G. S. MEIKLE.

RECTIFIER AND THE METHOD OF OPERATING THE SAME.

APPLICATION FILED OCT. 9, 1914.

1,182,290. Patented May 9, 1916.

Fig. 1.

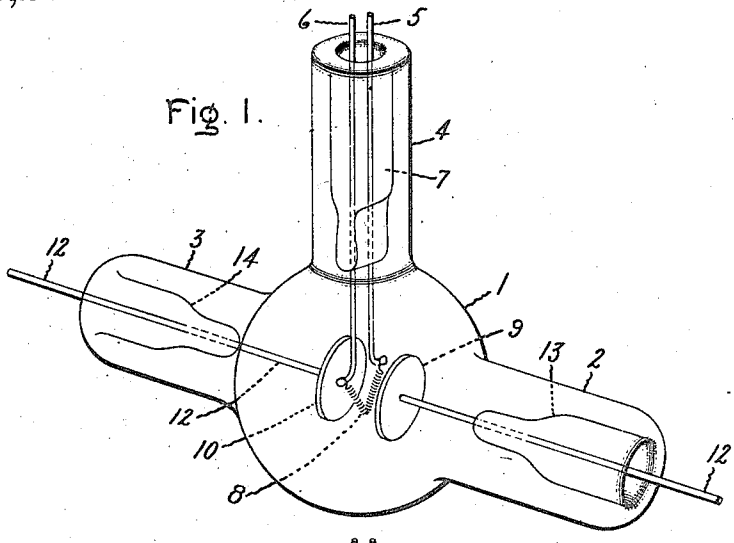


Fig. 2.

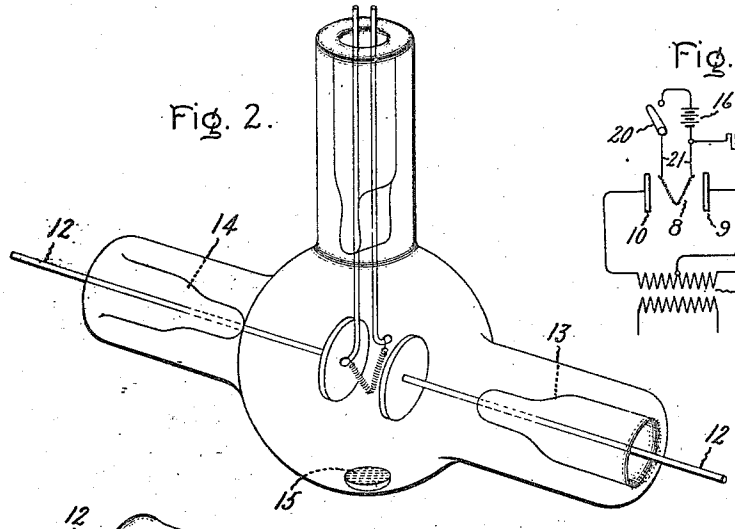


Fig. 4.

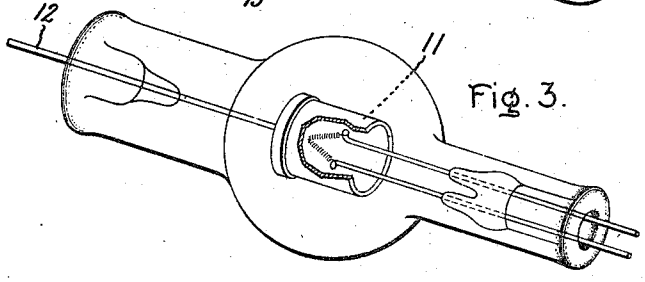


Fig. 3.

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UNITED STATES PATENT OFFICE.

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RECTIFIER AND THE METHOD OF OPERATING THE SAME.

1,182,290. Specification of Letters Patent. Patented May 9, 1916.

Application filed October 9, 1914. Serial No. 865,836.

To all whom it may concern:

Be it known that I, GEORGE STANLEY MEIKLE, a citizen of the United States, residing at Schenectady, in the county of Schenectady, State of New York, have invented certain new and useful Improvements in Rectifiers and the Method of Operating the Same, of which the following is a specification.

The present invention relates to the rectification of alternating current of a current and voltage range comparable to the range of the mercury arc rectifier, and is embodied in a device having an electron-emitting cathode, and an anode or anodes.

My device is distinguished in one aspect from various prior devices containing an incandescent cathode by the presence of an inert gas at a considerable pressure, as distinguished, for example, from the highly attenuated residual trace of gas present in an envelop exhausted to what is termed a "lamp vacuum." Although no very definite lower limit of pressure can be assigned, for practical purposes the gaseous pressure should not be much below one millimeter of mercury as at very much lower pressures a rapid electrical disintegration of the cathode occurs. The electrical characteristics of my new rectifier are substantially those of an electric arc.

My invention is embodied in a device containing a cathode of highly refractory material, such, for example, as tungsten, and an anode or anodes having a heat dissipating capacity enabling continuous operation at a given rated capacity at a temperature below about 727° C., at which temperature electron emission is relatively negligible, this device being filled with an inert gas of relatively appreciable pressure, preferably of the order of magnitude of atmospheric pressure. Electro-negative gases, such as water vapor, oxygen, chlorin, or the like should be carefully excluded.

My invention will be more completely understood by reference to the following description taken in connection with the accompanying drawings, of which—

Figure 1 illustrates a device embodying my invention containing an inert gas non-condensable at room temperature; Fig. 2 illustrates a modification in which a mercury atmosphere is employed; Fig. 3 illustrates one particular form of a half-wave rectifier; and Fig. 4 is a diagram of suitable electrical connections.

As shown in Figs. 1 and 2, the full wave rectifier in its simplest form comprises an envelop 1, which conveniently consists of glass and has three side arms 2, 3 and 4 provided for the convenience of sealing in the leading in conductors. The cathode conductors 5, 6 may, for example, consist of tungsten sealed directly into a stem 7 of low-expansion glass, such, for example, as sodium-magnesium boro-silicate, although any convenient seal may be used. The cathode comprises a filament 8 of tungsten, or other highly refractory material. The cathode is heated to incandescence during operation from any convenient source of current, for example, a battery as indicated at 16, Fig. 4. In some cases, the heating current may be cut off after the discharge or arc is started, particularly when the gaseous atmosphere is at high pressure, and enough energy will be liberated by the arc to maintain a portion of the cathode at a sufficiently high incandescence.

A clean, refractory metal, such as tungsten, at incandescence is a primary source of electrons as distinguished from a refractory oxid which appears to be a secondary source due to some obscure ionization phenomenon. As indicated in the drawing, the cathode filament is conveniently coiled so as to minimize the heat losses and at the same time provide maximum surface within a given space.

The anodes 9, 10, are relatively much larger than the cathode and may be conveniently of the form of disks, although, as shown in Fig. 3, the anode 11 in the half wave rectifier to advantage may have been the form of a cup or cylinder surrounding the cathode. The anodes preferably consist of tungsten although other highly refractory materials may be used. The anode terminals 12 also preferably consist of tungsten and may be sealed directly into stems 13, 14 of low expansion glass.

The envelop is first very carefuly evacuated and baked out at as high a temperature as the glass will stand without softening so as to remove residues of air and water vapor. Unless the anodes have been freed from gas previous to mounting, for example, by heating to a high incandescence in a vacuum, they should be freed from

deleterious gases in the tube by electron bombardment by impressing between the cathode while at incandescence and the anode to be purified a voltage high enough to cause an electron current to flow but insufficient to produce appreciable positive ionization. Deleterious gases are thereby driven out of the anode. The evacuation may then be continued and the voltage progressively increased as gas is removed. This method is disclosed and claimed in an application, Serial No. 795,610 filed by Irving Langmuir. A quantity of inert gas, such as nitrogen, argon, neon, krypton, or a globule of mercury, as shown at 15, Fig. 2, or a mixture of gases, is then introduced into the envelop. The gas is preferably at a relatively considerable pressure, for example, at a pressure varying from about one centimeter of mercury pressure upward to atmospheric pressure. No definite lower limit of pressure can be assigned, but the pressure should be high enough to largely suppress electrical disintegration of the cathode by the bombardment of ions. When the cathode operates in mercury vapor lower pressures are permissible than when the cathode is operating in a gas, such as argon or nitrogen. When the gaseous pressure is low, for example, in the case of mercury vapor, below about one centimeter of mercury, depending on the voltage, it is practically necessary to provide for greater electron emission at the cathode than necessary to convey the current, for example, by increasing the temperature of the cathodes. Thereby a negative field is established about the cathode, and the bombardment of the cathode by positive ions, and its disintegration is reduced by the presence of these electrons which apparently return to the cathode. In this manner it is possible to operate the cathode with a commercially fairly long life in gaseous pressures as low in the case of mercury vapor as one millimeter or even below.

At the higher pressures the electrical disintegration, or sputtering, of the cathode is correspondingly less and the useful life of the device is correspondingly longer, so that a high electron emission is not necessary to give a long life although, of course, a high electron emission may also be employed even at higher gas pressures. The thermal disintegration is also less at higher gas pressures. As the pressure of the gas increases beyond a certain limit varying with the nature of the gas, and which is in the case of mercury vapor about one centimeter of mercury pressure, the voltage drop in the tube increases. In most cases, however, it is desirable to operate at a gas pressure substantially above the region of minimum voltage drop in order to secure a fair life. However, when currents of low voltage are to be rectified and the highest efficiency is desired, the voltage drop permissible may make it desirable to sacrifice life to efficiency to some extent, and, therefore, to operate at the pressure of minimum voltage drop, but ordinarily this is not desirable.

When mercury vapor is used as the ionizable gas it should be understood that the size of the envelop should be so proportioned that it will operate at a temperature at which sufficient quantities of mercury will be vaporized to give the desired pressure of mercury vapor.

As shown in Fig. 4, the anodes 9, 10 may be connected to the terminals of a source of alternating current, such as the secondary of a transformer 17, the cathode 8 being connected to an intermediate point of potential in series with a load 18, and a series resistance 19. The device is started after suitable connections have been made by closing the switch 20 in the heating circuit 21 and heating the cathode to incandescence.

The anodes should be made of such size that heat will be dissipated from them at such rate that they will remain below the temperature at which appreciable electron emission occurs so as to prevent passage of current in the reverse direction when the anode is negative.

With a rectifier constructed as illustrated and above described, currents of many amperes depending on the size of the apparatus can be rectified without discharge of any current in the reverse direction with a low voltage drop, which in mercury vapor is about 8 to 15 volts, and which varies somewhat dependent upon the nature of the gas filling, temperature of the cathode, pressure of the gas, and similar conditions. When the current to be rectified has a voltage up to several hundred volts, the cathode and anodes are located relatively close together, as indicated in the drawing, but when the voltage is substantially higher than this the distance between the cathode and the anodes should be correspondingly increased.

The discharge is normally confined to a relatively narrow zone between the cathode and the anode, and has the general appearance of an ordinary open air arc. The electrical characteristics of the device are those of an arc, that is, an increase of current produces little appreciable instantaneous change of voltage. However, inasmuch as an increase of current will also increase the gas pressure, an increase of current is accompanied by an increase of voltage drop if sufficient time has elapsed for an adjustment of pressure. The instantaneous value of the voltage across the terminals must be lowered by an increase of current, as two rectifiers can not be operated in parallel

without some provision being made to divide the load.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. A rectifier comprising the combination of an envelop, a tungsten cathode, an anode of refractory material having a heat dissipating capacity great enough to operate below the temperature at which appreciable electron emission occurs, and an atmosphere of mercury vapor in which electro-negative gaseous impurities are absent at a pressure high enough to substantially prevent the electrical disintegration of the cathode.

2. A low voltage rectifier comprising the combination of an envelop, a tungsten cathode, an anode having a heat dissipating capacity great enough to operate below the temperature at which appreciable electron emission occurs, means for heating said cathode, and a quantity of mercury in said envelop which at the normal operating temperature of the device will have a pressure at which the electrical discharge is contracted into a comparatively restricted zone between the electrodes and said discharge has the electrical characteristics of an arc.

3. A rectifier comprising the combination of an envelop, a refractory cathode operable at a temperature of at least about 2000° C., an anode operable continuously below about 727° C. and a filling of gas inert with respect to the cathode at high temperatures, the pressure of said gas being substantially between the limits of about a centimeter of mercury and atmospheric pressure.

4. A rectifier comprising the combination of an envelop, a cathode consisting of conducting material operable without melting at a temperature in excess of about 2000° C., an anode large enough to operate below the temperature at which appreciable electron emission occurs, and an atmosphere of gas in said envelop inert with respect to the cathode at high temperature at a pressure high enough to substantially suppress electrical disintegration of the cathode.

5. A rectifier comprising the combination of an envelop, an electron emitting cathode, an anode having sufficient heat dissipating capacity to enable it to operate continuously below the temperature at which appreciable electron emission occurs, and an atmosphere of inert gas in said envelop at a pressure of at least about one millimeter of mercury at the operating temperature.

6. The method of reducing the disintegration of an electron-emitting incandescent cathode operating in a gaseous pressure low enough to permit considerable electrical disintegration of said cathode, which consists in increasing the temperature of the cathode to a value higher than necessary to convey the operating current whereby a negative electric field is established about said cathode by free electrons.

7. A rectifier comprising the combination of an envelop, a cathode of refractory material operable at incandescence above a temperature of about 2000° C., an anode having a heat-dissipating capacity great enough to be operable below the temperature at which appreciable electron emission occurs, and a filling of dry gas having at the operating temperature of the device a pressure of at least about one centimeter of mercury, said gas being inert with respect to the electrodes at the operating temperature.

8. A rectifier comprising the combination of a sealed envelop, a tungsten cathode, an anode having a heat dissipating capacity great enough to be operable below the temperature at which appreciable electron emission occurs, and a filling of gas inert with respect to the cathode when at incandescence and having at the operating temperature of the device a pressure materially above one millimeter of mercury, whereby electrical disintegration of the cathode during operation is substantially suppressed.

In witness whereof, I have hereunto set my hand this 8th day of October, 1914.

GEORGE S. MEIKLE.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.