1150 wds,
1 p. drawings

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AMENDED SPECIFICATION.

Reprinted as amended under Section 8 of the Patents and Designs Acts, 1907 and 1919.

PATENT SPECIFICATION

Convention Date (Germany): Sept. 3, 1924. **239,518**

Application Date (in United Kingdom): Sept. 2, 1925. No. 21,972 / 25.

Complete Accepted: Aug. 26, 1926.

COMPLETE SPECIFICATION (AMENDED).

Improvements in or relating to Electron Discharge Tubes.

We, SIEMENS - SCHUCKERTWERKE GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, of Berlin-Siemensstadt, Germany, a German company (part Assignees of Dr. LEO SZILARD, of 16, Faradayweg, Berlin-Dahlem, Germany, of Hungarian nationality), and Dr. LEO SZILARD, of 16, Faradayweg, Berlin-Dahlem, Germany, of Hungarian nationality,

do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

As is well known, hot cathode tubes are used for the control of electric currents. In such tubes, the current is conducted by the electrons which escape from the incandescent filament owing to the high temperature of the same. For the control of the current, between the incandescent filament and the anode of the tube, could be provided a grid influenced by a control voltage. It is difficult to obtain in this way high anode current intensities, and the life of the incandescent filaments is a limited one. At the same time it is necessary to use a considerable energy, the so-called heating energy, which restricts the efficiency of the tube to a low figure. In order to increase the current intensity in such a discharge vessel with control action, it has been already proposed to use for the discharge vessel the well known mercury vapour rectifiers, and to arrange control grids in front of the anodes. Although a sufficiently high anode current strength can be obtained in this way, it is on the other hand impossible to exercise an effective control of the anode current by the grid, as the vacuum in the space between the anode and the cathode is not sufficient for the control.

There are also known already electric discharge vessels in the form of mercury vapour rectifiers in which the vacuum in the space in which the anodes are contained, is higher than in the cathode space. This higher vacuum is obtained owing to the mercury vapour generated at the cathode, passing first through a tube narrowing at the mouth, and then, in the form of a jet, into the condensation chamber. This mercury vapour jet escaping from the mouth of the tube exercises a suction on the adjoining anode chambers, like in the case of a mercury vapour jet pump. These well known discharge vessels do not possess however any means for the control of the current between the anode and the cathode. The high pressure maintained in the neighbourhood of the cathode is rather intended to avoid the formation of an electric arc or a passage of current between the anodes themselves.

The invention has reference to a discharge tube with means for controlling the current between anode and cathode, by electrostatic or electro-magnetic means, in which the admission from the cathode chamber to the chamber in which the control takes place is effected through a contracted passage. Now experience has shown that, in spite of the presence of a conducting gas area of sufficiently great pressure in the cathode chamber, a sufficient vacuum will be obtained for the control in the controlling chamber through the suction action of a vapour jet, or the action of diffusion, both preferably in conjunction with the cooling of the contracted parts. The contraction already known per se of the inlet of the controlling chamber does not suffice for the arrangement according to the invention, on the contrary there is still essential the suction action of a vapour jet, as in the already known vapour jet pumps, or the diffusion action and preferably also the cooling of the contracted part as in the case of the already known diffusion pumps. If only the contraction be present, and if these latter effects are missing, the requisite vacuum cannot be obtained.

Although not in itself essential, it is preferable for the discharge tube according to the invention that the discharge in the neighbourhood of the cathode should have the nature of an independent discharge, more particularly of an arc discharge. By an "independent discharge" is meant a discharge which itself generates the ions which are required for maintaining it, as is the case in a glow discharge or in an electric arc discharge.

In that way is obtained a tube with the advantages of the high vacuum tubes, without the above mentioned drawbacks of the same.

The drawing shows a constructional example of the invention, in which the difference in pressure is maintained by means of an arrangement similar to that of a mercury vapour jet pump, as the mercury is evaporated from one chamber 14, and is condensed in the chamber 15. In the chamber 16, the vacuum is created. There the grid 2 of the electron tube and the anode 8 are located. The cathode 1 or 1^1 of the tube can be accommodated in the chambers 14 or 15, or the mercury in the lower part of the chamber 14 may serve as cathode. The higher vacuum in the controlling chamber 16 of the tube is generated by the vapour jet produced by the passing of the mercury vapour, out of the chamber 14 into the chamber 15.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. A discharge tube with means for controlling the current between anode and cathode, by electrostatic or electromagnetic means, in which the admission from the cathode chamber to the chamber in which the control takes place is effected through a contracted passage, characterised by the fact that through the suction action of a vapour jet or the diffusive action, both preferably in conjunction with the cooling of the contracted passage, in spite of the presence of a conductive gas area of sufficiently great pressure in the cathode chamber, there is obtained in the controlling chamber a vacuum sufficient for the control.

2. A discharge tube according to Claim 1, characterised by the fact that the anodes are mounted in the suction chamber of the tube fashioned as a vapour jet or diffusion pump, and by the fact that the controlling of the current takes place there, and the cathode is located in the pressure chamber or condensation chamber of the pump.

3. Discharge tubes substantially as hereinbefore described with reference to the accompanying drawing.

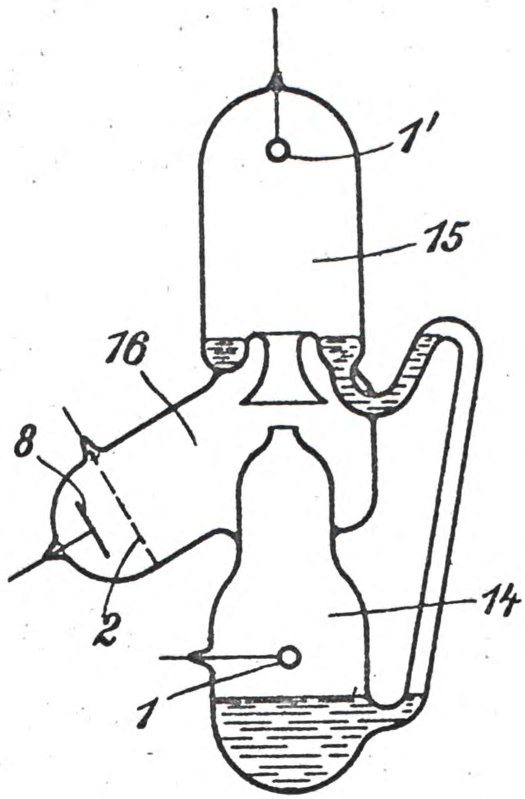
Dated this 2nd day of September, 1925.

HASELTINE, LAKE & Co.,
28, Southampton Buildings, London, England, and
15, Park Row, New York, N.Y., U.S.A.,
Agents for the Applicants.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1927.

(Amended Drawing)

[This Drawing is a full-size reproduction of the Original]



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original

Patented Jan. 1, 1929. **1,697,210**

UNITED STATES PATENT OFFICE.

LEO SZILARD, OF BERLIN, GERMANY, ASSIGNOR TO SIEMENS-SCHUCKERTWERKE AKTIENGESELLSCHAFT, OF BERLIN-SIEMENSSTADT, GERMANY, A CORPORATION OF GERMANY.

DISCHARGE TUBE.

Application filed April 20, 1925, Serial No. 24,575, and in Germany September 3, 1924.

This invention refers to a novel form of electronic discharge tube which allows of obtaining intense electronic currents in a high vacuum by comparatively simple means.

Hitherto considerable currents could only be obtained in a highly evacuated tube, such as for instance a triode by means of incandescent cathodes, requiring very large heating currents. On the other hand an electron discharge produced in a less high vacuum for instance by a mercury vapor arc while allowing large currents to pass, cannot be controlled by grids or similar means in a way which is possible with discharges in high vacuum triode tubes. For instance if a grid is interposed between cathode and anode of a mercury vapor rectifier it is possible to retard or to prevent the starting of the discharge by bringing the grid to a sufficiently high negative potential but it is impossible to influence or to suppress the arc once produced.

The present invention comprises a vacuum discharge tube divided into two main parts which are connected by a narrow communication path. In one part which contains the cathode a sufficiently high gas pressure is maintained so as to obtain an arc discharge. The electrons discharged in this part of the tube pass through the communication path to the other part of the tube where a high vacuum is maintained. The electron current can be influenced and interrupted in this part of the tube by means of grids charged at suitable potentials or by magnets much the same as in the well known, vacuum tubes.

In the annexed drawing the subject matter of the invention is represented in two embodiments. Figure 1 shows diagrammatically the simplest form, and Figure 2 shows another embodiment.

Referring to Figure 1, 1 is the first compartment of the tube containing gas at fairly low pressure, suitable to maintain an arc; 2 is a small tube through which small quantities of gas are continually admitted into compartment 1; 3 is a cathode; 4 is a second compartment; 5 is a communicating passage way between compartments 1 and 4; 6 is an outlet connected to a high vacuum pump (not shown); 7 is a grid set up in compartment 4; and 8 is an anode arranged in compartment 4.

This arrangement allows a small gas pressure to be maintained in compartment 1 and at the same time a high vacuum in compartment 4. If a discharge is caused between electrodes 3 and 8, this discharge will exhibit in compartment 1 the character of an arc according to the prevailing gas pressure; it will then by passing through communication 5 gradually change into a pure electronic current. This current can be controlled in compartment 4 by means of the grid 7 much the same as in an ordinary triode.

Another embodiment of the invention is shown in Fig. 2. It consists of a mercury vapor jet high vacuum pump of a well known type. Here again 1 represents the compartment having suitable low pressure for maintaining an arc discharge and the mercury pool 3 of which is used as a cathode. Compartment 1 discharges the vapor in a jet through nozzle 1[a], into condenser 9 which is cooled by a cooling jacket 10. 4 is the high vacuum compartment in which the vacuum is maintained by the well-known action of mercury jet pumps. The narrow throat formed between nozzle 1[a] and the jacket wall forms the small communicating passage 5, equivalent to passage 5 in Figure 1 for the discharge between compartments 1 and 4. The latter contains grid 7 and anode 8.

When the pump is working the pressure of mercury vapor in compartment 1 and in the stream of the vapor is high enough to allow of an arc discharge, while in compartment 4 a very high vacuum can be obtained. The arc discharge passing from the low pressure compartment through the gap 5 into compartment 4 now assumes the character of an electronic current and can then be controlled by the grid 7 as effectively as in a triode. If a suitable negative potential with respect to the cathode is applied to the grid, the current can be reduced to any value or be even stopped. The grid current will be small at the same time.

In the arrangement described above it is essential that the mercury vapor be prevented from entering the high vacuum part. In order to obtain this effect the width of the cooled gap should be of the same order or less than the width of the mean free path of the mercury molecules under the prevailing conditions. This is essential in order to obtain a sufficiently low mercury vapor pressure in the high vacuum part of the pump. Similar restrictive devices are used in every type of mercury vapor pump. Indeed any type of mercury vapor pump different in its detail arrangement from that shown can be fitted with electrodes according to the principle shown and be used for the purpose of the invention.

It is not necessary, in order to exercise the invention to use a mercury pump device as electronic discharge tube. Any mercury vapor tube may be used, provided the communication between the tube portion containing the cathode and that containing the electron controlling element is barred for the mercury vapor by cooled surfaces, the width of the passage along the cooled surface being at one point at least of the same order of dimension as the mean free path of the mercury molecules at that point. It is preferable to use a bent communication path such as would result for instance from an arrangement shown in Figure 2 in order to prevent molecules from flying in a straight line through the cooled passage without striking the walls. At any rate it is preferable to use a pump device; any gases will be removed then with certainty from the high vacuum chamber.

The vapor pressure in the high vacuum part of the tube is essentially equal to the saturation pressure of the mercury at the temperature of the cooled surfaces. By using other suitable cooling liquids instead of water and a cooling device connected to a small refrigerating machine, temperatures much below zero can be maintained. By choosing the right temperature one can arrive at any suitable vapor pressure in the high vacuum compartment. This vapor pressure can be chosen so that it is sufficiently low to permit the interruption of the current by means of a suitably charged grid and that there still will be left enough vapor there to supply enough positive ions to compensate the negative space charged.

Mercury vapor discharge tubes provided with grids are already known. In some of these tubes the vacuum in the neighborhood of the grid is higher than close to the cathode. However, the designers could not have intended to obtain in such devices a high vacuum close to the grid, such as is required for the purpose of the present invention, for the reason that even if one would cool the walls of such a prior art tube very intensely one would not obtain a sufficiently high vacuum in the neighborhood of the grid, for in these prior art devices the path open for the vapor to reach the grid is a very broad one. One would get in consequence a very large grid current if attempts were made to stop the electron current by imposing upon the grid a negative potential with respect to the cathode. This current is caused by the positive ions which are supplied by the vapor in large quantities and which make it impossible to control direct current effectively with mercury vapor tubes of the types suggested by others in the past.

In the tubes according to the present invention the mean free path of the molecules is (in the controlling part) of the order of centimeters. Therefore velocity of the positive ions is given by the formula

$$v=\sqrt{\frac{efl}{m}}$$

a homogeneous electrical field being presumed and collisions being neglected. (e is the charge of the ion, f is the field intensity, m the mass and l the length of the path.) As the mass of the mercury ion is 400,000 times as large as that of an electron the positive ions will transport $\frac{1}{600}$ part of the total current if the concentration of the positive ions and of the electrons is equal. This will occur at a certain critical vapour pressure. If the pressure is higher than this critical value the positive ions will prevail and there will result a positive space charge. If the pressure is lower than this critical value the electrons will prevail and there will result a negative space charge. In order to keep the potential drop between anode and cathode at a small value one should chose the vapour pressure above this critical value so as to avoid the negative space charge. It is, however, advisable to choose the vapour pressure at least so low that the grid current (caused by the positive ions which are supplied by the vapour) shall not exceed 10% of the main current. Such a vacuum is easily obtained in the controlling part of the discharge tubes according to the present invention.

I claim:

1. An electronic vacuum discharge tube having a compartment containing gas at a pressure to sustain an arc discharge, a cathode in said compartment, a second compartment, a communicating passage-way between said compartments, means for producing a high vacuum in said second compartment sufficient to allow control of the electron current due to the arc discharge in the said first compartment and controlling means to influence said electron current in said second compartment.

2. An electronic vacuum discharge tube having a compartment containing gas at a pressure to sustain an arc discharge, a cathode in said compartment, a second compartment, a communicating passage-way between said two compartments for directing the electron stream due to said arc discharge into said second compartment, cooling means operatively disposed relatively to said passage-way and designed to prevent vapors produced by said arc discharge from passing through said passage-way into said second compartment, means for producing a high vacuum in said second compartment sufficient to allow control of the electron current produced in said first compartment, and

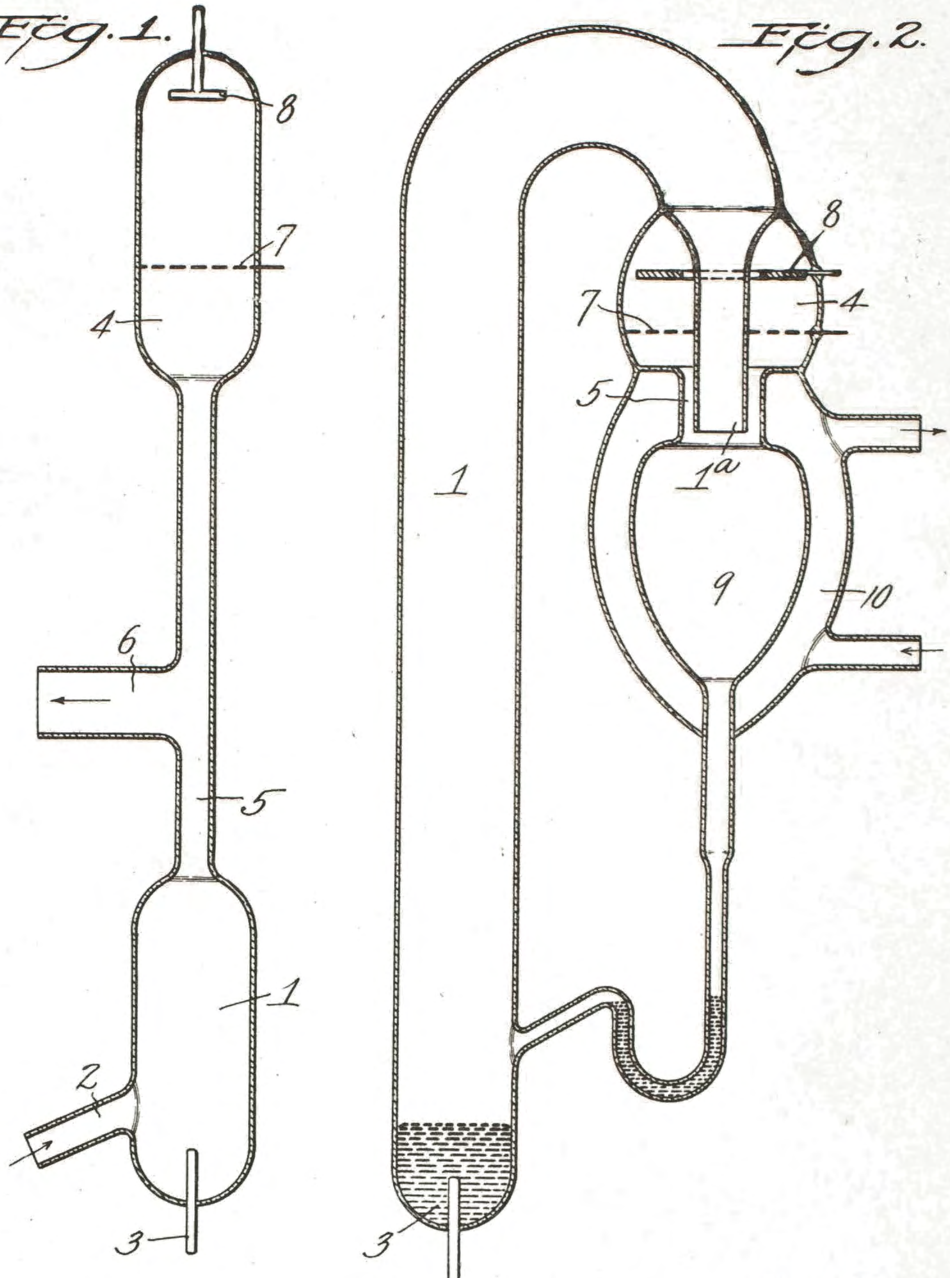
Jan. 1, 1929. 1,697,210

L. SZILARD

DISCHARGE TUBE

Filed April 20, 1925

Fig. 1. Fig. 2.



WITNESS

Inventor
LEO SZILARD

By his Attorneys

controlling means to influence the electron current in said second compartment.

3. An electronic vacuum discharge tube having a compartment containing gas at a pressure to sustain an arc discharge, a cathode in said compartment, a second compartment, a communicating passage-way between said two compartments for directing the electron stream due to said arc discharge into said second compartment, cooling means operatively disposed relatively to said passage-way and designed to prevent vapors produced by said arc discharge from passing through said passage-way into said second compartment, means for producing a high vacuum in said second compartment sufficient to allow control of the electron current produced in said first compartment, and a grid element for controlling the electron current in said second compartment.

4. An electronic vacuum discharge tube having a compartment containing gas at a pressure to sustain an arc discharge, a cathode in said compartment, a second compartment containing an anode, a suitably restricted communicating passage-way between said two compartments for directing the electron current due to said discharge between said cathode and anode, cooling means operatively disposed relatively to said passage-way and designed to prevent vapors produced by said arc discharge from passing through said passage-way into said second compartment, means for producing a high vacuum in said second compartment sufficient to allow control of the electron current produced in said first compartment, and a grid element disposed in said second compartment between the cathode and anode for controlling the electron current flowing to the anode.

5. An electronic vacuum discharge tube comprising a mercury vapor jet vacuum pump having at least a vapor generating compartment, a high vacuum compartment and a vapor condensing compartment, all suitably connected with each other, said vapor compartment containing a cathode and vapor at a pressure to sustain an arc discharge, said vacuum compartment designed to receive the electron current due to said arc discharge and having a high vacuum, means for controlling said electron current in said vacuum compartment and means for preventing vapor molecules from entering said vacuum compartment.

6. An electronic vacuum discharge tube comprising a mercury vapor jet vacuum pump having at least a vapor generating compartment, a high vacuum compartment and a vapor condensing compartment, all suitably connected with each other, said vapor compartment containing a cathode and vapor at a pressure to sustain an arc discharge, said vacuum compartment designed to receive the electron current due to said arc discharge and having a high vacuum, an anode and a grid in said vacuum compartment for electrostatically controlling the electron current flowing between the cathode and anode, and means for preventing vapor molecules from entering said vacuum compartment.

In testimony whereof I have signed my name to this specification.

LEO SZILARD.

Patented June 4, 1929. **1,715,874**

UNITED STATES PATENT OFFICE.

LEO SZILARD, OF BERLIN-DAHLEM, GERMANY, ASSIGNOR TO SIEMENS-SCHUCKERT-WERKE GESELLSCHAFT MIT BESCHRÄNKTER HAFTUNG, OF SIEMENSSTADT, NEAR BERLIN, GERMANY, A CORPORATION OF GERMANY.

DISCHARGE TUBE.

Application filed October 28, 1925, Serial No. 65,394, and in Germany November 5, 1924.

My invention refers to thermionic discharge tubes provided with means for controlling the electron current between the anode and cathode, and it refers in particular to the type of discharge tubes in which, for the purpose of obtaining a large current between the anode and cathode, an arc-like discharge occurs at the cathode.

One of the objects of my invention is to provide an electric discharge tube which is suitable to furnish a heavy current between the anode and cathode which can be effectively controlled by a controlling device.

A further object of the invention is the placing of the anode into one of the vapor spaces of a mercury vapor pump (either into the vaporizing space or into the vapor condensing space) and to arrange the control means of the anode current in the low pressure or vacuum chamber of the pump.

Lastly an object of the invention is in arranging in tubes of the above described character the anode in the vapor space of one mercury vapor pump and the cathode in the vapor space of a second mercury pump and to control the current between the anode and cathode in an evacuated space which is common to the two pumps.

I have illustrated in the accompanying drawings two forms in which my invention may be reduced to practice, without thereby wishing to limit the forms in which my invention may be effectively carried out. In these drawings—

Fig. 1 represents a partial longitudinal vertical section and partially a view of a pair of electric discharge vessels in accordance with the present invention and

Fig. 2 represents a modification thereof in which one vessel is made of annular shape suitable to surround the other discharge vessel.

Referring to Fig. 1, 1 represents the vaporizing chamber of a mercury vapor jet pump, 2 is the condensing chamber of the pump and 3 represents the nozzle. 4 is the return pipe connection through which the mercury 12 which has been condensed in chamber 2 is returned into chamber 1. Chamber 2 is jacketed as shown at 13 and suitable cooling fluid is led through the jacket for the purpose of condensing the mercury in chamber 2. The mercury in vaporizing chamber 1 may be continuously vaporized by heating the mercury 10 in the lower portion of the chamber by any suitable means known in the art.

A second similar mercury vapor jet pump is provided consisting of the vaporizing chamber 5, a condensing chamber 7 and the nozzle 6, condensing chamber 7 being similarly cooled by a jacket 13 as the previously described chamber 2. The mercury 12 which condenses in chamber 7 is also similarly returned to the vaporizing chamber 5 by means of a return pipe 4, and the lower portion of chamber 5, like that of chamber 1, is assumed to be heated by suitable known means. Between the two pumps extends a suction chamber 8, preferably also jacketed as shown, this chamber being in common with both vaporizing chambers 1 and 5, so that both pumps tend to evacuate chamber 8. Consequently, a substantially lower pressure exists in chamber 8 than in chambers 1 and 5.

The mercury 10 in chamber 1 constitutes the cathode of the system and the mercury 11 in chamber 5 constitutes the anode. 19 and 20 are respectively the two inlead connections for the cathode and the anode. With low loads a gas discharge, such as an arc discharge, may preferably also be maintained in the vapor jet between chambers 1 and 2, by means of an auxiliary source of current which may be connected between the terminals 19 and 15 to have a sufficient number of negative charge carriers available for the current passage. Only the terminals 19 and 15, to which this auxiliary source may be connected are shown.

In the vacuum chamber 8 is disposed a control grid 9 which has an inlead connection 18 and which is arranged in that chamber so that it stands in the path of the current passing between the cathode 10 and the anode 11. Since now in view of the greater pressure prevailing in the vaporizing chamber 1, an arc-like discharge occurs, a sufficient number of electrons are discharged from cathode 10 which are drawn over to the anode by way of the two nozzles 3 and 6. The positive charges which compensate the negative space charge in chamber 8 are produced in the spaces 5 and 7 and in the vapor jet passing from space 5 into space 7, this impact ionization being due to the greater pressure existing in spaces 5 and 7 than in space 8. Consequently, the current density of the discharge tube is very large owing on one hand to the particular form of the cathode and on the other hand to the removal of the effect of the space charge. Notwithstanding, however, a very effective control of the anode current is possible, since the control grid 9 is arranged in a space 8 which is sufficiently evacuated to make the control action effective.

In the modification shown in Fig. 2, the mercury jet pump which contains the cathode 10 is given an annular form which surrounds a centrally located mercury pump of the same character as that shown on the right hand side in Fig. 1. The central chamber in Fig. 2 contains the anode 11 whereas the bottom of the annular pump contains the cathode 10. The inleads 19 and 20 are arranged similar to the manner shown in Fig. 1. In Fig. 2, 21 constitutes the annular vaporizing chamber for the cathode mercury, 22 a correspondingly annular vapor condensing chamber. 24 is the return conduit for the mercury 12, condensed in chamber 22, to the vaporizing chamber. 25 and 27 are respectively the vaporizing and condensing chambers of the central pump which contains anode 11 in the bottom of chamber 25 and 34 is the return conduit for the mercury 12, condensed in chamber 27, to the vaporizer 25. 23 and 26 are respectively the nozzles of the annular and the central pump, nozzle 23 being in this case also of annular shape, surrounding the central nozzle 26. The common suction or vacuum chamber of the two pumps is shown at 28 and accordingly is of circular shape, containing the cylindrical control grid 29. The manner of operation of this pump system is exactly the same as that of the pump system shown in Fig. 1. Also in this case the cathode and anode mercury may be vaporized by any suitable means known to those skilled in the art.

Various other modifications or forms of the pumps may be arranged without departing from the spirit and scope of my invention for which I claim as new:

1. A thermionic discharge device having a discharge chamber through which an electronic discharge may occur, means constituting a cathode for maintaining said chamber evacuated and means in said chamber for controlling the discharge, an anode chamber containing an anode and a gas whose pressure is higher than the pressure existing in said discharge chamber during the operation of the device and a connection between said two chambers.

2. A thermionic discharge device having a discharge chamber through which an electronic discharge may occur, means for maintaining said chamber evacuated and means in said chamber for controlling the discharge, an anode chamber containing an anode and a gas whose pressure is higher than the pressure existing in said discharge chamber, during the operation of the device, said evacuation maintaining means comprising a cathode chamber containing a cathode and a gas whose pressure is higher than the pressure existing in said discharge chamber, and connections between said discharge chamber and said two other chambers.

3. A thermionic discharge device having a discharge chamber through which an electronic discharge may occur, means constituting a cathode for maintaining said chamber evacuated and means in said chamber for controlling the discharge, an anode chamber containing an anode and a gas of sufficient pressure to prevent a negative space charge of the electrons in said discharge chamber during the operation of the device and a connection between said two chambers.

4. A thermionic discharge device having a discharge chamber through which an electronic discharge may occur, means for maintaining said chamber evacuated and means in said chamber for controlling the discharge, an anode chamber containing an anode and a gas whose pressure is higher than the pressure existing in said discharge chamber during the operation of the device, said evacuation maintaining means comprising a cathode chamber containing a cathode and a gas of sufficient pressure to render an arc discharge possible at the cathode and connections between said discharge chamber and said two other chambers.

5. A thermionic discharge device having a discharge chamber through which an electronic discharge may occur, means constituting a cathode for maintaining said chamber evacuated, a control grid in said chamber for controlling the electronic discharge therethrough, an anode chamber containing an anode and a gas whose pressure is greater than the pressure in said discharge chamber during the operation of the device and a connection between said two chambers.

6. A thermionic discharge device comprising a mercury vapor pump having a vaporizing chamber, a vapor condensing chamber and a high vacuum chamber and suitable connections between said chambers, said vaporizing chamber containing an anode and mercury vapor of a pressure sufficient to prevent the occurrence of negative electronic space charges in the high vacuum chamber, and a control element disposed in said high vacuum chamber for controlling an electron current flowing through said chamber to said anode.

7. An electronic discharge device comprising two mercury vapor pumps, each having a vaporizing chamber and a vapor condensing

chamber and a high vacuum chamber common to both pumps, the vaporizing chamber of one pump containing a mercury anode and vapor of sufficient pressure to prevent the occurrence of negative electronic space charges in said high vacuum chamber, the vaporizing chamber of the other pump containing a mercury cathode and vapor of sufficient pressure to render an arc discharge at said cathode possible, said vacuum chamber containing a control electrode and having a sufficiently high vacuum to control by means of said electrode the electron current flowing from the cathode through said chamber to the anode.

In testimony whereof I affix my signature.

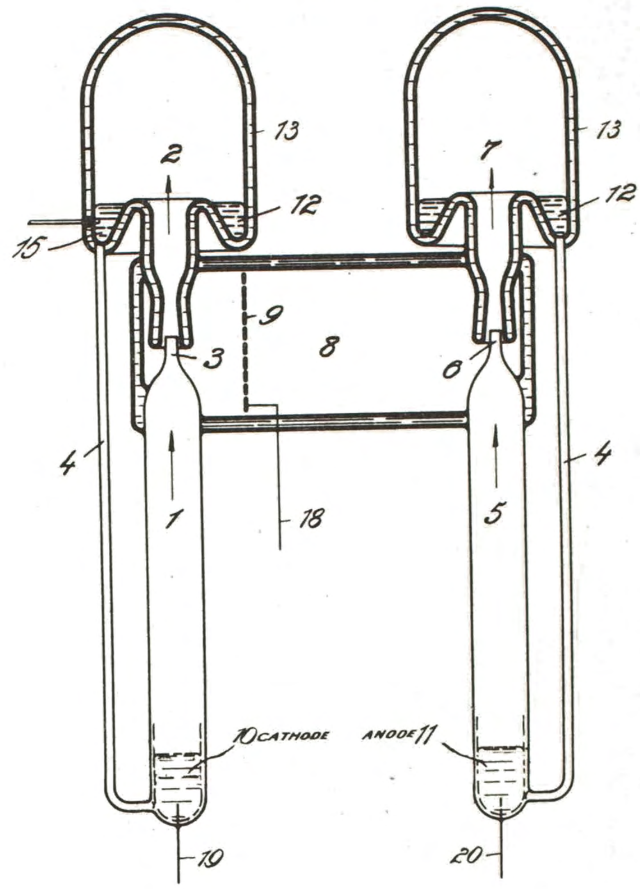
LEO SZILARD.

June 4, 1929. L. SZILARD 1,715,874

DISCHARGE TUBE

Filed Oct. 28, 1925 2 Sheets-Sheet 1

Fig. 1



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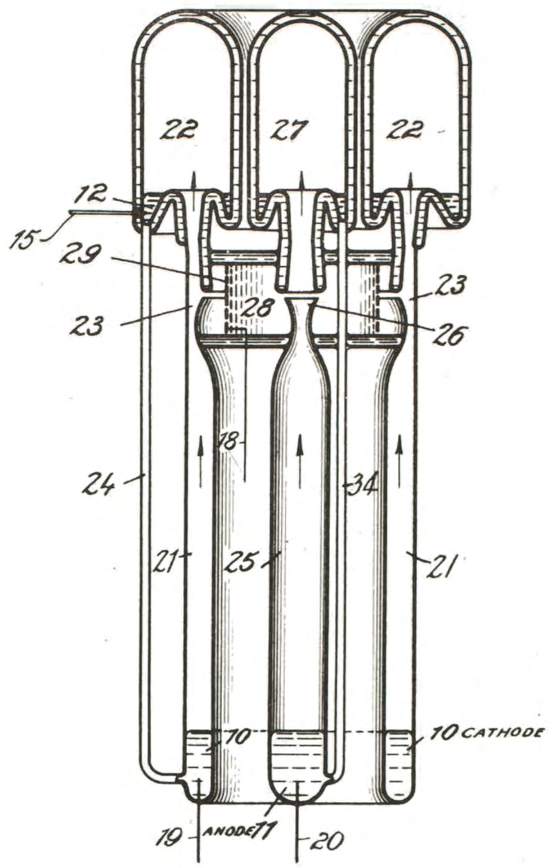
DISCHARGE TUBE

Filed Oct. 28, 1925 2 Sheets-Sheet 2

Fig. 2



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