United States Patent

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[33] **Netherlands**
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[54] ION SOURCE HAVING A PLASMA AND GRIDLIKE ELECTRODE

4 Claims, 3 Drawing Figs.

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[51] **Int. Cl.** **H05h 1/02,** H05h 1/18
[50] **Field of Search** 313/61, 63, 230, 231, 156, 157, 160, 161, 7, 7.5; 250/84.5, 41.9

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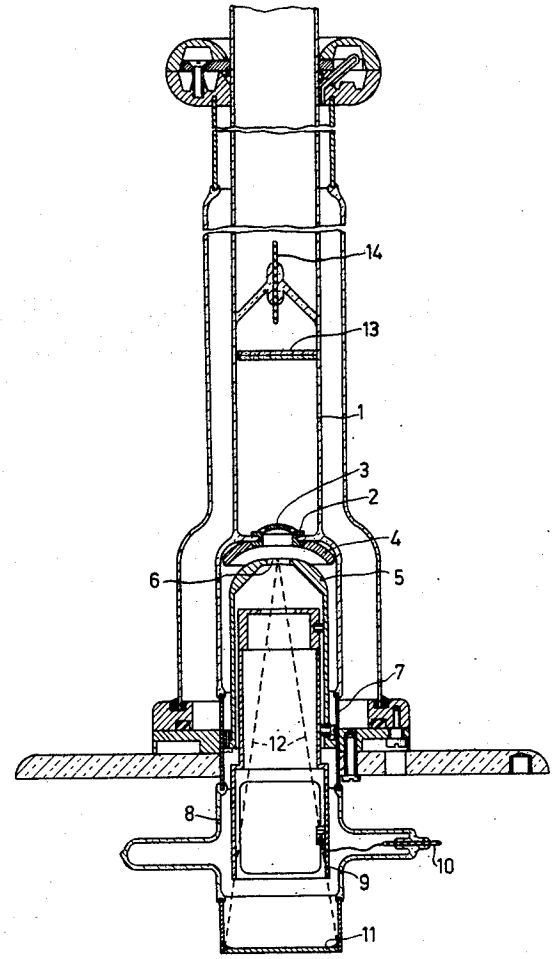
ABSTRACT: An ion source employing a plasma and a gridlike electrode forming part of the wall of a space in which ions are produced, the ions being accelerated by an accelerating electrode having an aperture the diameter of which is at least equal to half the diameter of the gridlike electrode and the resistance thereof to gas flow is so low that the pressure on each side is equal and so low that the ion flow is saturated. The gridlike electrode has an aperture of at least 1 mm. in diameter through which electrons accelerated against the ion flow may be collected in the plasma space.



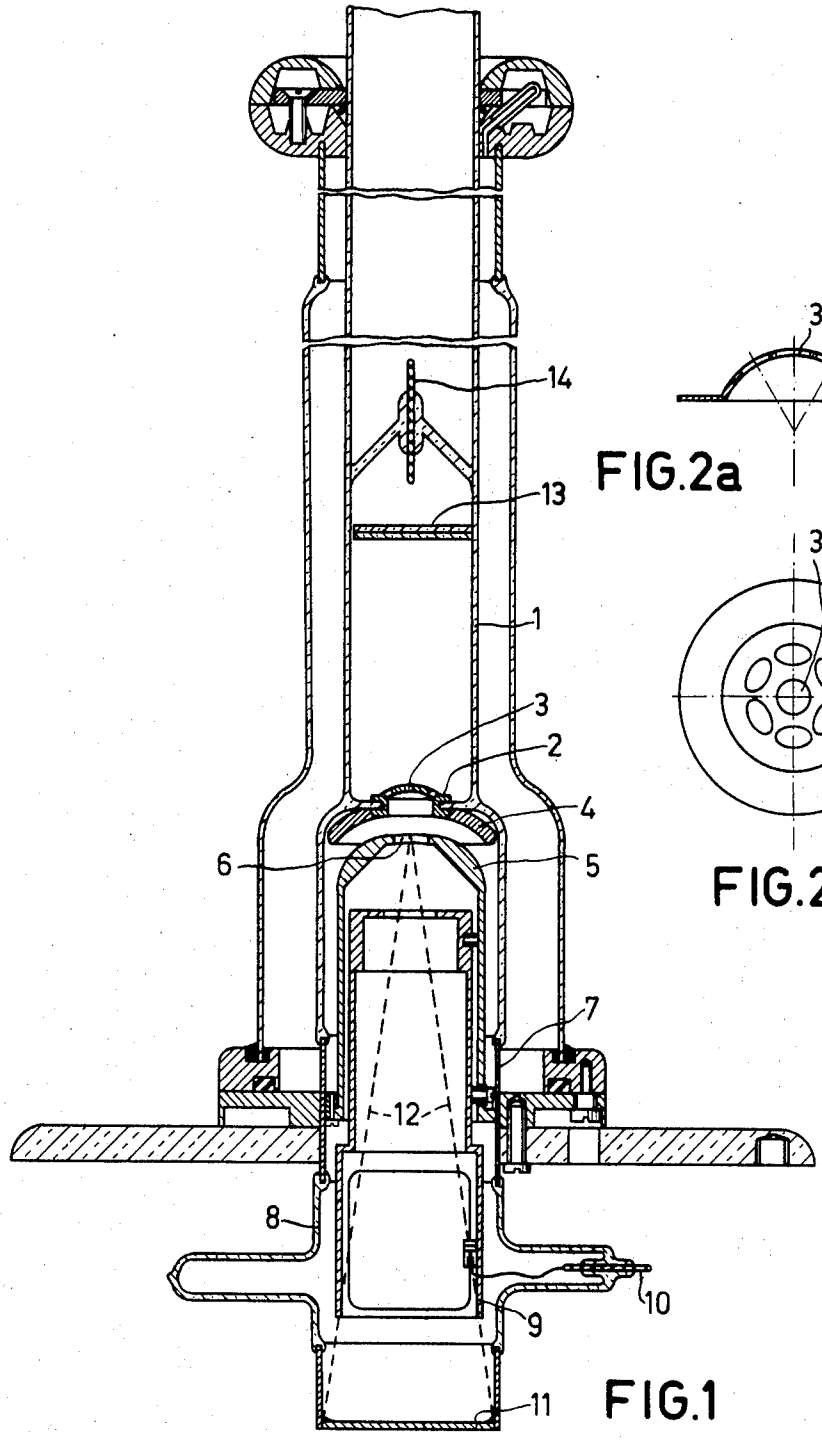


FIG.1

FIG.2a

FIG.2b

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ION SOURCE HAVING A PLASMA AND GRIDLIKE ELECTRODE

This application is a continuation of application Ser. No. 480,416, filed Aug. 17, 1965 and now abandoned.

This invention relates to ion sources intended especially for nuclear physical apparatus, such as a neutron generator, in which the ions are accelerated from a gridlike electrode forming part of the wall of a space in which ions are produced, by means of an extraction electrode having a single aperture.

Such an ion source for a mass spectrometer has been described already (see "Proton Production in the Low-voltage Arc," Lamar and Luhr, Physical Review 46, 87—94, 1934). The acceleration electrode is a narrow aperture (0.3 mm.) at the end of a long channel across which a high pressure difference occurs. The latter is necessary since in the mass spectrometer, in view of the high accelerating voltage and because dispersion is undesirable, the pressure must be low and the ions are produced in a low-tension arc at a gas pressure from 0.2 mm. to 0.6 mm. Although experiments have been described with an extraction electrode having a channel of 4 mm. in length and diameter, this electrode was covered with a fine gauze grid at the side of the arc. In this case also the pressure drop was still a factor of **20** to **40**. The mass spectrometer was replaced by an ion-collector electrode in a high-capacity pump system. The ion flow in known arrangements already is saturated if the voltage between the grid and the extraction electrode is approximately 200 volts. For this reason subsequent acceleration is necessary to obtain the comparatively high ionic velocities such as are required in a mass spectrometer. A high voltage between the grid in the wall of the discharge space and the extraction electrode would be impossible in view of the high pressure prevailing.

Ion sources are also known in which the ions are extracted from a high-frequency plasma through an aperture in the wall surrounding the plasma which does not contain a grid. A plasma boundary which fulfills the function of an emitter surface for the ions is thus formed by the action of the field of the extraction electrode which is in the form of a more or less long channel. A difficulty involved in this arrangement is that the plasma boundary depends as to shape and position upon the field of the extraction electrode and also upon the intensity of the ion flow relative to the density of the plasma. The variations in shape and position of the plasma boundary act upon the focusing of the ion beam, while instabilities may arise if the plasma boundary penetrates too far into the ionization space. In view of the latter the upper limit of the voltage between the plasma and the extraction electrode is approximately 10 kv. Subsequent acceleration is always necessary since in nuclear physical apparatus, such as, for example, neutron generators, accelerating voltages of approximately 150 kv. are frequently desirable. Known constructions also invariably operate with a pressure drop and a pump.

An object of the invention is to provide an ion source which affords advantages with respect to known constructions.

According to the invention in an ion source intended more particularly for nuclear physical apparatus, such as a neutron generator, ions are accelerated from a gridlike electrode which forms part of the wall of a space in which ions are produced, by means of an extraction electrode. This electrode has a single aperture, the diameter of which is at least equal to half the diameter of the gridlike electrode and the resistance thereof to gas flow is so low that the pressure at each side is equal and so low that the ion flow is saturated at the accelerating voltage used which is upwards of 20 kv. The gridlike electrode has a central aperture of at least 1 mm in diameter through which electrons accelerated against the ion flow may be collected in the plasma space. The gridlike electrode may

be in the form of a woven grid having a large central hole, but according to the invention the gridlike electrode is preferably a cap in the form of a spherical segment having a central aperture and one or more rings of apertures surrounding it. The heat dissipation of the said grid may thus have a favorable value.

In one embodiment of the invention the extraction electrode houses a braking electrode for the electrons produced by the ions substantially on the ion-collector electrode so that these electrons cannot be accelerated in the opposite direction.

The invention will be described with reference to the accompanying drawing in which:

FIG. **1** is a cross-sectional view of an ion source according to the invention; and

FIGS. **2***a* and **2***b* show respectively in cross section and plan view an enlarged view of the grid.

The ion source shown in FIG. **1** includes a glass cylinder enclosing a space in which a discharge plasma is formed by means of high-frequency discharge generated in hydrogen or in a mixture of hydrogen and its isotopes at a pressure of 0.01 mm. The lower end of the glass cylinder **1** is partly closed by a spherical segment cap **2** of molybdenum having a diameter of approximately **15** mms. The cap **2** has seven bores as seen in FIG. **2***b* each 3.5 mm. in diameter, the central bore being designated **3**. An extraction electrode **5** having an inlet aperture **6** is positioned opposite the gridlike electrode **2** and the rounded portion **4** is located externally thereof. The extraction electrode extends downwards in a metallic cylinder **7** which forms part of the wall of the vacuum space. The latter merges into a glass cylinder **8** which houses a braking electrode **9** provided with a connector **10**. The ion-collector electrode is designated **11** and the boundary of the ion beam is shown in broken lines at **12**. Any electrons accelerated through the aperture **3** to the discharge space despite the presence of the braking electrode are collected on a metal plate **13**. The accelerating voltage is applied between a connecting pin **14** which terminates in the conducting discharge plasma, and the accelerating electrode **5**. The electrode **2** and the pin **14** are at the same potential due to the presence of the conducting plasma.

I claim:

1. An ion source comprising a vessel housing an ionizable medium in one portion thereof and having a wall constituted by a gridlike electrode communicating with a second portion of said vessel and constituting a plasma boundary when said ionizable medium is converted to a plasma by a high-frequency discharge, an extraction electrode within said latter portion for accelerating ions produced therein, said extraction electrode having an aperture the diameter of which is at least equal to half the diameter of the gridlike electrode and the resistance to gas flow is so low that the pressure on each side thereof is equal and so that the ion flow is saturated with an accelerating potential applied to said extraction electrode of at least 20 kilovolts, said gridlike electrode having a central aperture at least 1 mm in diameter whereby electrons accelerated counter to the ion flow may be collected in the other portion of the vessel.

2. An ion source as claimed in claim **1** in which the gridlike electrode is a woven grid having a large central hole.

3. An ion source as claimed in claim **1** in which the gridlike electrode is a cap in the form of a spherical segment having a central aperture and at least one ring of apertures surrounding it.

4. An ion source as claimed in claim **1** in which the extraction electrode houses a braking electrode for the electrons produced within the ion-collector electrode.