United States Patent

[11] 3,631,283

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[21] Appl. No. 812,708
[22] Filed Apr. 2, 1969
[45] Patented Dec. 28, 1971
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[32] Priority Apr. 9, 1968
[33] France
[31] 147478

[54] **DEVICE FOR PRODUCING HIGH INTENSITY ION BEAMS**
6 Claims, 6 Drawing Figs.

[52] **U.S. Cl.** 313/63, 313/180, 313/231
[51] **Int. Cl.** H01j 17/26, H05h 1/00
[50] **Field of Search** .... 313/63, 231, 180; 204/323; 250/41.9 (3), 41.9 SB, 41.9 SE

[56] **References Cited**

UNITED STATES PATENTS

2,507,652	5/1950	Smith	313/180 X
3,287,598	11/1966	Brooks	313/63 X
3,288,993	11/1966	Steinhaus et al.	250/41.9 (3)
3,332,870	7/1967	Orbach et al.	204/323
3,387,218	6/1968	Friichtenicht et al.	250/41.9 (3) X
3,476,968	11/1969	Omura	313/231 X

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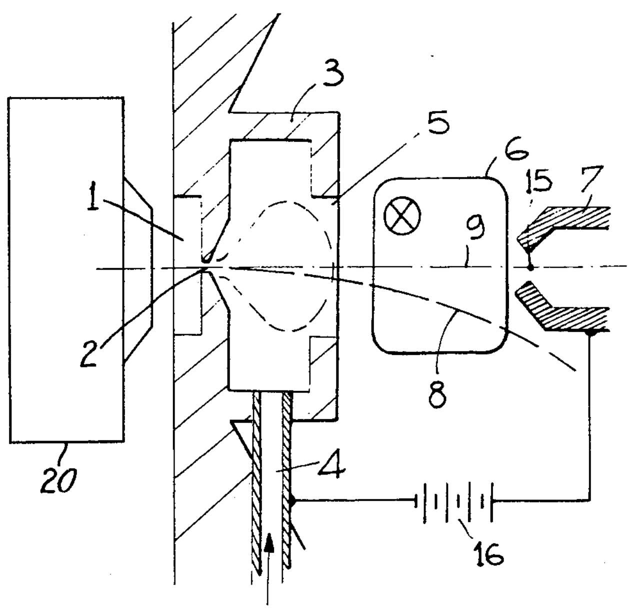
ABSTRACT: A gas or vapor is ionized by passing it through a plasma jet, hydrogen plasma for example; the ionization takes place in an enclosure, the wall of which either contains devices for injecting the gas or vapor to be ionized, or devices for vaporizing by local heating solid samples of the same substance.



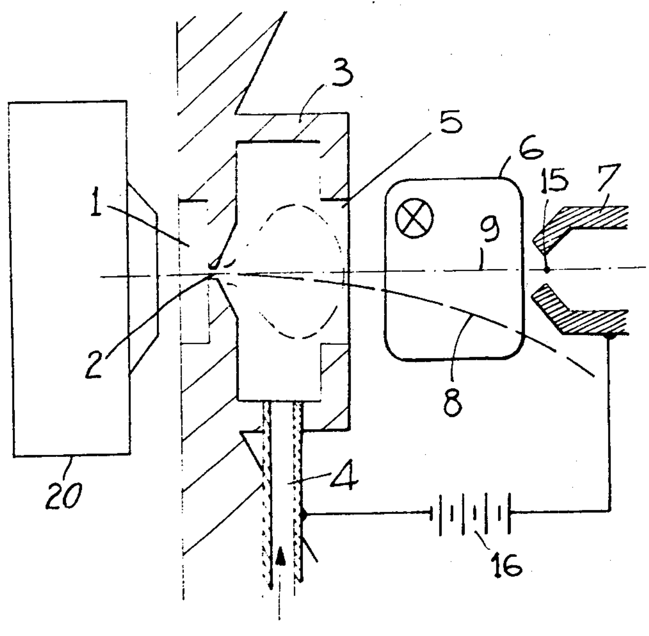


Fig.1

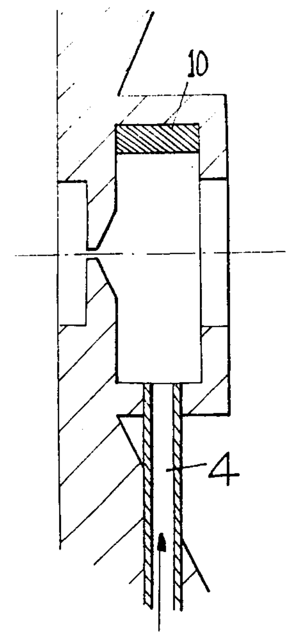


Fig.2

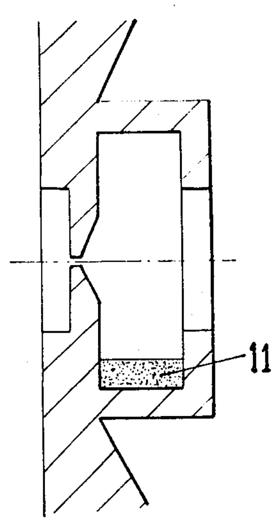


Fig.3

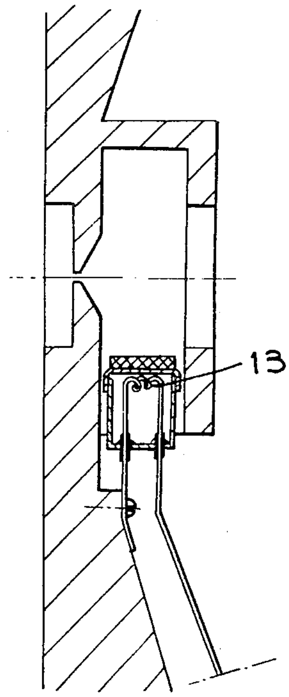


Fig. 4

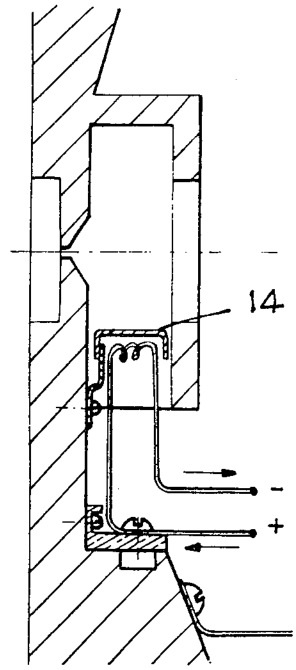


Fig. 5

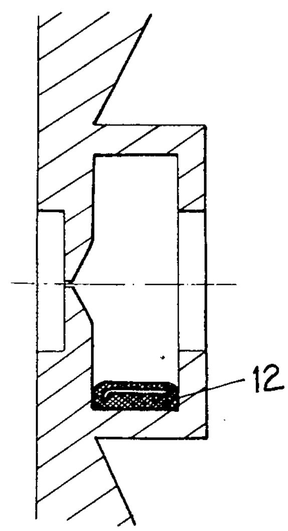


Fig. 6

DEVICE FOR PRODUCING HIGH INTENSITY ION BEAMS

It may be necessary to produce high intensity positive ion beams of high geometrical and energetic definition As is well known, duoplasmatron devices make it possible to obtain from a gas, such as hydrogen for example, ion beams of the kind in question.

However, when ion beams of other chemical elements, such as metals for example, are desired, the duoplasmatron proves useless, in particular because of the poor ionization efficiency and of the contamination of and deposits produced on the electrodes.

It is in object of this invention, to avoid these drawbacks to provide a system for creating and accelerating ion beams of the most varied kinds (boron, aluminum, indium phosphorous, arsenic, antimony and so on).

According to the invention, there is provided a system for producing high intensity ion beams by electric charge exchange reactions between a plasma beam and a chemical material, comprising a reaction chamber in which said charge exchange takes place, this chamber having an input orifice for said plasma beam introduction, means for introducing said chemical material in gaseous form into said beam, and an output orifice for the exit of the reaction products created in said chamber.

For a better understanding of the invention and to show how the same may be carried into effect, reference will be made to the drawings accompanying the ensuing description and in which:

FIG. 1 illustrates diagrammatically a system according to the invention; and

FIGS. 2, 3, 4, 5, and 6 illustrate modifications of FIG. 1.

The invention provides for a metal chamber 3 with an input orifice 2 and output orifice 5, a duct 4, connected to an external reservoir and opening into the chamber 3, an arrangement 6 for generating a magnetic field in a direction perpendicular to the plane of FIG. 1 beyond the orifice 5, and finally a metal cylinder 7 with an orifice 15, located beyond the zone of the magnetic field, its potential in relation to the chamber being determined by a voltage source 16.

The plasma, a mixture of hydrogen ions and electrons which is created by any known means at 1, for example by a duoplasmatron 20, is injected through the orifice 2 into the chamber 3 which constitutes a volume of quasi-constant potential, where the injected plasma expands to form a kind of bubble, thus forming an expansion chamber.

There is also introduced into the chamber 3, through the duct 4 which is connected to an external reservoir, the element which is to be ionized, for example in gaseous form.

Two simultaneous phenomena then take place as a consequence of the mixing of the gas with the plasma:

The electrons of the plasma ionize the gas G by collision, extracting an electron from it in accordance with the following relationship:

$$G_{neutral}+3_{-}\rightarrow G_{ion+}+2e_{-} \quad (1).$$

The hydrogen ions of the plasma also ionize the gas G by charge exchange, in accordance with the relationship:

$$G_{neutral}+H_{ion+}\rightarrow G_{ion+}+H_{neutral} \quad (2).$$

Finally, the two phenomena lead to the creation of ions of the gas considered, which is the purpose of the device in accordance with the invention.

These ions, mixed with electrons, as the reaction (1) indicates, and thus creating a new plasma, leave the expansion chamber 3 through the orifine 5 in the form of a beam which can be put to appropriate use.

The plasma beam is "polluted" by a number of hydrogen ions, which have not been involved in the above reaction, and it can be purified by using an appropriate separator, for example, a magnet 6, so that said ions describe trajectories such as those indicated by 8 while the useful ions, are only slightly deflected and describe trajectories such as those indicated by 9.

On the other hand, in certain applications, where it is an ion beam which is wanted and not a plasma, the undesired electrons may be extracted from it by arranging on its trajectory a metal electrode of cylinder from 7, raised to an appropriate potential vis-a-vis the expansion chamber so as to pick up the free electrons contained in the beam.

Finally, it is possible to neutralize the beam of ionized vapor by passing it through a gas where the metal ion recovers the necessary electron for its neutralization without losing its kinetic energy. A source of focused and accelerated neutral molecules is thus obtained.

The injection of the gas or vapor for ionization, in accordance with the present invention, can be carried out in a variety of ways depending upon its nature.

FIG. 1 illustrates the device corresponding to a first method which will be termed "cold method" and in which, as already indicated, the gas is directly introduced through a duct 4 into the expansion chamber 3; this is the case, for example, of oxygen and hydrocarbons.

FIG. 2 relates to the case of a vapor obtained from a metal body for example; the vapor is developed externally of the chamber in a separate enclosure prior to being directed into the duct 4. In this way a vapor jet can be produced with traverses the expansion chamber, for example transversely and whose kinetic energy is absorbed by a condensation collector 10 located opposite the orifice of the duct 4.

FIG. 3 relates to another method in which the vapor is produced from a given chemical element directly within the chamber 3. A location 11 is created in the expansion chamber and it is there that the element is placed in the solid state. If its vapor pressure is high it can be vaporized by the heat introduced by the plasma bubble itself and this is the case, for example, with lithium in powder form, which vaporizes easily at around 200° C.

In the more general case where a higher temperature is needed, there is provided in the wall of the expansion chamber a kind of crucible arrangement heated by the transfer of energy from an external source.

FIG. 4 illustrates an example of the device in which use is made of the Joule effect, a heater filament 13 being located in the wall of the chamber 3. In a preferred embodiment electron bombardment of the wall from a hot cathode 14 of directly or indirectly heated kind and raised to a negative potential with respect to the wall (FIG. 5), may be used.

In the case where the chemical element is liquid, mercury for example, a cavity or channel 12 is formed in the wall of the expansion chamber 3 as shown in FIG. 6.

Of course the invention is not limited to the embodiments described and shown which were given solely by way of example.

What is claimed is:

1. A system for producing high intensity ion beams by electric charge exchange reactions between a plasma beam and a chemical material, comprising
   - a duoplasmatron device for production of said plasma beam,
   - a reaction expansion chamber in which said charge exchange takes place, said chamber having on a side a wall separating it from said duoplasmatron device, said wall having an orifice for the introduction of said plasma beam, means for introducing said chemical material in gaseous form into said chamber, and there being on the opposite side of said chamber an output wall with an orifice for the exit of the reaction products created in said chamber,
   - said expansion chamber being dimensioned for allowing said beam to expand as a bubble and means, downstream said output orifice, for extracting from said reaction products a pure ion beam of said chemical material.

2. A system as claimed in claim 1, in which said introducing means is formed by a tubular duct, opening into said chamber.

3. A system as claimed in claim 2, in which at least the wall portion of said reaction chamber, facing the opening of said

tubular duct into said chamber, is formed by a refractory material.

4. A system as claimed in claim 1, in which said introducing means is a cavity located in a wall of said chamber, wherein said chemical material is placed.

5. A system as claimed in claim 1, in which said introducing means is a cavity located in a wall of said chamber, wherein said chemical material is placed and means for heating said chemical material to vaporize it.

6. A system as claimed in claim 5, in which said heating means is an electron source placed in front of at least a portion of said chamber wall and raised to a negative potential with respect to it.

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