in view, one feature of the invention provides for the more positive limiting of electrons in the reverse direction to short paths without appreciably affecting the paths of electrons traveling from the hollow cathode to the anode.

Other features of the invention consist of certain novel features of construction, hereinafter described and claimed, the advantages of which will be apparent to those skilled in the art upon reference to the following description.

In the drawings Fig. 1 is an elevation in section of an apparatus embodying the features of the present invention shown in connection with a simple rectifying circuit; Fig. 2 is a sectional elevation of a modification of the invention; Fig. 3 is a section on line 3—3 of Fig. 1; and Fig. 4 is a section on line 4—4 of Fig. 2.

The illustrated embodiment of the invention provides a conducting surface adjacent the opening in the cathode for the purpose of positively determining the selective operation upon the electron paths. To this end, two modifications of the invention are shown, the first employing such a conducting surface connected with the cathode and the second employing the desired surface in cooperation with the anode. In the first modification a baffle plate is preferably placed opposite the opening in the cathode and spaced a short distance therefrom. By this means electrons passing from the interior of the cathode are enabled to take curved paths between the baffle plate and the opening and pass therefrom to the anode. However, upon reversal of potential the electron paths, because of their inertia, are unable to follow the electrostatic lines of force through all their convolutions and therefore impinge upon the baffle plate without having traversed sufficiently long paths to initiate conduction. The second modification employs a long axial pin connected to the anode and extending into a concentric well formed in the cathode in such a manner that the interior surface of the cathode performs the same function as the baffle plate in the other modification.

Referring to Figs. 1 and 3, the first modification of the invention comprises a receptacle 6, preferably of glass, filled with an inert gas such as helium. Supported within the receptacle are an anode 9 and a cathode 10 of conducting material, the latter being hollow and having a surface opposing that of the anode and separated therefrom by a distance which is short and comparable to the mean free path of electrons in the gas, that is a distance such that electrons traveling directly across the gas space between the electrodes produce insufficient ionization to initiate substantial conduction, the mean free path of the electrodes being understood to be the average distance traversed by the electrons without ionizing impact with gas molecules (or atoms). This surface of the cathode is provided with an opening about which

extends a sleeve 11 enclosing a circular passage 13. Opposing this passage and spaced a short distance from the sleeve 11 is provided a baffle plate 15, which is supported upon a suitable pin 16 riveted or otherwise attached to the rear surface of the cathode. Both electrodes are supported in the receptacle by suitable straps 18 sealed into the receptacle. The simple rectifying circuit shown in Fig. 1 comprises a generator 40 and a transformer 41, the secondary of which is connected in series with the electrodes 9 and 10 and with a suitable load indicated in the figure. As previously stated, this form of the invention depends, in addition to the space charge effect, upon the selective action of the baffle plate in allowing electrons to pass from the hollow cathode to the anode and in cutting short the paths of electrons passing from the anode to the cathode. With this arrangement, it is possible to operate the device at much higher voltages with a better degree of rectification than the simpler type without the baffle plate.

The modification shown in Figs. 2 and 4 comprises also an anode 9 and a cathode 10 immersed in a receptacle 6 and having opposite faces separated by distances which are short and of the order of magnitude of the mean free path of electrons in the gas. In this case, however, the cathode is provided with a long sleeve 12 extending nearly to the internal surface of the cathode. The anode is provided with a pin 17 extending into the well surrounded by the sleeve 12. In order to prevent disappearance of the gas and deterioration of the electrodes, it is desirable to enclose in the cathode a small amount of conducting material which becomes liquid at the operating temperatures of the device. A suitable material for this purpose is pure tin which melts at 232° C. and which has a very low vapor pressure at ordinary operating temperatures. The surface of the tin should come fairly close to the end of the sleeve 12 in order that it may serve the same purpose as the baffle plate shown in Fig. 1. By this means also it is possible to employ fairly high voltages and obtain a high degree of rectification, that is to say, a condition in which practically no current passes from the anode to the cathode under a reverse potential.

I claim:

1. A gaseous discharge device comprising a tube containing a hollow electrode, another electrode presented to the interior of the hollow electrode, said electrodes having adjacent surfaces within an insulatingly short distance from each other, and a projection extending inwardly of and from the hollow electrode.

2. A gaseous discharge device comprising a tube containing a hollow cathode, an anode presented to the interior of the hollow cathode, said electrodes having adjacent surfaces within an insulatingly short distance from each other, and a projection extending inwardly from the hollow cathode.

3. A gaseous conduction discharge tube comprising an envelope housing a gas, a hollow cathode having a reentrant opening and an anode spaced from said opening an insulating distance, said cathode housing a baffle projecting from its inner wall to a point adjacent the inner end of said reentrant opening.

CHARLES G. SMITH.