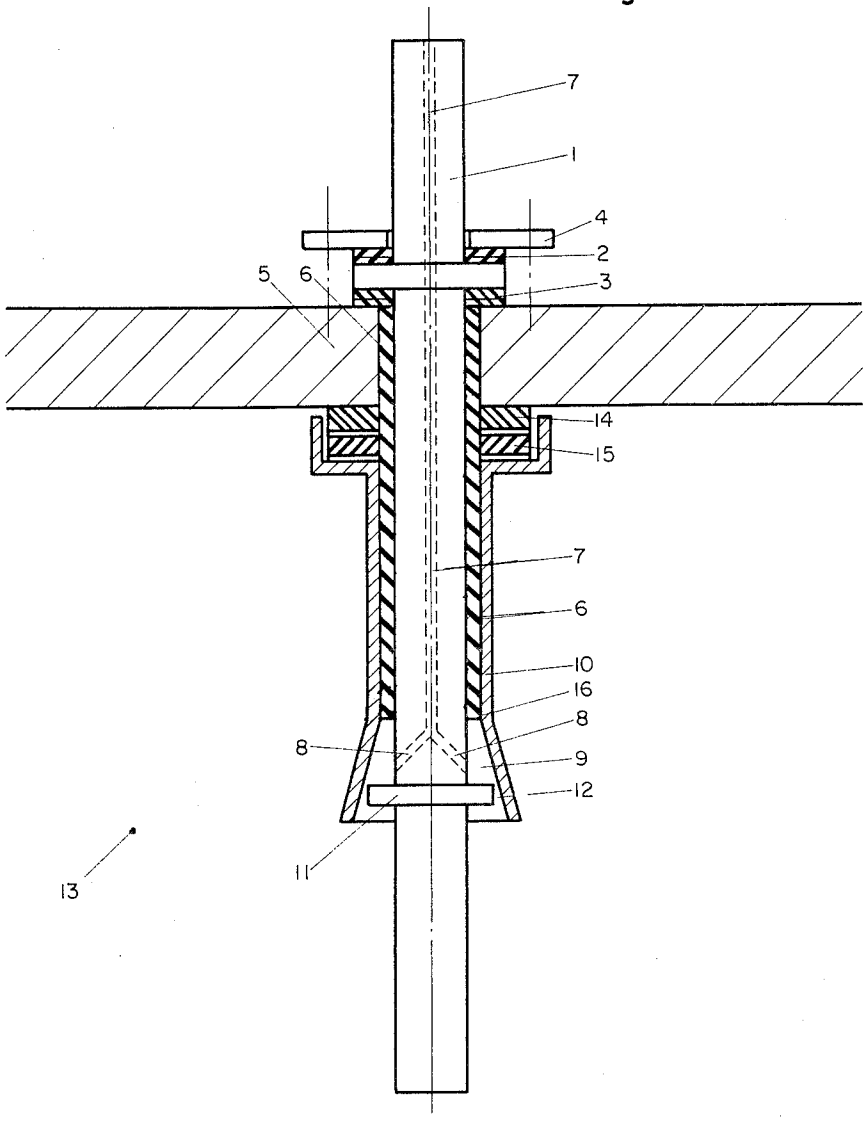
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CURRENT LEAD-IN FOR DISCHARGE CHAMBERS

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Fig. 1



INVENTOR
HORST RORDORF
BY
Bacon & Thomas
ATTORNEYS

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Fig. 2

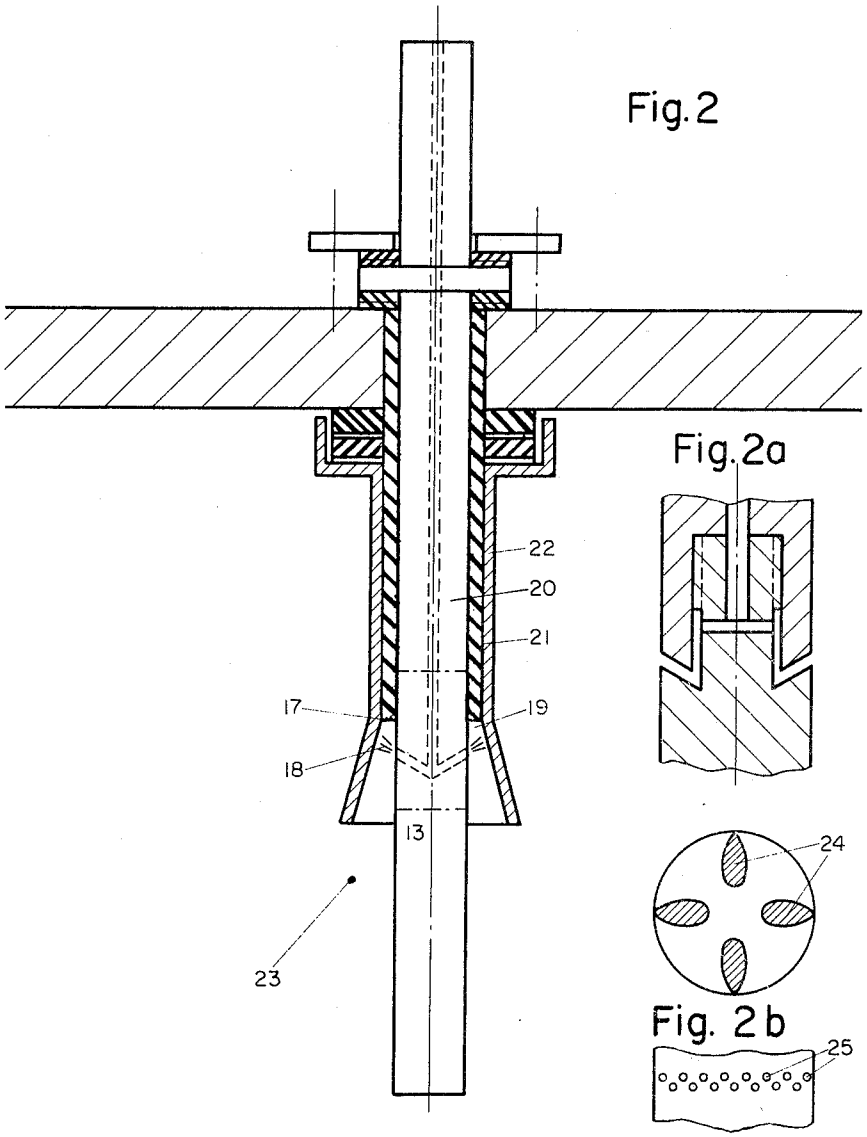


Fig. 2a

Fig. 2b

Fig. 2c

INVENTOR
HORST RORDORF
BY
Bacon & Thomas
ATTORNEYS

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CURRENT LEAD-IN FOR DISCHARGE CHAMBERS

Horst Rordorf, Ifangstrasse 17, Weiningen, Zurich, Switzerland

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The present invention relates to current lead-ins for discharge chambers designed for the performance of chemical, metallurgical or other technical processes under the action of electrical discharges in gas particularly glow discharges, in which gas is continuously passed through the chamber during the process.

The arrangement of current lead-ins extending into and insulated from discharge chambers entails difficulties because the insulating material may be destroyed after a short period of operation within the discharge chamber at the points of contact between energized metal parts and insulating members due to the attack by electrical discharges, particularly where discharge energy is high. Such damage may cause the insulating members involved to become useless and result in breakdowns. By way of example, if the lead-in to the electrode carrying the cathodic potential in a glow discharge chamber is covered by a glow seam extending as far as the insulator, the latter will be destroyed by the glow discharge at the junction point between the electrode lead-in and the insulator where the intensity of the glow discharge is high.

In order to avoid destructions of this kind, the occurrence of electrical discharges at the points of contact between energized metal parts and insulating members must be prevented. To this end, various arrangements and processes have been devised. One of the most common measures comprises the provision of protective gaps delimited by metallic walls which are located between the discharge chamber and the insulating material designed to insulate the energized members, the width of such gaps being so reduced that an electron released at the wall of the protective gap which carries the cathodic potential cannot, on its path to the wall of the protective gap carrying the anodic potential, produce so many ions as are on an average required to release a new electron at the wall 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 operating pressure in the discharge chamber is comparatively low. Above an upper pressure limit $p_0=c.\lambda_0/d$ 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 mean free length of path of the electron involved and, accordingly, proportional to the pressure. When the upper pressure limit is reached, the average number of ions produced by an electron on its way through the gap has increased sufficiently 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 pressure limit, 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 flat gap in order, amongst other things, to making a further reduction of the gap width possible. This enabled the upper pressure limit to be quite substantially raised to a level normally entirely sufficient.

In order, however, to become entirely independent of this upper pressure limit, 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 limiting pressure.

The solution of this problem was achieved for current lead-ins with an energized inner lead and an insulator provided for its insulation, for discharge chambers designed for the performance of such chemical, metallurgical or other technical processes under the action of electrical gas discharges, and particularly glow discharges, in which gas is continuously passed during the process. The present invention provides such a current lead-in with means designed to form, between the junction points between metal and insulator which are subjected to the attack by discharges on the one hand and the discharge chamber on the other, a zone comprising at least a portion of the gas flowing through said chamber, the said zone possessing a pressure so much higher than the mean pressure in the discharge chamber that no glow discharge can be set up within the zone.

This is achieved preferably by means designed to inhibit the efflux of gas from the zone of higher pressure into the discharge space within the chamber. These means inhibiting the gas efflux may advantageously be so dimensioned that the gas is held up and so that the zone of higher pressure is formed at least largely by dynamic pressure.

The means inhibiting the gas efflux may advantageously be so adjustable that the flow resistance formed thereby may be varied.

In order to supply the gas, the inner lead is preferably designed, in the portion of its length which passes through the wall of the chamber, as a gas inlet provided with one or more orifices so arranged that the zone of higher pressure is produced, when gas is flowing, at a point of discharge between the inner lead and insulator but within the discharge chamber.

A current lead-in with an insulator enclosing the inner lead may, by way of example, advantageously be designed so that the gas supply line opens into an annular space enclosing the inner lead, the said space being delimited by the inner lead, the end of the insulator and a metal jacket embracing part of the length of the insulator, and within which space the zone of higher pressure is formed when gas is flowing. This annular space is preferably delimited, in the direction toward the discharge chamber, by a ring connected with the inner lead, the said ring being so dimensioned and arranged that only a narrow annular gap remains open for the escape of the gas between the ring and the metal jacket. The metal jacket embracing the insulator should preferably be arranged so that it has no electrical potential thereon.

Two embodiments of the present invention are described in greater detail in conjunction with the drawings in which:

FIG. 1 shows a current lead-in according to this invention in which the zone of higher pressure is obtained, by dynamic pressure, in a space of restricted cross-sec-

tion which has an opening communicating with the discharge chamber,

FIG. 2 shows a current lead-in according to this invention in which the zone or higher pressure is formed by the configuration of the gas stream, and

FIGS. 2*a*, 2*b* and 2*c* illustrate structural details of different forms of the invention.

In principle, the operation of the invention is based on the fact that a certain voltage is required to maintain, e.g., a glow discharge at a given gas pressure. The level of this voltage is essentially dependent on the gas pressure existing in the discharge chamber, but is entirely independent of the voltage in the range of the normal cathode drop and only slightly dependent thereon in the area of high-energy glow discharges. At a certain mean pressure present in the discharge chamber and with a corresponding voltage which produces a glow discharge in the discharge chamber, it is therefore possible to prevent the formation of a glow discharge in any desired zone by locally increasing the gas pressure. In discharge chambers designed for the performance of such processes in which gas is continuously passed through the chamber, the gas stream itself may advantageously be employed to obtain such a local pressure increase, by forming a dynamic pressure zone through which the gas must flow.

By way of example, the embodiment of a current lead-in according to this invention is based on this principle of forming a dynamic pressure zone. In FIG. 1 an inner lead **1** carrying a cathodic potential is attached to the outside of the wall **5** of the discharge chamber by means of the insulating sealing plates **2** and **3** and the clamping plate **4**, and insulated from the chamber wall **5** by means of the insulating tube **6**. The gas to be passed through the chamber is supplied to the said chamber via the bore **7** provided in the inner lead. Through the orifices **8** of this gas supply line, the gas will flow into the annular zone **9** which encloses the inner lead, the said zone **9** being delimited, apart from the inner lead, by the insulating tube **6**, a metal jacket **10** and a ring **11** carried by the inner lead. The metal jacket **10** embraces the insulator **6** on the portion of its length which projects into the interior of the chamber and is attached to the inside of the chamber wall **5** by means of the insulating sealing plates **14** and **15**.

The gas present in the annular zone **9** can emerge only through the narrow annular gap **12** between the ring **11** and the metal jacket **10**, in which gap high flow resistance inhibits the free efflux of the gas. Accordingly, the gas flowing into the zone **9** through the orifices **8** will be restrained in this zone. The dynamic pressure thus built up in the zone **9** is higher by the pressure drop at the flow resistance of the gap **12** than the pressure in the interior **13** of the chamber.

If the quantity of gas passed is predetermined according to the volume supplied per unit time, the dynamic pressure in the zone **9** is proportional to the pressure in the discharge chamber independently of the absolute pressure value, the said ratio being determined by the product of the flow resistance of the gap **12** and the gas volume supplied per unit time. If the gas volume passed is determined according to the weight supplied per unit time, the pressure drop at the flow resistance of the gap **12** and the pressure difference between the dynamic pressure in the zone **9** and the pressure in the discharge chamber are constant independently of the absolute value of the pressure.

In general, any desired values can be set for the dynamic pressure and the pressure in the discharge chamber while the amount of gas passed is optional. By way of example, the pressure in the discharge chamber may be kept constant by an appropriate pump arrangement while the desired level of the dynamic pressure in the zone **9** can be adjusted by appropriately setting the pressure of the gas supplied.

The flow resistance of the gap **12** is advantageously so adjusted that the dynamic pressure in the zone **9**, independently of whether the gas passed is determined according to the volume supplied or the weight per unit time, is at all events sufficiently high relative to the pressure in the discharge chamber to prevent the formation of a glow discharge in the zone **9**. The level of flow resistance in the gap **12** may, e.g., be changed by modifying the cross-section and, respectively, the width of the gap **12**. In certain applications it may be of advantage to provide the current lead-ins with means for altering the width of the gap **12** and thereby the flow resistance therethrough particularly if the discharge chamber for which the current lead-ins are designed is to be employed in continuously varying operating conditions or if it is designed for use in a laboratory for the performance of a variety of processes.

If the current lead-in is designed for an operation in which the quantity of gas passed is determined independently of the absolute pressure value, and by the volume supplied per unit time; the flow resistance may be smaller than in cases where operating conditions vary because the ratio between the dynamic pressure and the pressure in the discharge chamber remains constant. By way of example, in many applications a dynamic pressure/discharge chamber pressure of 2:1 will suffice to prevent the occurrence of a glow discharge in the dynamic pressure zone. The constancy of this ratio, however, will be maintained only while the flow resistance may be regarded as being substantially linear, i.e. while the pressure drop at the flow resistance is caused mainly by the friction of the gas molecules on the fixed walls forming the flow resistance so that it is approximately proportional to the number of the gas molecules passing the flow resistance.

In designing the current lead-in it should further be ensured that the flow resistance of the gas supply line to the dynamic pressure zone, i.e. the bore **7** in FIG. 1, is as low as possible relative to the flow resistance in gap **12**.

In the determination of the flow resistance in gap **12**, account should be taken of the discharge energy to be supplied to the discharge chamber. The flow resistance should be so controlled that the pressure in the dynamic pressure zone will at all times be so much higher than the pressure in the discharge chamber that the highest possible voltage at any possible pressure level in the discharge chamber is insufficient to cause a glow discharge in the dynamic pressure zone.

Provision of such a high dynamic pressure in the zone **9** ensures that no glow discharge can be produced at the junction point **16** between the inner lead and the insulator, and the insulator is thus protected against the harmful attack by the glow discharge.

FIG. 2 shows a further embodiment of a current lead-in according to this invention which differs from the current lead-in of FIG. 1 in that the necessary dynamic pressure in a zone in front of the transition point **17** between the inner lead and the insulator is obtained in a manner. The flow of the gas supplied is here controlled in such a manner that the gas forms, inwardly of the junction point **17**, a closed jet cone or jet ring **1** with flow in the radial direction. This causes a pressure to be built up in the annular zone **19** which, owing to the delimitation of the zone **19** by the inner lead **20**, the insulator **21** and the metal jacket **22** and the fact that the gas can flow out of this zone **19** only through the jet cone **18**, is about the same as the pressure existing within the jet cone **18**. From the jet cone **18**, the pressure rapidly decreases in the direction of the interior of the chamber **23**.

With a current lead-in so arranged, care should be taken that the pressure is kept substantially constant along a circumferential line on the jet cone, i.e. that the flow should be uniform in all radial directions. FIGS. 2*a*,

2*b* and 2*c* show means for meeting this requirement. FIG. 2*a* show show the portion of the inner lead in the region of the jet cone **18** might be designed. FIG. 2*b* shows another possibility and represents a section of the inner lead at the point where the jet cone is discharged around the inner lead. The streamlined design of the connecting pieces **24** which join the upper and lower portions of the inner lead prevents zones with a lesser flow density relative to the ambient zones from being formed behind the connecting pieces. FIG. 2*c* in turn reveals a further possibility and is an exterior view of the point of the inner lead where the jet cone is formed around the inner lead. The staggered rows of holes **25** represent the orifices of holes which extend from the gas line located at the centre of the inner lead to the outer surface thereof. The fact that these orifices are staggered enables a closed jet cone to be formed.

Besides the embodiments shown in FIGS. 1 and 2 there are many other possible means for creating zones of higher pressure relative to the mean pressure in the discharge chamber and inwardly of the transition points subject to the attack by discharges. The invention is therefore not limited to the embodiments shown but is to be limited only by the scope of the appended claims.

Having now particularly described and ascertained 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 apparatus for performing processes in electrical discharges in gas comprising: means defining a wall of a chamber; a current lead-in extending through said wall; insulation between said lead-in and said wall; means for conducting a continuous stream of gas into and through said chamber; means for directing at least a portion of said stream into a zone encompassing the junction between said insulation and said lead-in, in said chamber; means for confining said gas in said zone sufficiently to maintain a gas pressure in said zone higher than the pressure in said chamber whereby to prevent any glow discharge in said zone.

2. Apparatus as defined in claim **1** wherein means are provided to restrict flow of gas from said zone into said chamber to maintain said higher pressure in said zone.

3. Apparatus as defined in claim **2** wherein said last-named means comprises a flow passage communicating said zone with said chamber, said flow passage being dimensioned to offer greater resistance to gas flow than said means for directing said portion into said zone whereby said higher pressure is produced by dynamic pressure from said portion.

4. Apparatus as defined in claim **3** wherein the dimensions of said flow passage may be adjusted whereby to vary the pressure in said zone.

5. Apparatus as defined in claim **1** wherein said means for conducting said stream comprises a passageway through said lead-in; and orifices in said lead-in adjacent said junction, communicating with said passageway and arranged to direct said gas into said zone.

6. Apparatus as defined in claim **5** wherein said insulation surrounds said lead-in and has an inner end face; a metal jacket surrounding said insulation and extending inwardly of said chamber past said end face, in spaced relation to said lead-in, the annular space bounded by said lead-in, insulation end face, and extending portion of said jacket comprising said zone.

7. Apparatus as defined in claim **6** including an annular ring on said lead-in, spaced from said end face and extending toward said jacket; the outer periphery of said ring being adjacent but spaced from said jacket to define therewith a narrow annular space constituting said flow passage.

8. Apparatus as defined in claim **6** wherein said metal jacket is insulated from any source of electrical voltage whereby it is at zero potential.

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DARRELL L. CLAY, *Acting Primary Examiner.*

JOHN P. WILDMAN, JOHN F. BURNS, *Examiners.*