DISCHARGE CHAMBER WITH CURRENT LEAD-IN

Filed March 27, 1962

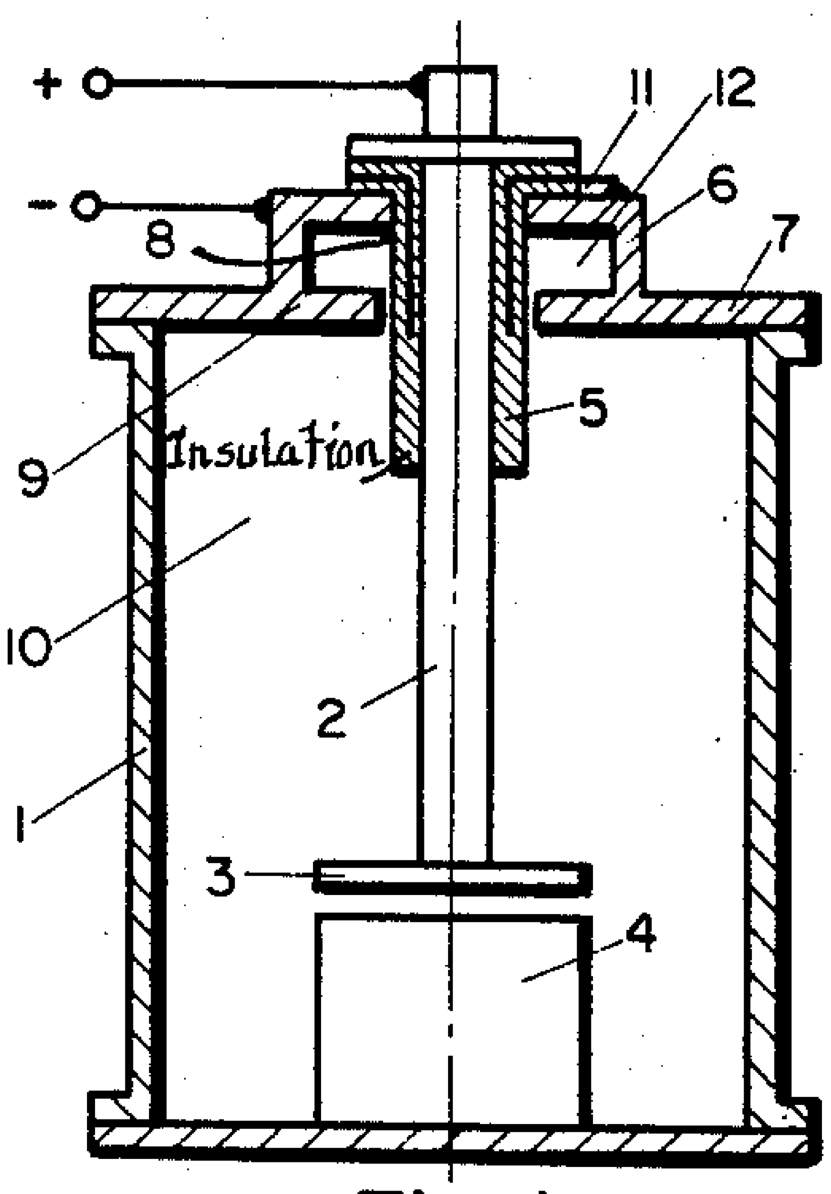

Fig. 1

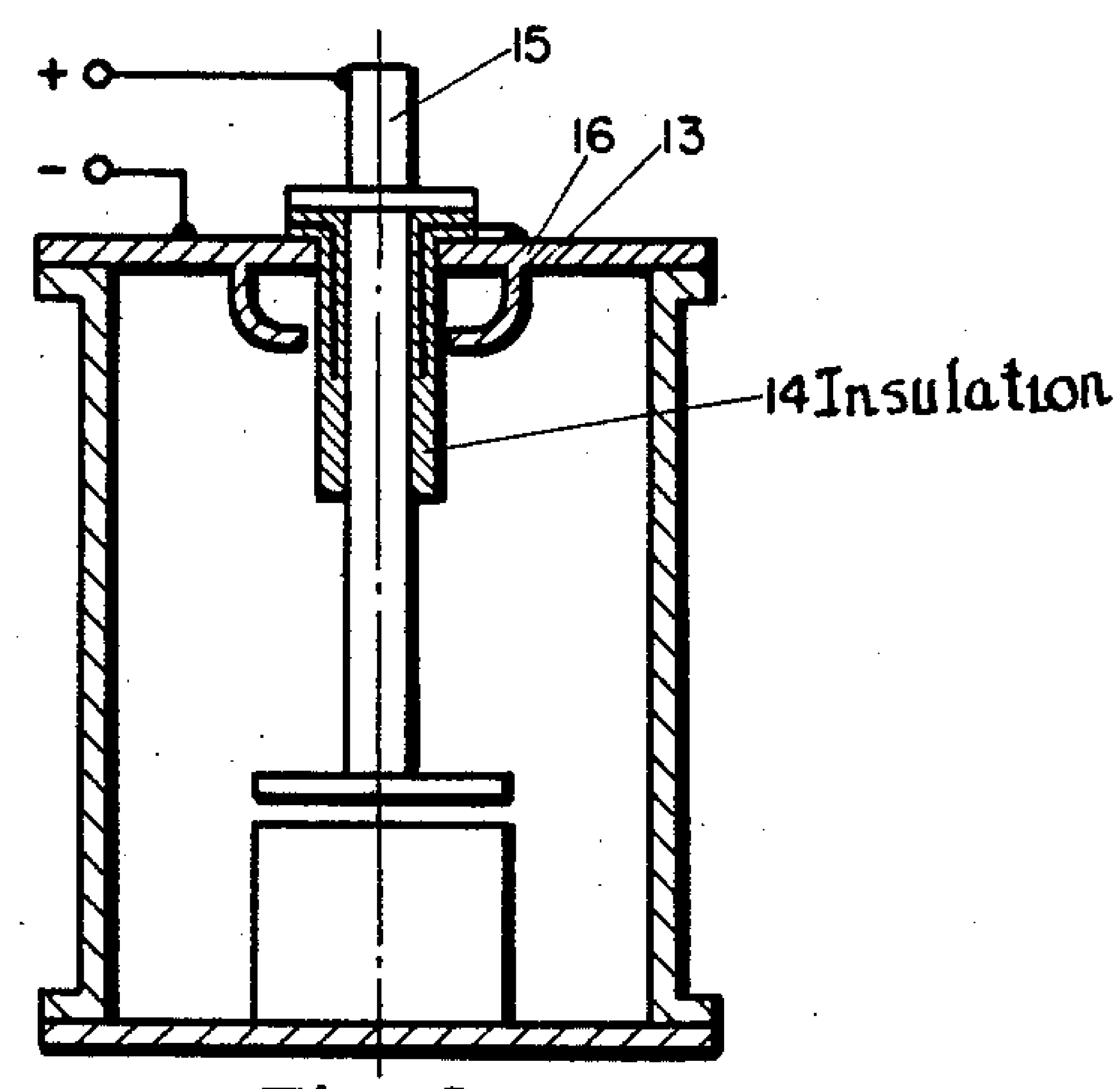

Fig. 2

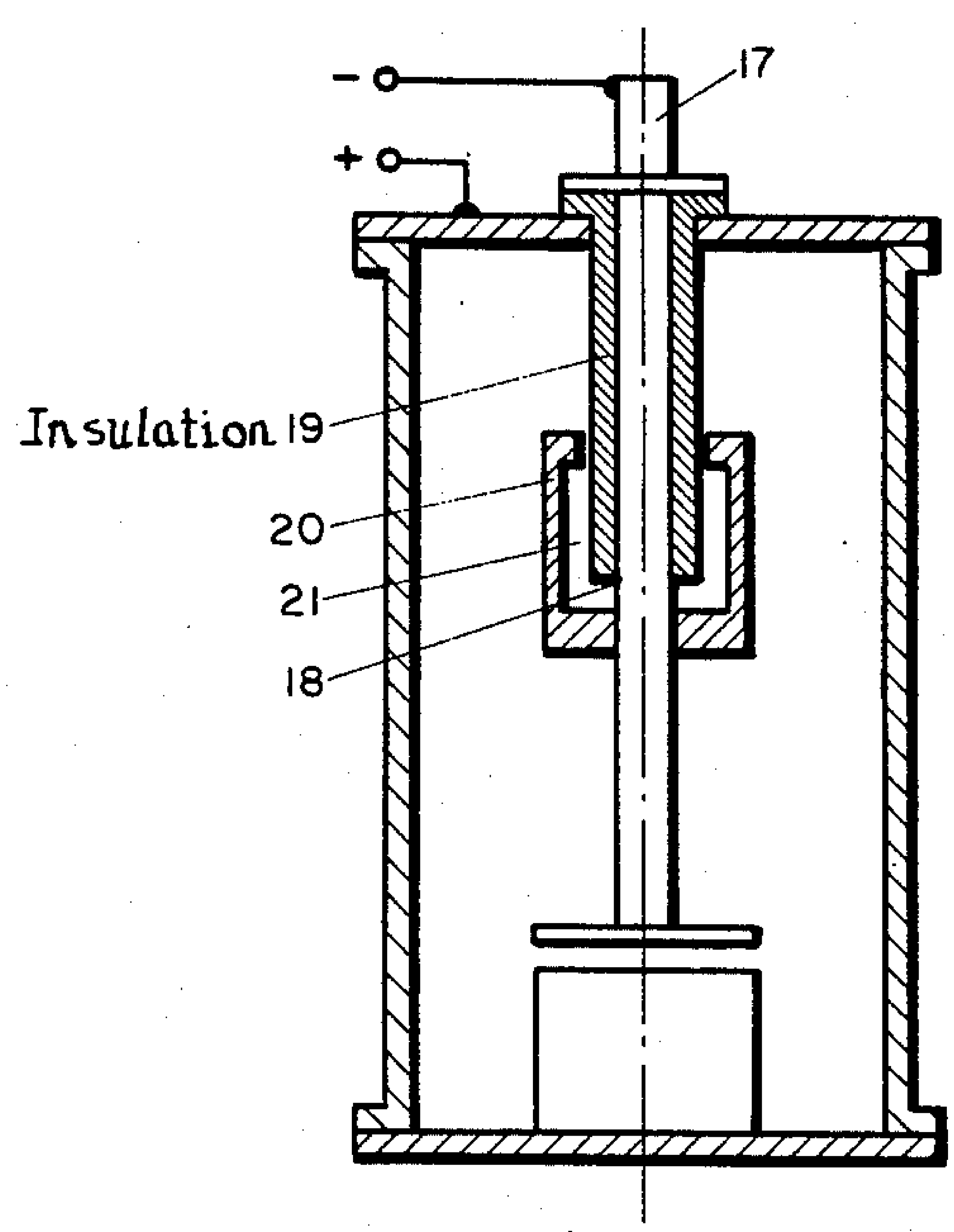

Fig. 3

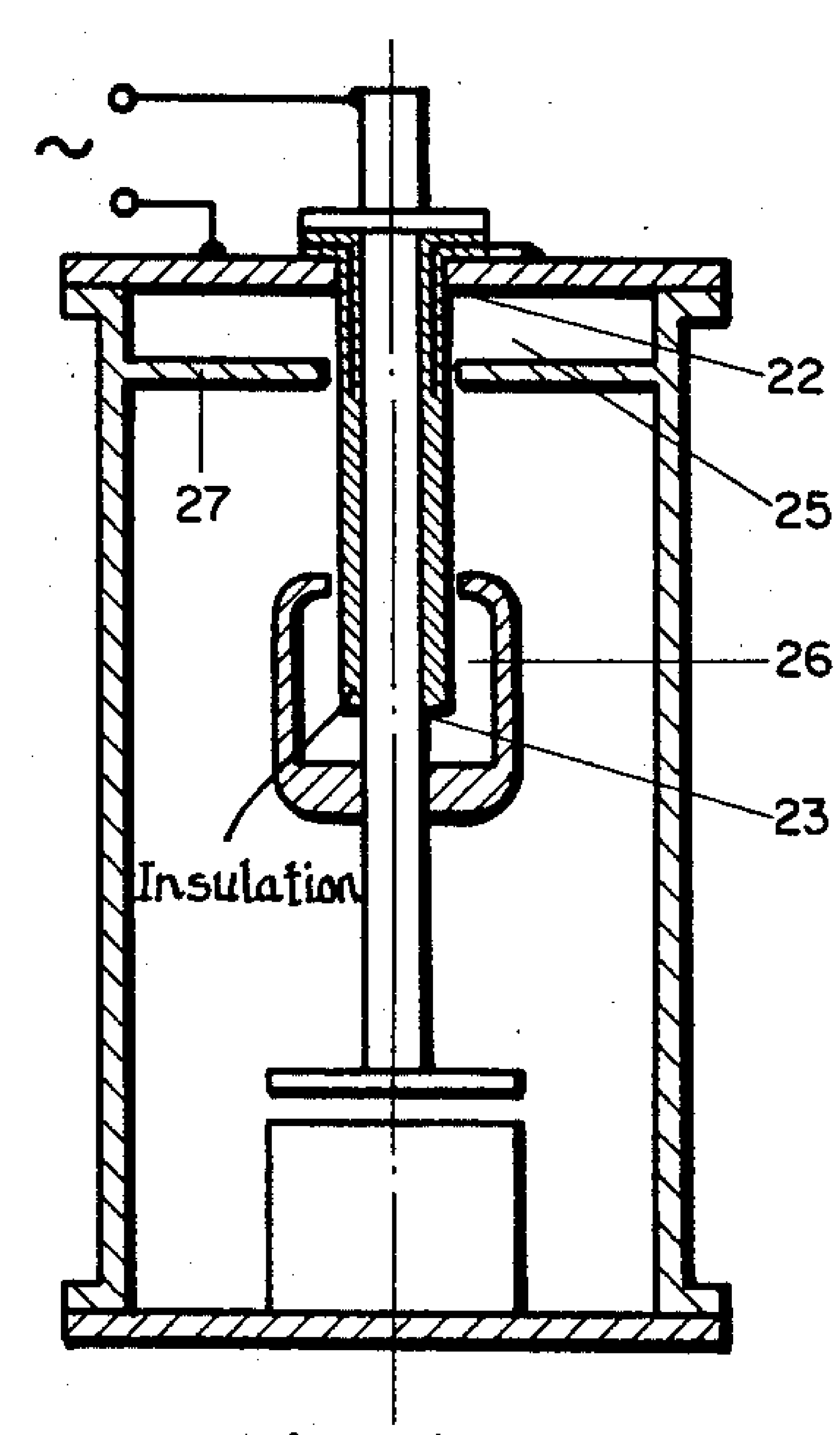

Fig. 4

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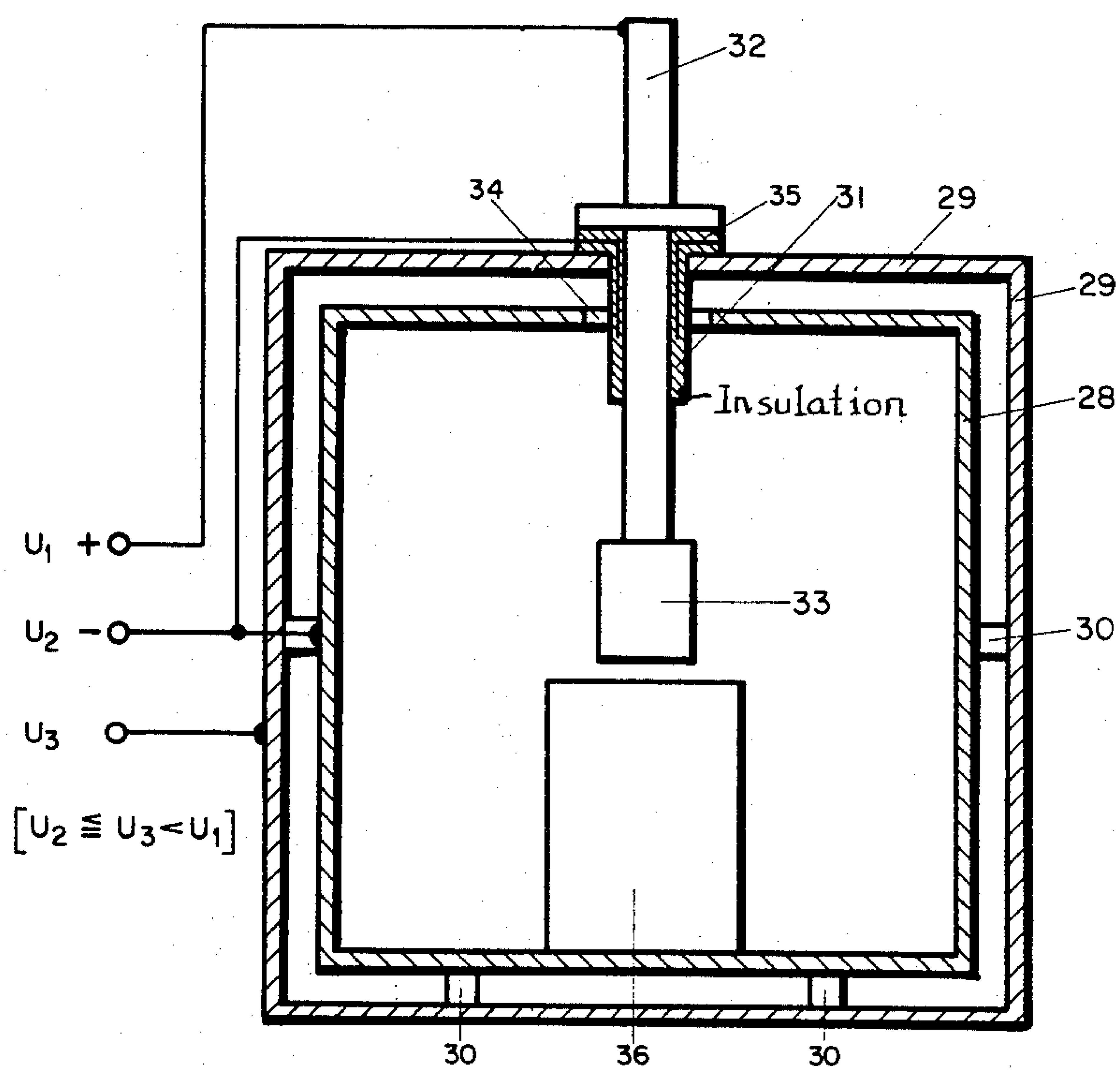

Fig. 5

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3,180,816
Patented Apr. 27, 1965

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3,180,816
DISCHARGE CHAMBER WITH CURRENT LEAD-IN

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Filed Mar. 27, 1962, Ser. No. 182,792
Claims priority, application Switzerland, Mar. 30, 1961, 3,806/61
10 Claims. (Cl. 204—312)

The present invention relates to devices for the performance of chemical, metallurgical or other technical processes under the action of electrical gas discharges, in particular glow discharges, comprising a discharge chamber and at least one current lead-in provided with an energized inner lead and an insulator designed to insulate the former.

The design of current lead-ins for discharge chambers entails difficulties because the insulating material within the discharge chamber at the junction points of the energized metal parts and the insulating bodies may be destroyed by electrical discharges with high discharge energy after a brief operating period, which may cause the corresponding insulating members to become useless and thus result in breakdowns. By way of example, if the lead-in of a glow discharge chamber to the electrode carrying the cathodic potential is covered by a glow seam extending as far as the insulator, the latter will be destroyed, where the intensity of the glow discharge is high, by the glow discharge at the junction point between the electrode lead-in and the insulator.

In order to avoid such destruction, the occurrence of an electrical discharge at the points of contact between the energized metal parts and the insulating members must be prevented. To this end, various arrangements and processes have been proposed. One of the most common measures is to arrange, between the discharge chamber and the insulating material provided to insulate the energized parts, protective gaps delimited by metallic walls, of which the gap width is so narrow that an electron released at the wall of the protective gap carrying the cathodic potential cannot produce, on its path to the wall of the protective gap carrying the anodic potential, so many ions as are on an average required to release a new electron at the wall of the gap carrying the cathodic potential. Where the gap width is so dimensioned, the number of electrons produced at the wall carrying the cathodic potential cannot increase so that no independent discharge will be set up within this protective gap. Provision of such protective gaps between the discharge space and the point of contact between metal and insulating material therefore enables the harmful action of electrical discharges on the insulating material to be avoided.

These protective gaps have in practice been found to be effective where the pressure in the discharge chamber is comparatively low in operation. Above an upper limit pressure $p_0=c.\lambda_0/d$ which, with a mean proportionality constant c, is proportional to the relationship λ_0/d of the mean free length of path λ_0 of the gas under normal pressure present in the discharge chamber to the gap width d, these protective gaps however become ineffective. This may be explained by the fact that the number of ions which may on an average be produced by an electron per unit path is inversely proportional to the pressure. When the upper limit pressure is reached, the average number of ions produced by an electron on its way through the gap has increased sufficiently on an average to enable a new electron to be released so that an independent discharge can be maintained. With a predetermined type of gas and therefore λ_0 predetermined, this upper limit pressure, as may be seen from the above equation, can be increased only by reducing the gap width. The effectiveness of the gap width is therefore limited in the upward direction relative to the pressure existing in the discharge chamber because the gap width cannot be reduced at will, for purely mechanical reasons. It has therefore been proposed to design the protective gap, which was previously known only in the form of a cylindrical gap, as a flatgap in order, amongst other things, to create the possibility of further reducing the gap width. This enabled the upper limit pressure to be quite substantially raised to a level normally entirely sufficient.

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In order, however, to become entirely independent of this upper limit pressure, new means independent of this interrelationship had to be sought. The problem underlying the present invention was therefore to provide a current lead-in in which the protection of the insulating material against the attack by electrical discharges is ensured independently of an upper limit pressure.

According to this invention, a device for the performance of technical processes under the action of an electrical gas discharge, in particular a glow discharge, with a discharge chamber and at least one current lead-in provided with an energized inner lead and an insulator designed to insulate the former, is provided with means enabling a zone of such low field intensity to be produced in the gas space between the junction points between metal and insulator subjected to the attack by discharges on the one hand and the discharge chamber on the other, that no glow discharge can be set up within the said zone.

The means for providing a zone of low field intensity preferably consists of at least one additional electrode arranged in the gas space between an endangered junction point on the one hand and the metal parts adjoining the gas space carrying a potential opposed to that of the metal at the junction point and so designed that it will screen off the junction point against the potential opposed to that of the metal parts, the potential of the said additional electrode being so chosen that the field intensity between it and the metal at the junction point will not suffice to start a glow discharge. The additional electrode is preferably so connected that it possesses the same potential as the metal at the junction point. The additional electrode may advantageously be mechanically and electrically connected to the part which forms the metallic side of the junction point.

In current lead-ins with an insulator enclosing the inner lead it is advantageous to design the additional electrode in such a manner that it encloses the insulator at a point intermediate of the junction point and the metal parts of opposite potential adjacent the gas space, and that such a space is left at the point of enclosure between the electrode and the insulator so that contact between the electrode and the insulator is impossible. This space between the electrode and the insulator is preferably larger at the point of enclosure than the fall space thickness of the cathode fall.

As is known, the space between the cross-over of the Crookes dark space and the negative glow light, and the upper surface of the cathode is known as "fall space thickness." In this region from the upper surface of the cathode to the cross-over place of the Crookes dark space and the negative glow light, the potential rises very rapidly. This rapid rise in potential is known as the "cathode fall." Such terminology is fully described in "Fundamental Processes of Electrical Discharge in Gases," by L. B. Loeb, published by John Wiley & Sons, Inc., New York, 1947; chapter 6 describes the above terminology.

It may, by way of example, be advantageous in a device according to this invention, to design the discharge chamber with two walls, to attach the insulator and the inner lead of the current lead-in to the outer wall, and to employ the inner wall as an additional electrode and to provide it with a hole through which the insulator extends.

In a device according to the invention, the additional electrode is preferably designed as a metal jacket conductively connected to the part forming the metallic side of the junction point which it so closes relative to the discharge chamber that the gas space is connected with the discharge chamber only via the space between the metal jacket forming the additional electrode and the insulator.

In certain applications it may be of much advantage with a view to enhancing the screening action of the additional electrode to connect the additional electrode to a potential of such a level that the potential difference between the part forming the metallic side of the junction point and the metal parts adjacent to the gas space with the opposite potential is smaller than the potential difference between this metal part of opposite potential and the additional electrode. The effect of such an initial potential applied to the additional electrode is about the same as the negative potential of the grid of an electronic valve. In either case, the transconductance of the anode to the cathode may be reduced to almost zero.

A number of embodiments of the present invention is described in greater detail in conjunction with the drawings in which:

FIG. 1 is a diagrammatic view of a discharge chamber according to the invention, designed for voltages of invariable polarity, in which the inner lead of the current lead-in is to be connected to the positive pole;

FIG. 2 is a further diagrammatic view of a discharge chamber according to this invention, with a current lead-in for voltages of invariable polarity in which the inner lead is to be connected with the positive pole;

FIG. 3 is a diagrammatic view of a discharge chamber according to this invention, with a current lead-in for voltages of invariable polarity in which the inner lead of the current lead-in is to be connected to the negative pole;

FIG. 4 is a diagrammatic view of a discharge chamber according to this invention, with a current lead-in, which may be employed for voltages of both invariable and variable polarities, and

FIG. 5 is a diagrammatic view of a double-walled discharge chamber, with current lead-in, for voltages of invariable polarity in which the inner lead of the current lead-in is to be connected to the positive pole.

In the diagrammatic view of a device according to this invention represented in FIG. 1, the discharge chamber **1** is connected as the cathode and the inner lead **2** of the current lead-in is connected to the anode **3** arranged at a small distance from the work **4** connected to the discharge chamber **1**. The insulator **5** enclosing the inner lead **2** is attached to the top member **6** of the cover **7** of the discharge chamber. The formation of a glow discharge at the junction point **8** between the top member **6** carrying cathodic potential and the insulator **5** must be prevented. To this end, the cover **7** of the discharge chamber is so designed that, together with its top member **9**, it forms an additional electrode which carries a cathodic potential as well and is arranged between the junction point **8** and the metal parts adjacent to the discharge space **10** carrying an anodic potential, i.e., between the portion of the inner lead **2** adjacent to the gas space and the anode **3** so as to screen off the junction point **8** against the transconductance of these metal parts which carry an anodic potential. The cover portion **9** being provided with a bore through which the insulator **5** extends without touching the cover portion **9**, destruction of the insulator at this point is impossible. On the other hand, a further additional electrode **11** is inserted in the wall of the insulator **5**, which also carries a cathodic potential and prevents transconductance of the inner lead **2** via the insulator **5** into the gas space **12**.

Accordingly, the gas space **12** is enclosed by metal parts carrying the same potential virtually on all sides so that the field intensity within the gas space **12** is almost equal to zero, ensuring that no glow discharge can be set up within this zone or at the junction point **8**. In dimensioning the discharge chamber it is advantageous to select a small distance between the work and counter-electrode, i.e., in FIG. 1 between the work **4** and the anode **3**, relative to the distance between the additional electrodes adjacent to the discharge chamber and metal parts carrying about the same potential on the one hand, and the metal parts adjacent to the discharge chamber and carrying the opposite potential. Basically, this also applies to all other embodiments of devices according to this invention and it is due to the fact that the glow discharge is desired to be set up mainly between the work and the counter-electrode.

It should here be pointed out that FIG. 1 and all other figures represent only diagrammatic views of devices according to this invention and have for their object clearly to disclose the invention. For the sake of clarity, the drawings are not to scale and many non-essential details have been omitted.

FIG. 2 shows a device according to this invention which differs from that shown in FIG. 1 only by the fact that the additional electrode formed by the cover portion **9** in FIG. 1 is here formed by a cover member **13** projecting into the discharge chamber and that the insulator **14** and the inner lead **15** of the current lead-in are directly attached to the cover **16** of the discharge chamber. The operation of the device according to FIG. 2 is the same as that shown in FIG. 1; in particular, both devices are designed for operation with invariable polarity, the inner lead requiring connection to the positive pole.

FIG. 3 shows a device according to this invention which is also designed for operation with invariable polarity and in which the inner lead **17** is to be connected to the negative pole. Accordingly, the junction point subjected to the attack by discharges is the point **18** between the inner lead **17** and the insulator **19**. The additional electrode **20** conductively connected to the inner lead **17** is therefore so designed that it encloses, together with the inner lead **17**, the gas space **21** with metal parts carrying the same potential on virtually all sides so that the field intensity within the gas space **21** is almost equal to zero and no glow discharge can be formed within this zone and, accordingly, at the junction point **18**. The insulator **19** extends through a bore provided in the additional electrode **20** without contacting the said electrode, so destruction of the insulator **19** at this point is impossible.

FIG. 4 shows a device according to this invention for connection to a voltage source having varying polarity. Naturally, this device may also be operated from a voltage source having invariable polarity; the latter may be selected at will. It is seen that the device according to FIG. 4 is approximately a combination of those according to FIGS. 2 and 3. In FIG. 4 both junction points between metal and insulator, **22** and **23**, are protected from the attack by electrical discharges by gas spaces **25** and **26** arranged in front of them which have a field intensity that may be disregarded. This is a necessity only for varying polarities because both the inner lead and the discharge chamber at time carry a cathodic potential. A point to be noted in connection with FIG. 4 is the advantageous arrangement of the additional electrode **27**.

FIG. 5 shows a particular design of the device according to this invention. The discharge chamber is here provided with double walls and the inner wall **28** is insulated from the outer wall **29** by means of insulators **30**. The inner wall **28** forms the additional electrode which encloses the insulator **31** and which is here also the cathode. The inner lead **32** carrying an anodic potential and the insulator **31** are attached to the outer wall **29** of which the potential may be selected as desired. In this case, applying an initial potential to the outer wall **29** relative to the inner wall 28 so that the potential difference between the outer wall 29 and the anode 33 is smaller than the potential difference between the inner wall 28 and the anode 33, ensures that a glow discharge cannot enter the gap 34. However, if the potential of the outer wall 29 is the same as that of the inner wall 28, the insulators 30 may be replaced by conductive members. The further additional electrode 35 inserted in the insulator 31 may be connected to either the outer or the inner wall. The distance between the anode 33 and the work 36 should be relatively small in this case as well.

Attention is called to the fact that the invention is not limited to the embodiments here represented. By way of example, the inner lead of the current lead-in may, to perform chemical processes, be designed as a nozzle through which gas is continuously supplied to the interior of the discharge chamber. The invention generally relates to protecting junction points between metal and insulators subjected to attack in discharge chambers against such attack by electrical discharges by arranging zones of low field intensity in front of them.

Having now particularly described and accertained the nature of my said invention and the manner in which it is to be performed, I declare that what I claim is:

1. In a device for carrying out processes by an electrical glow discharge in a gaseous atmosphere within a chamber and wherein two conductive parts are at different potentials with one of said parts comprising a current lead-in extending through the other part with an insulator therebetween, means for protecting said insulator against destruction by said glow discharge at the junction between said insulator and an adjacent conductive part, comprising: conductive wall means spaced from said junction, and having an edge extending toward and spaced from but closely adjacent said insulator, said wall means being arranged to substantially encompass a substantial body of said gas around said junction; and means for applying a potential to said wall means of the same order of magnitude as that of said adjacent part whereby the field intensity in said body of gas is so low that no glow discharge can occur therein.

2. A device as defined in claim 1 including a further electrode embedded within the material of said insulator and surrounding said lead-in in the region of said body of gas; and means for applying to said further electrode a potential of the same order of magnitude as that of said adjacent part.

3. A device as defined in claim 2 wherein said further electrode surrounds said lead-in at least from said junction to said edge.

4. A device as defined in claim 2 wherein said further electrode is electrically connected to said wall means whereby it is at the same potential.

5. A device as defined in claim 1 wherein said means for applying a potential to said wall means is arranged to charge said wall means to a potential differing from that of said adjacent part which is less than the potential difference between said parts.

6. A device as defined in claim 1 wherein said wall means is electrically connected to said adjacent part whereby its potential is the same as that of said adjacent part.

7. A device as defined in claim 1 wherein said wall means is secured to and extends directly from said adjacent part.

8. A device as defined in claim 1 wherein said wall means comprises the walls of said chamber; said adjacent part comprising an outer enclosure spaced from said wall means.

9. Advice as defined in claim 1 wherein the space between said edge of said wall means and said insulator comprises the only communication between said chamber and said body of gas.

10. A device as defined in claim 1 wherein the spacing between said edge and said insulator is larger than the fall space thickness of the cathode drop.

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