May 27, 1930. H. C. RENTSCHLER ET AL 1,760,525

RECTIFIER

Filed Dec. 15, 1926

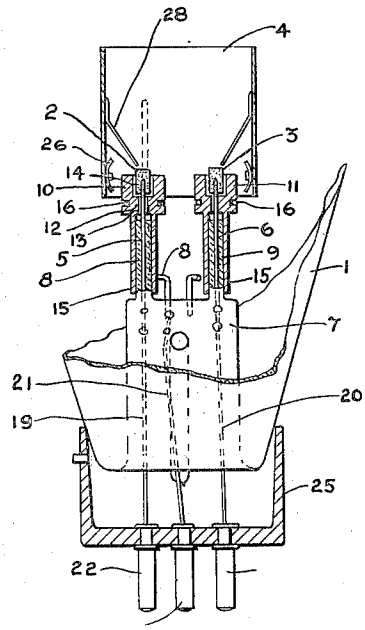


Fig. 1.

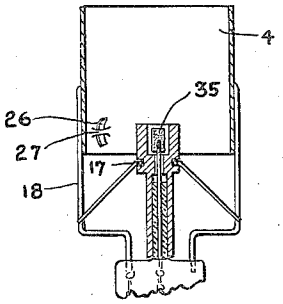


Fig. 3.

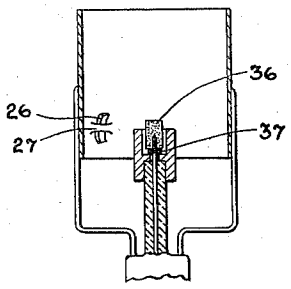


Fig. 4.

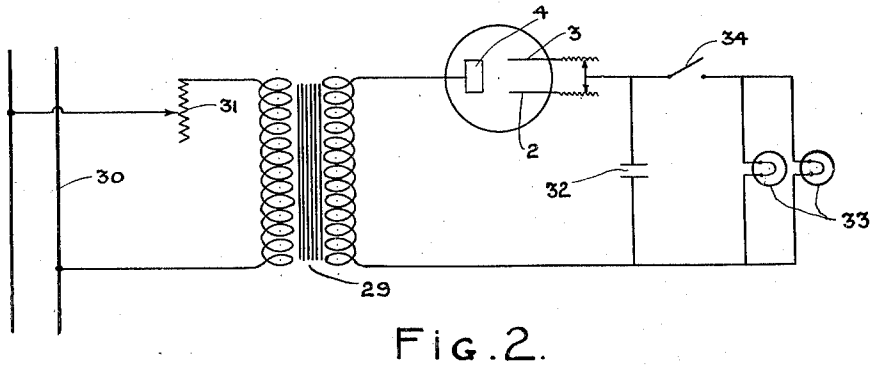


Fig. 2.

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UNITED STATES PATENT OFFICE

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RECTIFIER

Application filed December 15, 1926. Serial No. 154,987.

This invention relates to electric discharge devices and more particularly to glow discharge devices in which a rarefied gaseous atmosphere is employed. The invention is especially concerned with the production of a gaseous discharge rectifier of alternating current employing a monatomic gas such as argon, neon or helium or a mixture of such gases and depending in part at least, upon the point-to-plate discharge principle and in part to the dissimilarity of the electrode materials.

Considerable difficulty has hitherto been experienced in producing alternating current rectifiers of this type capable of operation at high potentials, which depend on gas ionization for conduction of the current and are independent of thermionic emission. Among the most serious difficulties is the disintegration or decomposition of the insulation surrounding the point electrode. This decomposition of the insulation produces a conducting film on the insulation, thus increasing the effective area of the point electrode and causing back current to flow through the rectifier in considerable amounts.

Another source of trouble with this type of device is the disintegration of the point electrodes, causing destruction of the electrodes and forming conducting deposits on the insulation, thus increasing the back current or causing electrical leakage between the electrodes. Ion bombardment of the interior surface of the envelope is also an objectionable feature in such devices, resulting in the release of gases from the walls of the envelope and contaminating the gaseous filling. This contamination of the gaseous filling increases the starting and operating potential of the device and produces a large increase in the potential drop through the rectifier, often causing it to become entirely inoperative.

One of the objects of the present invention is to produce a gaseous discharge rectifier capable of supplying relatively high voltage direct current which will overcome the above mentioned difficulties and which will have a long life, uniform operating characteristics and a low voltage drop.

Another object is to produce such a device in which the discharge will be substantially entirely in one direction, that is, in which the back current will be sufficiently small to be unobjectionable.

Another object is to provide an improved electrode construction and a method of treating the electrode so as to reduce the back current in the device, due to impurities in the electrode to an unobjectionable degree.

Other objects and advantages will hereinafter appear.

We have found that when the anode of a point-to-plate discharge device utilizing a monatomic gas at suitable pressure is composed of carbon or graphite properly isolated from its surrounding insulation and suitably disposed with respect to the cathode and when the active cathode surface is formed of a suitable material and the residual gases and impurities thoroughly removed from the device and from the electrodes so that the carbon or graphite anode is free from impurities and the device contains only a pure inert gas, the discharge between the electrodes takes place almost entirely in one direction even at high voltages.

The carbon or graphite anode, we have found, overcomes the difficulties which heretofore have been experienced, due to disintegration of the anode in operation. The graphite, however, must be specially treated to completely remove all gases and impurities therefrom since otherwise the back current may be objectionably high. The carbon or graphite anode should be as pure as is commercially obtainable and should preferably be treated out after incorporation into and sealing off of the device by appropriate electrical treatment to complete the purification and degasification thereof. We have found that the back current with graphite electrodes is much smaller than with metal, so that for the same degree of rectification it is possible to employ much larger graphite anodes than is possible with metallic anodes. In place of the carbon anode, a metal such as thorium, uranium or titanium may be employed.

The insulation adjacent the anode is dis-

posed out of contact with the active portion of the anode in such manner as to hinder the heating and consequent decomposition of the insulation, due to the discharge and the insulation is so arranged as to preclude the formation of continuous conducting paths between the anode or the anode leads and such portions of the insulation as are capable of being rendered conductive either by dissociation of the insulating material or deposition of the electrode material thereon.

The ion bombardment of the insulating portions of the device, such as the interior surface of the envelope, may be reduced to an inappreciable amount by employing argon as the gaseous filling. We have discovered that at the gas pressure necessary for operation of the device, that the discharge in argon is confined very closely to the space between the electrodes and does not extend to any extent to the walls of the device.

Low starting and operating potential may be obtained by employing a metallic getter, such as misch metal, on the cathode which serves not only as a clean-up agent to remove gaseous impurities initially, but also serves throughout the life of the device to maintain the gaseous filling in a pure condition. The misch metal, moreover, forms an active surface on the cathode of low cathode drop and thereby greatly facilitates the discharge.

In order that the invention may be more fully understood, reference will be had to the accompanying drawing in which:

Fig. 1 is an elevation partly in section of a full wave rectifier embodying the present invention;

Fig. 2 is a diagrammatic arrangement of apparatus employed in treating the electrodes and developing the starting and operating characteristics of the device;

Fig. 3 is a sectional view of the electrode assembly of a half wave rectifier of slightly modified construction;

Fig. 4 is a further modification of a half wave rectifier.

The device shown in Fig. 1 comprises an envelope 1 containing a pair of anodes 2 and 3, a cathode 4 and a filling of monatomic gases or a mixture of gases such as argon, neon or helium. Argon, however, is preferred since it causes the discharge to be restricted substantially to the interelectrode space, whereas with both the neon and helium at high voltages, intense ion bombardment of the glass envelope may take place.

The anodes 2 and 3 are preferably composed of carbon or graphite and are carried by support wires 5 and 6, which also serve as current conductors and are sealed in the press 7 of the device. In order to restrict the discharge to the anodes 2 and 3, the support wires are enclosed in glass or quartz sleeves 8 and 9 and immediately adjacent the anodes both the support wires and the glass sleeves are protected by highly refractory insulating material, such as sleeves 10 and 11 of lavite. Each of the lavite sleeves is provided intermediate its ends with a web 12 having a perforation 13 through which the support wire extends. One end of each of the anodes 2 and 3 is threaded interiorly for attachment to the threaded end 14 of the support wire. For a reason which will appear more fully hereinafter the anodes and their support wires are spaced a slight distance from the interior surface of the lavite sleeve, and the web portion 12 of the lavite sleeve is spaced away from the end of the glass or quartz tubes. In order to maintain the parts accurately in concentric spaced relation the support wires 5 and 6 fit rather closely in the bore of the glass or quartz sleeves 8 and 9 and the cylindrical lower portion 15 of each of the lavite sleeves closely engages the glass tubes. Intermediate their ends, each of the lavite sleeves is provided with a circumferential groove 16 in which a wire 17 is wrapped and one or both ends of this wire welded or otherwise suitably secured to the support wires 18 from which the cathode is supported. This is more clearly seen in Fig. 4.

The cathode 4 is of cylindrical shape and preferably formed of iron although molybdenum may also be used if desired.

The anodes 2 and 3 and the cathode 4 are provided with current conducting leads 19, 20 and 21 connected to the terminals 22, 23 and 24 respectively, of the base 25. A piece of misch metal 26 which for convenience may be in the shape of a wire or ribbon, is secured to the cathode 4 in any desirable manner, such as welding, but as shown is retained in place by a strap 27 struck up from the surface of the cathode. The plate is treated out and the misch metal is vaporized either before or after the gaseous filling is introduced by high frequency induction current. Starting tips or wires 28 may be secured to the cathode and the free ends brought into proximity to the end of each of the anodes to get lower and more uniform starting voltage during the life of the rectifier.

The pressure of the gaseous filling depends upon the particular gas or mixture of gases used. For example, with argon the pressure is preferably of the order of 5 mm. of mercury, whereas with neon or helium it is necessary to use a considerably higher pressure in order to obtain the requisite operating characteristics. In general, a gas pressure of from 2 to 10 mm. may be employed, depending upon the gas used and the current output desired.

After the device has been sealed off, it is necessary to subject the same to a seasoning treatment in order to develop the starting and operating characteristics thereof, degasify the anodes and clean-up all of the gaseous

impurities coming from the anode assembly or from the cathode so that the tube will contain only pure inert gas. This may be accomplished by the apparatus shown in Fig. 3 which comprises a step-up transformer 29, the primary winding of which is connected to an alternating current source 30 through a resistance 31 or other suitable voltage regulating device. The secondary of the transformer has one terminal connected to the cathode 4 of the device and the other terminal of the secondary is joined through a condenser 32 to the anodes 2 and 3. A load 33 in parallel to the condenser 32 may be thrown in or out of the circuit by a switch 34.

The cathode 4 is first degasified and thus treated out during the high frequency flashing process which vaporizes some of the misch metal and renders the gas filling pure. The anodes 2 and 3 are then best treated by passing a discharge through the device in such manner as to heat the same, thus liberating the impurities and gases therefrom. Referring to Figure 3, if the switch 34 is left open the condenser 32 charges up from the rectified current and on the reverse cycle when the anodes become negative, imposes a relatively high potential between the anodes serving as a cathode and the cylinder or plate as anode, thus heating up the graphite anodes and liberating the gases and impurities therefrom. During all this time the misch metal on the plate and that which has been vaporized, takes up the impurities liberated from the anode and maintains the gas pure. In some cases it may be necessary to then operate the device with the load 33 in the circuit, causing a sufficiently heavy discharge to pass between the plate 4 and the anodes to vaporize more of the misch metal from the plate and thus further clean such impurities as have been liberated from the anodes during the treatment before described.

If desired, in place of using the arrangement shown in Fig. 3 a high voltage direct current discharge may be passed through the device in such direction as to render the electrodes 2 and 3 negative and then in a reverse direction so as to make the electrode 4 the cathode.

The anodes 2 and 3 are spaced from the lavite sleeves a slight distance so as to prevent the discharge from coming in contact with the lavite and decomposing the same. Referring to Fig. 1, for instance, if the anode 2 and the lavite sleeve 10 were in contact, the discharge at the point of contact between these two members would heat up the insulation and decompose the same with the formation of a metallic surface thereon, and causing the back discharge to be largely concentrated at this point thus producing further heating and reduction of the insulation. In a short time the entire insulator may be rendered conductive and instead of having a small anode, the effective area of the electrode may include the entire exterior surface of the insulator, thus very materially increasing the back current and lowering the efficiency of the rectifier. By spacing the electrode and the insulator from each other, there is little likelihood of the insulation decomposing under the discharge but should such decomposition take place or should it become coated with carbon volatilized from the anode, it will not be in electrical contact with the graphite and hence will take no part in the discharge. By spacing this insulator from both the anode and support wire, a long path is created between the exterior surface of the insulator and the anode support wires so as to insure that there will be no electrical contact therebetween. It will be noted that the web portion 12 of the insulator forms on the under side thereof, what may be termed a shadow zone, so that any carbon volatilized from the anode and moving outwardly therefrom in straight lines cannot become deposited on the under side of the web. This zone at least, is therefore, fully protected from deposition of conducting material and forms an insulating gap between the exterior surface of the insulator and the lead wire of the anode.

In Fig. 4 the graphite anode 35 is set below the surface of the lavite insulator which construction it has been found, gives the effect of a smaller effective point for the electrode.

In Fig. 4 there is shown a construction which is suitable for lower voltages. In this modification the construction is somewhat simplified by reducing the degree of isolation of the anode and its insulation. The lavite sleeve is maintained in position on the quartz or glass tube by the expedient of screwing the anode tightly against the web portion of the insulator. A metal washer 37 is inserted between the lower end of the graphite and the web portion of the insulator, however, to prevent actual contact of the graphite with the insulation. This contact is objectionable since the carbon apparently facilitates the reduction of the refractory oxide of which the insulator is composed.

If still lower operating voltages are to be employed, that is, voltages of from 100 to 150 volts, direct current output, the metal washer may be omitted and the graphite brought into actual contact with the insulation.

The misch metal serves through out the life of the device to maintain the gas in pure condition and the operating and starting characteristics uniform, and due to its presence on the surface of the cathode greatly reduces the cathode drop and renders it possible to start the discharge at low potentials. The spacing of the anode and cathode is not critical and by way of illustration, excellent results have been obtained, employing a cylindrical cathode of about one inch in diameter

and one and one-half inches long with the anodes disposed therein, adjacent the lower end thereof, or if desired, the anodes may extend well up within the interior of the cathode.

Obviously many changes and modifications may be made in the construction of the device and we do not desire to be limited except in accordance with the annexed claims.

What is claimed is:

1. An electric discharge device comprising an envelope containing a monatomic gas, a cathode therein of large area and an anode of relatively small area, whereby a unidirectionally electric discharge may be obtained, said anode being composed of carbon in a substantially pure and gas-free condition and a quantity of misch metal on said cathode for reducing the cathode resistance.

2. A gaseous discharge rectifier comprising an envelope containing a monatomic gas at a pressure of from 2 to 10 millimeters, an anode composed of carbon and a cathode of large effective area having a metal of the cerium group of rare earth metals disposed thereon.

In testimony whereof, we have hereunto subscribed our names this 14th day of December, 1926.

HARVEY CLAYTON RENTSCHLER.
WILLIAM WALTER MERRYMON.