Nov. 29, 1932. L. F. PERROTT 1,889,612

RECTIFYING APPARATUS

Filed July 16, 1931

Fig. 1.

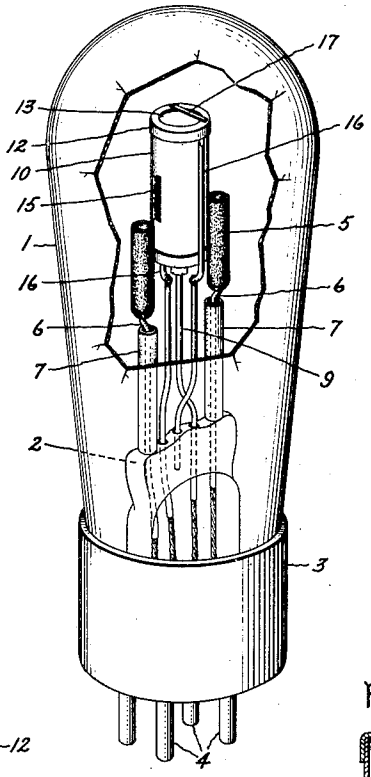


Fig. 2.

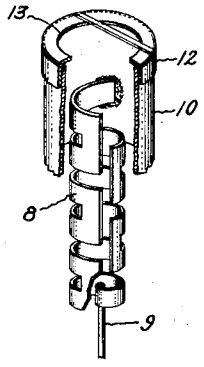


Fig. 4.

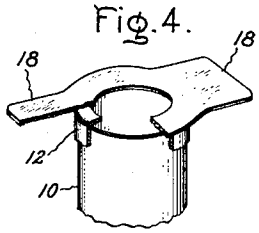
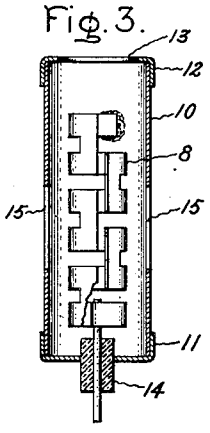


Fig. 3.



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UNITED STATES PATENT OFFICE

LAURENCE F. PERROTT, OF REVERE, MASSACHUSETTS, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

RECTIFYING APPARATUS

Application filed July 16, 1931. Serial No. 551,214.

This invention relates to electrical discharge devices of the type employing ionized gas or vapor, and more particularly to rectifiers for alternating current. Tubes of this character may employ as the ionizable medium, a vapor such as mercury, which has a relatively low ionizing potential and which, initially, is in a condensed or liquid state.

An object of the present invention is to provide a power rectifier utilizing solely a vapor as the ionizable medium and having a relatively long operating life. The invention is directed more especially to an improvement in the starting properties of devices of this sort.

It has been found that in arc or glow discharge devices which carry considerable current, there may be a considerable amount of sputtering at the electrodes during the time interval immediately following the application of the applied voltage until a stable vapor pressure is reached within the tube. This sputtering, which is due in part to the preliminary high voltage drop in the tube, caused by the temporary absence of vapor, may give rise to etching or disintegration of the electrodes, particularly of the cathode. The bombarding effect, in some cases, is sufficiently intense to destroy the active coating on the cathode which passes off as a vapor and which may cause a short-circuiting arc to form directly between the anodes.

In order to prevent these conditions, it has been proposed heretofore to delay the application of the anode voltage for an appreciable length of time after the energization of the cathode and for this purpose, time delay devices have been used. During the time interval between the application of the filament and anode voltages, the heat from the cathode causes vaporization of the mercury in sufficient quantity to preclude sputtering when the voltage subsequently is applied to the anode.

I have discovered in accordance with my invention, that in the smaller type of power tube the time delay accessory is not necessary but that the delay effect may be accomplished solely by the configuration of the electrodes. In this manner, I am enabled to eliminate the time delay devices and to that extent provide a more simple arrangement. The configuration of the electrodes is such that during the transition period when the vapor pressure is being built up within the tube and before it has reached a stable condition, the discharge is constrained to travel a long path between the electrodes, which reduces the intensity of current impact therewith to a value below disintegration. However, when the proper vapor pressure has been obtained, the discharge shifts automatically to a shorter path so that the tube operates with a comparatively low voltage loss and with relatively high efficiency. The invention will be better understood when reference is made to the following description and accompanying drawing in which Fig. 1 represents, in perspective, a rectifier tube made in accordance with the present invention; Fig. 2 is a view partly broken away of a portion of the cathode; Fig. 3 shows a cross-section of the shield with the cathode in elevation, while Fig. 4 illustrates a modified form of shield.

Referring to Fig. 1, numeral 1 designates an evacuated envelope terminating in a press 2 and secured to a base 3 in which four contact pins 4 are mounted. The anodes 5, of which there are two in the case of a full-wave rectifier and one in the case of a half-wave rectifier, take the form of cylinders hollowed out at the top to increase the heat radiating surface and to focus the arc at the end of the anode. The anodes are constituted preferably of rod carbon, graphite, nickel or the like. They are supported from the press 2 by means of stiff wires or conductors 6, which are carried through the stem to connect with a pair of contact pins 4. Protective sleeves 7, of glass or other insulating material are fitted over the anode conductors at the place where they emerge from the press to prevent the wires from being pitted during operation of the tube and to insure insulation at this place.

The cathode 8 consists of arcuate strips of metal, for example, nickel, joined together at their opposite ends by short transverse pieces so as to constitute a rigid, self-supporting member. The cathode conveniently

is made from a punching and rolled to a cylindrical form. The lower end of the cathode is carried on a solid conductor 9 sealed in the press, and the upper end is secured directly to a cylindrical shield 10 which surrounds the cathode. The cathode preferably is coated in any suitable manner with an electronically active material, for example, barium. When barium is employed, the material conveniently may be applied as a paste of barium carbonate ($BaCO_3$) with any suitable binder, and the member 10 heated to a temperature (about 1200° C.) by a high frequency coil, a bombarding discharge, or in any other suitable manner, at which the active material is observed to flow over the surface to form a transparent, uniform layer. The shield 10 which may be fabricated of nickel is closed at the bottom by a cap 11; there is also a cap 12 at the top provided with a relatively large opening 13. The lower cap carries a bushing 14 of porcelain or other insulating material which serves to insulate the conductor where it passes through the bottom of the shield. In addition to the opening 13, the shield is also provided with a pair of oppositely positioned slits 15, preferably of elongated and rectangular dimension, cut in the periphery of the shield in the plane of the anodes and cathode. These slits may be positioned at any suitable height with respect to the anodes and it is found that the tube operates satisfactorily when the lower end of the slit is approximately on a level with the top of each anode. The shield may be mounted in the envelope between two vertical stay rods 16 which are fused in the press. One of these rods is extended to the exterior of the envelope to serve as a leading-in conductor for the cathode. Connections are also taken from the other end of the cathode and from the anodes through the press.

After evacuation of the envelope in the usual manner, including thorough denudation of gas occluded in the envelope and electrodes by baking or otherwise, a gas-absorbing material, termed a "getter", is flashed. This getter, which may consist of a strip 17 of magnesium conveniently is attached to the upper end of the shield, as shown. A drop or two of mercury is admitted to the envelope which upon vaporization, serves as a source of positive ions.

The current to be rectified is usually supplied through a suitable transformer (not shown) the primary of which may be connected to the ordinary alternating current house supply, A tube of this character is capable of passing a relatively large current at a voltage suitable for battery charging devices or as a substitute for motor-generator sets, also for energizing filaments of radio tubes and for similar purposes. The discharge between one anode and the cathode during each half of the alternating current cycle takes on the appearance of an arc, the current stream being characterized by a low voltage drop and by a flat or slightly negative volt-ampere characteristic depending upon the configuration of the electrodes and the vapor pressure employed. The current stream concentrates as a glow about each of the slits 15 inasmuch as these openings offer a path between electrodes for the discharge. Obviously, in directing the arc stream, the shape, size and position of the slits distinctly affect the operating characteristics and the life of the tube. The use of the shield greatly improves the operation and enhances the tube life; in general the smaller the size of the slit in the shield for a given voltage drop, the more favorable will these factors become. The proper shape, size and position of the slits depend upon many considerations, including the vapor pressure, the voltage employed, the configuration of and the distance between electrodes, and are best determined by test under operating conditions. The shield performs the functions of reflecting the barium or other electronically active material which evaporates from the cathode, back to this member in addition to preventing the contamination of the cathode by material removed from the anode by bombardment. Inasmuch as the shield is at cathode potential and it is situated fairly close to the anodes, the bombarding effect of the electronic discharge on the anodes and leads is much less than in the absence of the shield. The provision of the shield has been covered broadly in the Simon and Bareiss application Serial No. 280,877, filed May 26, 1928, entitled "Electric rectifiers" and specifically, in the Fitz-Patrick Patent No. 1,794,283, both assigned to the same assignee as the present case.

It has been observed in the case of vapor devices, and prior to the time that the vapor reaches its stable operating pressure, that the arc tends to concentrate as an intense, destructive discharge about the cathode, even when the tube is provided with a slitted shield. This discharge usually produces sputtering which may cause removal of the active coating from the cathode. The coating is driven off as a vapor and may give rise to the formation of a short-circuiting arc directly between the anodes. The sputtering effect is probably due to the fact that the pressure of the vapor during the preliminary period is less than normal, in fact, is practically zero at the instant the voltages are applied, and must be gradually built-up to the required value. Moreover, the cathode during this period, comes up to its operating temperature more rapidly than the remainder of the elements including the envelope, so that the arc tends to bombard the cathode vigorously through the slits under the driving force of the high voltage drop. It has been proposed,

heretofore, to delay the application of the anode voltage for a short time after the cathode is energized in order to evolve sufficient vapor in the tube before the anode voltage is applied. Whereas the prior art has offered time delay relays for this purpose, I provide an improved electrode structure which not only prevents undue sputtering at the electrodes, particularly at the cathode, but allows the simultaneous application of both cathode and anode voltages without injurious effects.

This improvement takes the form of the additional opening 13 in the top of the shield which provides an optional path for the discharge during the time when the vapor pressure is increasing to its normal value. With the opening at the top, as well as at the sides of the shield, the entire arc does not pass through the slit adjacent the anode, but a large portion of the current stream traverses the longer path through the top opening. As the arc continues to flow alternately from each anode to the cathode through this opening, the temperature within the tube rises and causes an increase in mercury vapor pressure with a correspondingly reduced voltage drop. When approximately stable pressure and voltage conditions have been reached, the arc shifts automatically from the opening at the top to the opening at the side so that the tube may then operate in the usual manner.

The size and shape of the opening at the top of the shield is best determined by experiment, as they depend not only on the voltages applied but also upon the geometry and the material of the electrodes. In general, this opening is so designed as materially to confine the emission of the cathode to the interior of the shield until the mercury vapor pressure has attained a predetermined value. A tube, improved in the manner described, operates satisfactorily under moderate loads and has a fairly long life notwithstanding the simultaneous application of the cathode and anode voltages and the absence of time delay devices.

The current path from the anode to the cathode through the top opening may be modified further if desired, by providing the cap member 12 with extensions 18 as shown in Fig. 4. These extensions conveniently may be stamped from a single piece of metal, secured, as by welding, to the cap member. I have found in some cases, that these extensions add longer life to the tubes and more particularly, further enhance their starting characteristics.

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

1. A rectifier comprising an envelope which terminates in a stem, a cathode and anode supported from said stem, a condensible ionizable medium in said envelope adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a shield mounted about the cathode and adapted to be maintained at a fixed potential with respect thereto, said shield having a discharge opening at the periphery in the plane of the anode and cathode and having another opening at the end remote from said stem.

2. A rectifier comprising an envelope which terminates in a stem, a cathode and anode supported from said stem, a condensible ionizable medium in said envelope adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a shield completely enclosing said cathode except for discharge openings at the periphery in the plane of the anode and cathode, and also at the end of the shield remote from said stem, said shield being adapted to be maintained at a fixed potential with respect to said cathode.

3. A rectifier comprising an envelope which terminates in a stem, a cathode and anode supported from said stem, a condensible ionizable medium in said envelope adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, means shielding the electrodes from bombardment during the transition period before the ionizable medium has attained the proper operating pressure, said means comprising a hollow metallic member adapted to be electrically charged and enclosing the cathode except for a discharge opening located in the plane of the cathode and anode, said member having an additional opening at the end remote from the stem and closed at the end nearer the stem.

4. A rectifier comprising an envelope which terminates in a stem, a cathode and a plurality of anodes supported from said stem, said anodes being mounted on opposite sides of the cathode, a condensible ionizable medium in said envelope adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a shield mounted about the cathode and adapted to be maintained at a fixed potential with respect thereto, said shield having a plurality of discharge openings in the plane common to the cathode and anodes and having another opening at the end remote from said stem.

5. A rectifier comprising an envelope which terminates in a stem, a cathode and a plurality of anodes supported from said stem, said anodes being mounted on opposite sides of the cathode, a condensible ionizable medium in said envelope adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a shield mounted about the cathode and adapted to be maintained at a fixed potential with respect thereto, said shield having a

plurality of discharge openings in the plane common to the cathode and anodes, said shield having another opening at the end remote from the stem and being closed at the end nearer the stem.

6. A rectifier comprising an envelope terminating in a stem and containing a condensible ionizable medium adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a plurality of anodes and a cathode of elongated dimension supported from said stem, said cathode being coated with electronically active material and means for shielding the cathode from positive ion bombardment during the transition period before the ionizable medium has attained the proper operating pressure, said means comprising a hollow metallic member of elongated dimension connected to the cathode and enclosing the latter except for an opening at the end of the shield remote from said stem and a plurality of small discharge openings in the plane common to the cathode and anode members, said last mentioned openings being of a rectangular, elongated shape having the long dimension in said common plane and of a length less than that of the hollow metallic member.

7. A rectifier comprising an envelope terminating in a stem and containing a condensible ionizable medium adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, a plurality of anodes and a cathode mounted on said stem, said cathode being coated with an electronically active material, means for shielding the cathode from positive ion bombardment, said means comprising a hollow member enclosing the cathode and connected thereto, said member being closed at the end nearer the stem and open at the end remote from the stem whereby a discharge is permitted to flow through the open end during the period before the vapor pressure has attained a stable condition, said member having a plurality of oppositely disposed openings in the plane of the anodes and cathode through which the discharge is permitted to flow after the vapor pressure has attained a stable condition.

8. A rectifier comprising an envelope terminating in a stem and containing an anode, a cathode, and a condensible ionizable medium adapted to be heated to a pressure sufficiently high to support an arc-like discharge at the impressed voltages, means for causing the arc to take a relatively long path between the electrodes while the pressure of the medium is undergoing change and for causing the arc automatically to shift to a shorter path after a stable pressure condition has been reached, said means comprising a hollow metallic shield enclosing the cathode except for a discharge opening at the end of the shield remote from said stem, and a small discharge opening in the plane common to the anode and cathode.

In witness whereof, I have hereunto set my hand.

LAURENCE F. PERROTT.