Aug. 10, 1937. W. DÄLLENBACH 2,089,540

MERCURY VAPOR RECTIFIER

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Fig. 1

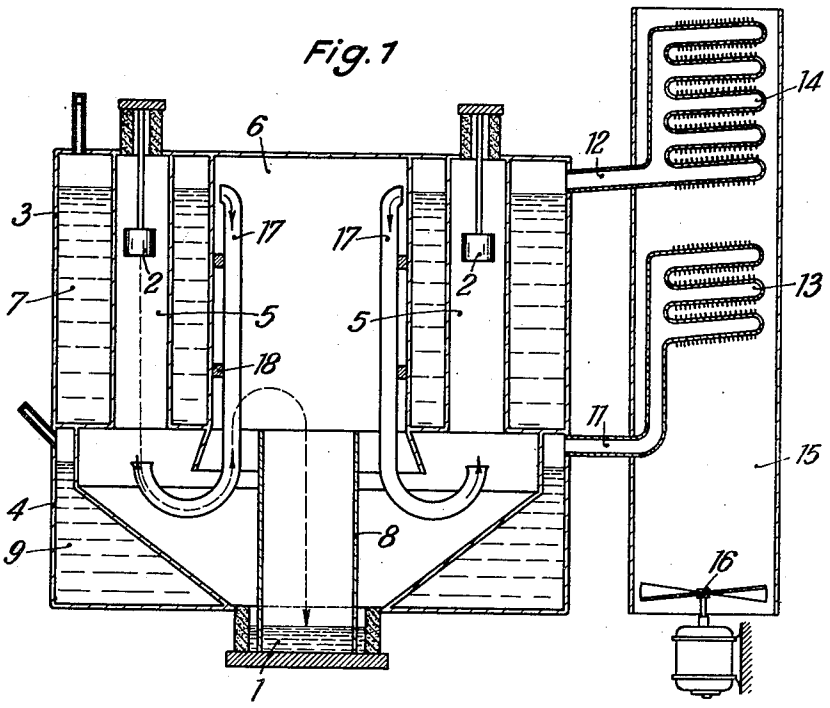
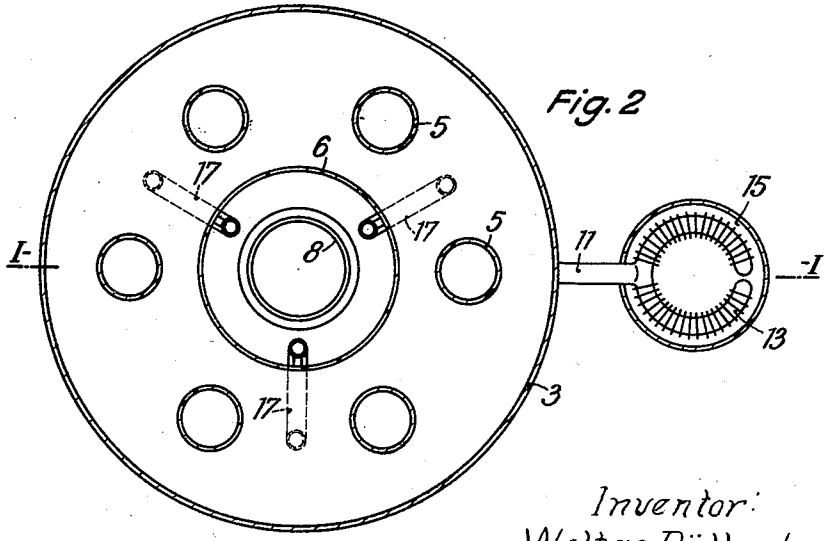


Fig. 2



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Fig. 3

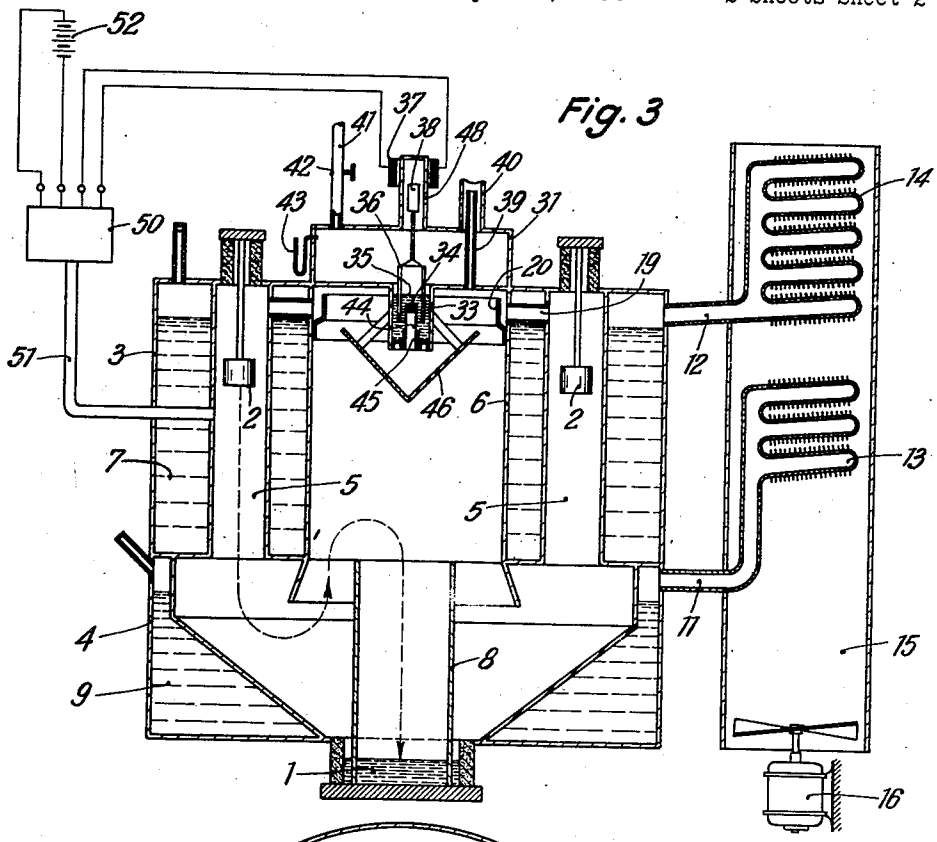


Fig. 4

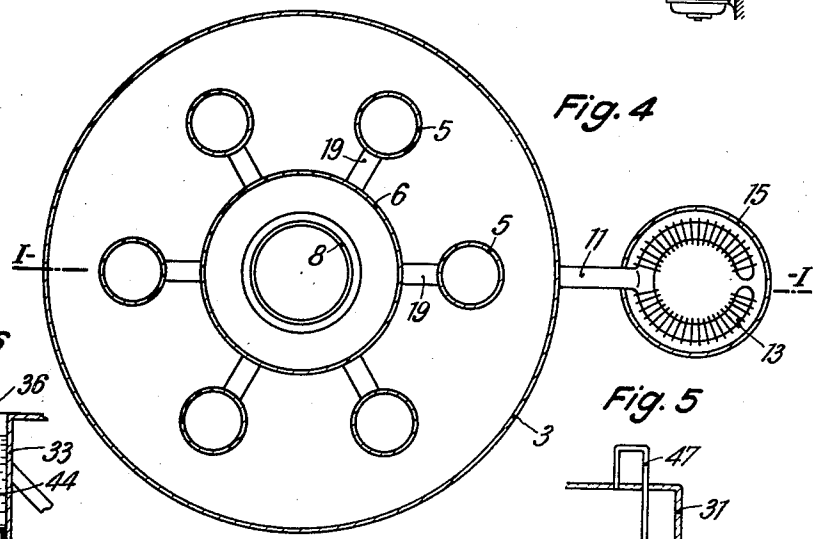


Fig. 6

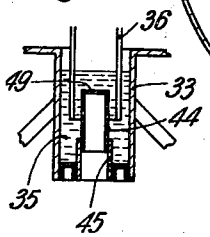


Fig. 5

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UNITED STATES PATENT OFFICE

2,089,540

MERCURY VAPOR RECTIFIER

Walter Dällenbach, Berlin-Charlottenburg, Germany

Application September 24, 1934, Serial No. 745,353
In Germany September 26, 1933

17 Claims. (Cl. 250—27.5)

My invention relates to mercury vapor rectifiers, and has more particular reference to mercury vapor rectifiers with metallic vacuum vessels separated from the vacuum pump in which a plurality of anodes disposed within protecting sleeves or chambers are associated with a common mercury cathode. The purpose of the anode protecting sleeves or chambers is to prevent striking back which can arise due to ions from the arc to the adjacent anodes travelling to an anode which at that moment is a blocking anode.

A further reason for striking back is that the stream of mercury vapor which originates at the cathode and is in extremely violent motion, carries large quantities of mercury ions along with it. Further with large discharge current positive ions are conveyed from the vicinity of the anodes to the cathode by means of the arc passing to the cathode. This conveyance of positive ions results in a further reduction of the gas or vapor pressure in the vicinity of the anodes. The electrons which move towards the anodes during the time the current is allowed to pass from the anodes, are then no longer capable of producing a sufficient number of positive ions in the vicinity of the anodes as due to the small density of neutral gas or vapor particles, the probability of an impact of electrons with such particles is too small. Consequently a negative electron space charge exceeds the positive ion charge in the vicinity of the anodes. Thus the electron space charge is no longer compensated by an equal and opposite positive ion charge as is necessary for maintaining a small voltage drop in the arc. Consequently when this phenomenon occurs the voltage drop in the arc increases considerably with the current. As this auxiliary voltage drop in the arc is localized in the vicinity of the anode surface the electrons now impact on the anodes at particularly high speed. This results in a considerable heating of the anodes which may lead to a destruction thereof or to striking back. It has further been found that the electron space charge occurring at the anode surface can occasion very high frequency oscillations which in turn give rise to striking back.

According to my invention, in order to avoid striking back and a big drop in the arc chemically inactive gases are introduced into the vacuum vessel in an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury.

All the rare gases viz: helium, neon, argon, krypton, xenon, can be employed as chemically inactive gas.

As the direct stream of mercury vapor from the cathode is in general precipitated in a separate condensation chamber, there is the possibility that the rare gas introduced into the vessel in accordance with my invention will be displaced into and retained in the upper part of this condensation chamber by the action of the stream of mercury vapor, so that in spite of the introduction of rare gas there is after a time a decrease in the number of gas particles in the vicinity of the anodes.

It is therefore a further feature of my invention to provide separate connections between the parts of the vacuum vessel in which the direct stream of mercury vapor from the cathode tends to compress the rare gas which has been introduced and the space in the vicinity of the anodes. In this way it is possible for the gas to revert to the vicinity of the anodes. There is therefore a continuous circulation of the gas, caused by the stream of mercury vapor from the cathode.

Further, consideration must also be given to the absorption of gas which is certainly very small but which invariably occurs. In the case of vacuum discharge vessels, which must maintain their properties for many thousands of working hours, it is necessary appropriately to supplement the quantity of rare gas. It is therefore a further feature of my invention to provide for the chemically inactive gas a separate reservoir which communicates with the vacuum vessel and to open and close the connection between reservoir and vacuum vessel by separate means dependent upon the gas pressure in the vacuum vessel.

Further advantages and features of my invention are set out in the following description and in the drawings as well as in the claims which constitute a part of my application.

Fig. 1 shows a longitudinal section along the line I—I of Fig. 2 through a rectifier together with the associated condensers,

Fig. 2 shows a horizontal cross section through the apparatus shown in Fig. 1,

Fig. 3 shows a longitudinal section through a second embodiment of a rectifier, which is provided with a device for automatically introducing the chemically inactive gas,

Fig. 4 shows a corresponding horizontal section,

Fig. 5 shows a modification of a part of the automatic device shown in Fig. 3,

Fig. 6 also shows a further modification on an enlarged scale.

1 is the mercury surface serving as cathode

of the rectifier and 2 are the six anodes which are accommodated in anode tubes 5. The vacuum vessel comprises an upper portion 3 and a lower portion 4. Disposed in the upper part is the cowl 6 serving for condensing the main quantity of the mercury evaporating from the cathode 1. The anode tubes 5 and the cowl 6 are surrounded by the cooling liquid 7. In the lower part 4 a guide tube 8 which directs the mercury vapor to the condensation surface 6 is arranged above the cathode 1. The lower portion is cooled by the cooling liquid 9. The path of the arc from an anode to the cathode 1 is indicated by a broken line. The condensers 13 and 14 which are connected by conduits 11 and 12 with the cooling chambers serve for condensing the boiling cooling liquid. The condensers are arranged in an air channel 15 and are cooled by the fan 16.

As already stated, the rare gas which has been introduced will collect in the upper part of the condensation space 6 under the action of the mercury stream. To enable the rare gas to pass into the vicinity of the anodes 2, tubular conduits 17 are provided which may be secured by means of supports 18. The inlet apertures of the conduits 17 face the cooled wall of the condensation chamber as shown in Fig. 1. In this way the mouth of the tube is disposed outside the direct current or mercury vapor. In addition it is advantageous to remove the rare gas from the condensation chamber at a point which is comparatively cool.

In the construction according to Figs. 3 and 4 direct connecting tubes 19 are provided between the anode chambers 5 and the condensation chamber 6 in place of the tubes 17. In order to protect the ends of the tubes from the direct current of mercury vapor, a separate screen 20 is provided. With such an arrangement there is a continuous circulation of the rare gas substantially along the path followed by the current of ionized gases.

31 is the reservoir for the rare gas used as chemically inactive gas. The reservoir 31 is made of sheet iron or the like and forms a constructional unit with the condensation chamber 6. In the base of the reservoir is a tubular socket 33 in which is inserted the gas-permeable body e. g., a glass frit. The glass frit 34 is preferably fused in vacuum tight manner to a glass tube 44 which is fused to a metal tube 45 welded to the socket 33 by means of an intermediate member. During operation of the apparatus the glass frit 34 is normally covered by the mercury 35 and thus is sealed. Instead of the glass frit 34 an apertured disc 49 can be employed as indicated in Fig. 6. The diameter of the bore in the disc and the pressure in the reservoir 31 must be so chosen that the mercury 35 is not forced through the bore. A displacement member 36 dips into the mercury. This member is raised by the coil 37 through the intermediary of the magnet core 38 which moves in a tube 43 preferably of non-magnetic steel. When the member 36 is raised the level of the mercury 35 drops and the frit 34 is exposed so that rare gas can flow from the reservoir 31. The energizing of the coil 37 is automatically controlled by a vacuum measuring device in dependence upon the vacuum within the actual vacuum vessel in such manner that if the vacuum becomes too high, gas is allowed to pass. The vacuum measuring device comprises the actual vacuum meter 50 which is connected with one of the anode sleeves 5 by a conduit 51. A suitable construction of vacuum meter can be employed; e. g., a hot wire vacuum meter arranged in a Wheatstone bridge circuit and adapted when the gas pressure in the anode sleeve 5 drops below a predetermined value, to close a contact whereby a battery 52 is connected to the coil 37 so that, as stated above, the displacement body 36 is raised to a greater or lesser extent.

A screen 46 is provided to prevent excessive heating of the apparatus for regulating the admission of the rare gas.

For exhausting the actual vacuum vessel a conduit 39 which passes through the reservoir 31 is provided. This conduit 39 is disposed within a tube 40 of larger diameter which is connected to the vacuum pump. In this way it is attained that the actual vacuum vessel and the reservoir are simultaneously exhausted by way of the tube 40. When the evacuation is complete the tube 40 and the tube 39 are collapsed and sealed so that the reservoir 31 is connected with the vacuum vessel only by way of the frit 34.

Instead of the evacuating conduits shown in Fig. 3 a conduit 47 as shown in Fig. 5 can be utilized. With such an arrangement of the conduit 47 it is again possible to evacuate both vessels through a common connection. After the evacuation has been completed the portion of the conduit 47 which lies outside the vessels is collapsed.

As soon as the evacuation and sealing have been effected, the mercury 35 which is necessary for sealing the frit 34 is introduced through the pipe 41. Thereafter the reservoir 31 is charged with rare gas through the same pipe. The conduit 41 can then also be sealed by fusion or be closed by a cock or valve 42 or the like.

It is also possible to eliminate the pipe 41, and to introduce the mercury 35 and the rare gas into the reservoir through the tube 40 of Fig. 3 after the evacuation of the reservoir has been completed and prior to the collapsing of the conduit.

A preferably shortened mercury manometer 43 is provided for indicating the pressure of the rare gas in the reservoir.

The reservoir for the rare gas can be disposed at any other convenient point on the vacuum vessel instead of at the upper end of the condensation chamber.

The automatic device for introducing further gas into the vacuum vessel, can be constructed in any convenient manner differing from that described and illustrated which is given by way of example only.

The invention is of particular importance for apparatus in which the vacuum vessel is made of metal because as the cooling can be more readily controlled, these permit of higher specific loads and consequently necessitate a more precise maintenance of the gas density in the vicinity of the anodes.

What I claim is:

1. A vacuum discharge vessel comprising a vacuum vessel, a plurality of substantially parallel, non-confronting anodes, protective sleeves for said anodes isolating each anode from the others, and a mercury cathode, said vacuum vessel having introduced thereinto a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel.

2. In a vacuum discharge vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding

to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of substantially parallel, non-confronting anodes within said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, separate connecting paths between the anode spaces and the parts of the vacuum vessel in which the rare gas collects under the action of the stream of mercury vapor during the operation of the apparatus.

3. In a vacuum discharge vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of anodes within said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, a condensation space above said mercury cathode for the stream of mercury vapor rising from the cathode during the operation of the apparatus, separate connecting paths between the anode spaces and the coolest parts of the condensation space, and protecting screens shielding the ends of the connecting paths in the condensation space from the direct stream of mercury vapor.

4. In a vacuum discharge vessel, in combination a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of anodes within said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, a condensation space above said mercury cathode for the stream of mercury vapor rising from the cathode during the operation of the apparatus, cooling chambers surrounding said condensation space, a cooling medium in said cooling chambers, tubes open at both ends and having one end in the upper part of the condensation space and the other end at the aperture of the anode sleeves, and means for securing said tubes to the inner walls of said condensation space.

5. In a vacuum discharge vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of anodes within said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, a reservoir filled with rare gas, a connection between said reservoir and the vacuum vessel, means adapted to open and close said connection in dependence upon the pressure within said vacuum vessel.

6. In a vacuum discharge vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of anodes within said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, a reservoir filled with rare gas and mounted on the vacuum vessel, an open connecting tube between the vacuum vessel and the reservoir, a gas-permeable body incorporated in the connecting tube in vacuum-tight manner, a liquid impermeable to gas and adapted to form a seal in the tube above said gas-permeable body, a displacement body dipping in said liquid and determined by the depth to which it is immersed whether said liquid covers said gas-permeable body or not, and means adapted to control the depth of immersion of said displacement body in dependence upon the vacuum in said vacuum vessel.

7. In a vacuum discharge vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimetre of mercury, a plurality of anodes within said vacuum vessel, anode protective sleeves for said anodes, a mercury cathode, a reservoir filled with rare gas and mounted on the vacuum vessel, an open connecting tube between the vacuum vessel and the reservoir, a disc provided with a fine aperture and mounted in vacuum tight manner in said connecting tube, a liquid impermeable to gas and adapted to form a seal in said tube above said disc, a displacement body dipping in said liquid and determining by the depth to which it is immersed whether or not said disc is covered by said liquid, and means adapted to control the depth of immersion of said displacement body in dependence upon the vacuum in said vacuum vessel.

8. In a vacuum discharge vessel according to claim 6, a magnet core to which the displacement body is secured, an exciter coil adapted on increasing excitation to attract said magnet core so as to lift the displacement body whereby the gas permeable body is no longer covered by the impermeable liquid, and a vacuum measuring device adapted to control the excitation of the coil so as to increase the same when the gas pressure in the vacuum vessel decreases.

9. In a vacuum discharge vessel according to claim 6, a connecting pipe on the reservoir for the rare gas adapted for the simultaneous evacuation of the vacuum vessel and the reservoir and also adapted after evacuation for the admission of the liquid impermeable to gas necessary for covering the gas permeable body as well as for the admission of the rare gas.

10. In a vacuum discharge vessel according to claim 5, a manometer adapted to indicate the pressure of the rare gas in the reservoir.

11. In a vacuum discharge vessel according to claim 5, a suction conduit terminating in the reservoir and a second suction conduit terminating at one end in the vacuum vessel and at the other end in said first mentioned suction conduit.

12. In a vacuum discharge vessel according to claim 5, a suction conduit mounted on the reservoir for the rare gas and a second suction conduit terminating in the vacuum vessel and spaced from the walls of said first suction conduit.

13. In a vacuum discharge vessel according to claim 4, a tube terminating at one end in the vacuum vessel and at the other end in the reservoir and having a part of its length disposed outside both vessels.

14. In a vacuum vessel, in combination, a vacuum vessel containing a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimeter of mercury whereby substantially vacuum pressures are maintained in said vessel, a plurality of substantially parallel, non-confronting anodes with-

in said vacuum vessel, anode protective sleeves for said anodes isolating each anode from the others, a mercury cathode, and means to permit the passage of the rare gas which collects in the vessel under the action of the stream of mercury vapor during the operation to the space surrounding the anodes.

15. A vacuum discharge vessel comprising a vacuum vessel, a mercury cathode, a plurality of substantially parallel, non-confronting anodes, protective sleeves for said anodes isolating each anode from the others, said anodes being spaced substantially from said cathode and disposed so that the paths between the cathode and anodes are tortuous, said vacuum vessel having introduced thereinto a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimeter of mercury whereby substantially vacuum pressures are maintained in said vessel.

16. A vacuum discharge vessel comprising a vacuum vessel, a mercury cathode, a plurality of substantially parallel, non-confronting anodes, protective sleeves for said anodes isolating each anode from the others, said anodes being spaced substantially from said cathode and disposed so that the paths between the cathode and anodes are tortuous, said vacuum vessel having introduced thereinto a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimeter of mercury whereby substantially vacuum pressures are maintained in said vessel, and means to permit the passage of the rare gas which collects in the vessel under the action of the stream of mercury vapor during the operation to the space surrounding the anodes.

17. A vacuum discharge vessel comprising a vacuum vessel, a mercury cathode, a plurality of anodes, protective sleeves for said anodes isolating each anode from the others, said anodes being spaced substantially from said cathode and disposed so that the paths between the cathode and anodes are tortuous, passing first upwardly and then downwardly and then upwardly, said vacuum vessel having introduced thereinto a quantity of rare gas of an order of magnitude corresponding to a pressure of a few hundredth parts of a millimeter of mercury whereby substantially vacuum pressures are maintained in said vessel, and means to permit the passage of the rare gas which collects in the vessel under the action of the stream of mercury vapor during the operation of the space surrounding the anodes.

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