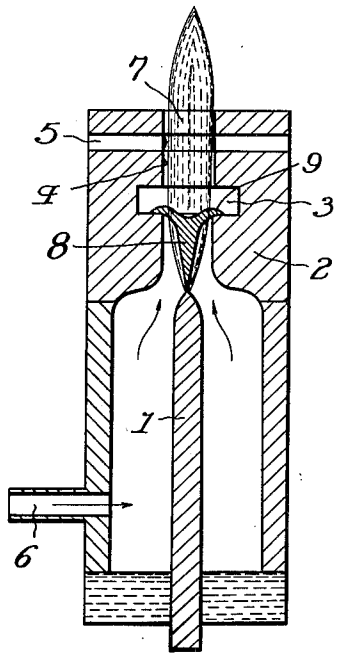
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PLASMA FLAME GENERATOR

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PLASMA FLAME GENERATOR

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This invention relates to improvements in plasma flame generators, and more particularly it relates to a new plasma flame generator having optimum characteristics as a light source means especially for spectral analysis or for other scientific measurements.

The analytical method of introducing sample materials in powder or mist form into a flame and carrying out quantitative and qualitative analysis of the material by means of the resulting emitted light, that is, the so-called flame photometric analysis method, is an excellent method fulfilling various conditions such as those of sensitivity, precision, and reproducibility which are necessary for analysis. However, since the temperatures which can be attained by chemical reaction have an upper limit, the elements to which the said method could be applied have heretofore been limited to special substances, such as alkalis and alkaline earths, which are readily excited even at relatively low temperatures.

The so-called electrical discharge methods, wherein electrodes are made to contain sample materials, then by carrying out arc discharge or spark discharge, the said sample materials are caused to be excited and emit light, are known. These methods are advantageous in that any sample material can be readily excited and caused to emit light. On the other hand, however, since their procedures entail erosion of the electrode materials, the maintenance of stable conditions over a long period is difficult. For this reason, there is still room for improvement of these methods in the matter of precision and reproducibility.

There is yet another known method wherein a solution sample of an active substance is introduced into the space between opposed electrodes, and arc discharging or spark discharging is carried out between the said electrodes. By this method, however, since the solution or its vapor of the said active substance contacts the high temperature electrodes, the erosion of these electrodes is severe, and numerous difficulties are entailed in actual practice.

In view of the above-described circumstances in the prior art, it is an object of the present invention to provide a new and improved plasma flame generator having highly desirable characteristics and a wide range of applicability.

It is another object of the invention to provide a plasma flame generator as above-stated which is of relatively simple construction.

It is a particular object of the invention to provide a plasma flame generator as above-stated which is particularly suitable and effective for use as a spectral analysis light source.

The foregoing objects have been achieved by the present invention, which, briefly described, provides a plasma flame generator, that is, an apparatus which ejects high temperature ionized gas generated by electrical discharge through an opening between electrodes, which has been improved, and which is so adapted that, when a sample or other active substance is introduced into the high temperature ionized gas, no effect is imparted to the stability of the electrical discharge.

The nature of the invention, its details, and the manner in which its objects may best be achieved will be more

clearly apparent by reference to the following description of one representative embodiment of the invention, taken in conjunction with the accompanying illustration, which is an elevational view, in section, showing the said embodiment, which is a plasma flame generator suitable for use as a sample light-emission apparatus particularly for spectral analysis.

Referring to the drawing, the illustrated generator consists essentially of a cathode **1** and an anode **2**, both of such configuration as to form a space therebetween suitable for both electrical discharge and flow of gas supplied through a gas inlet **6**. The anode **2** is provided with an annular groove or cavity **3** disposed about the gas flow path, downstream from the electrical discharge gap, and with a sample feeding passage **5** leading into the gas flow path further downstream. The gas flow passage from the gap between the electrodes to the outside functions as a jet nozzle **4**.

The above-described plasma flame generator has the following operation. When an arc discharge is caused to be created between the electrodes **1** and **2** as a flow of inactive gas is sent through the gas inlet **6**, the arc column **8** thus created is pushed by the said gas flow and extends into the jet nozzle **4**, forming an electrode foot point **9** on the anode side in the cavity **3** at the intermediate point in the jet nozzle **4** as indicated in the drawing. The cavity **3** prevents any further extension of the arc column and causes the electrode foot point to be retained in this position. Accordingly, electrode foot points are fixed to the extreme end of the cathode **1** and to the interior of the cavity **3** positioned at an intermediate point in the jet nozzle **4** of the anode **2**, whereby an extremely stable discharge is maintained.

The term "electrode foot point" is a general designation of such points at which the arc current flows from the anode to the arc, i.e., the anode foot point, and at which the arc current flows from the arc to the cathode, i.e., the cathode foot point. These points are prone to be damaged by bombardments of electrons or ions which flow in from the arc, and the bombardment causes erosion of the electrodes and unstable electric discharge. Especially, wear of the electrodes becomes more intense when gas or vapor other than inert gas contacts the electrode foot point. Accordingly, it inevitably is necessary to avoid contact of the sample material with the electrode foot point at the time of its introduction into the plasma jet flame. Also, in order to attain stable electric discharge, the electrode foot point should be secured in a fixed position.

High temperature ionized gas generated by the electrical discharge flows through the jet nozzle **4** as a plasma flame jet **7** to be ejected out through the outlet at the end. Into this jet **7** is introduced an analysis sample through the sample feeding passage **5**, which is formed at an intermediate point between the cavity **3** and the jet outlet as described previously. The analysis sample is dissociated and excited in the plasma flame jet by the high temperature therein and emits its characteristic spectrum. Then, by measuring the wavelength and intensity of this spectrum by means of a known method, qualitative and quantitative analysis of the sample material can be accomplished.

As is apparent from the above description, in the instant generator the introduction of the sample is made after the flow of the high-temperature ionized gas has passed the electrode foot points, and the said electrode foot points are fixed to the cavity **3** formed at an intermediate point of the jet nozzle **4** and the cathode **1** and is prevented from extending any further toward the exit. Accordingly, no matter what sample material is injected, there is no possibility of this sample material contacting the high-temperature electrode foot points and causing erosion of

the electrodes. Thus, the problem of electrode erosion is thereby solved.

Furthermore, since arc-discharge plasma is utilized, the desired high temperature can be easily attained. Accordingly, not only can this generator be applied to the high emission of various materials, but, when used as a spectral analysis light source, this generator exhibits remarkable effectiveness in the stability of its electrical discharge due to the fixing of its electrode foot points, in its greatly increased sensitivity and precision, and in its greatly improved reproducibility.

The plasma flame generator according to the present invention is not limited to the spectral analysis light source as described above, but can be applied effectively for a wide range of uses such as that as a light source for general measurements in physics and chemistry or for welding and flame-cutting equipment.

Although this invention has been described and illustrated in detail with respect to a particular embodiment thereof, some or various changes and modifications may be made within the full intended scope of the invention, as defined by the appended claims.

What is claimed is:

1. A plasma flame generator comprising, in combination, a rod-shaped cathode; an anode enveloping said cathode leaving a space therebetween for the flow of inert gas and for facilitating an electrical discharge; said anode extending above the upper end of said cathode and narrowing thereabove; a nozzle forming the upper extremity of said anode and provided with an annular groove intermediate between said cathode and the outlet of said nozzle; a sample feeding passage disposed near the outlet of said nozzle; and an inlet for an inert gas near the lower end of said anode.

2. A plasma flame generator comprising, in combination, a rod-shaped cathode; an anode enveloping said cathode leaving a space therebetween for the flow of an inert gas and for facilitating an electrical discharge; said anode extending above the upper end of said cathode and narrowing thereabove; a nozzle forming the upper end of said anode and provided with an annular groove intermediate between said anode and the outlet of said nozzle, said groove forming and fixing electrode foot points; a sample feeding passage disposed near the outlet of said nozzle; and an inlet for an inert gas near the lower end of said anode.

3. In a plasma flame generator provided with a rod-shaped cathode; an anode enveloping said cathode leaving a space therebetween for the flow of inert gas and for facilitating an electrical discharge; said anode extending above the upper end of said cathode and narrowing thereabove; a nozzle forming the upper end of said anode; and an inlet for an inert gas at the lower end of said anode; the improvements which comprise said nozzle being provided, at a point intermediate between the upper end of said cathode and the nozzle outlet, with an annular groove thus forming and fixing electrode foot points; and a sample feeding passage disposed near the outlet of said nozzle.

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