United States Patent

[11] 3,619,684

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[21] Appl. No. **31,147**
[22] Filed **Apr. 23, 1970**
[45] Patented **Nov. 9, 1971**
[73] Assignee **U.S. Philips Corporation**
[32] Priority **Apr. 28, 1969**
[33] **Great Britain**
[31] **21453-69**

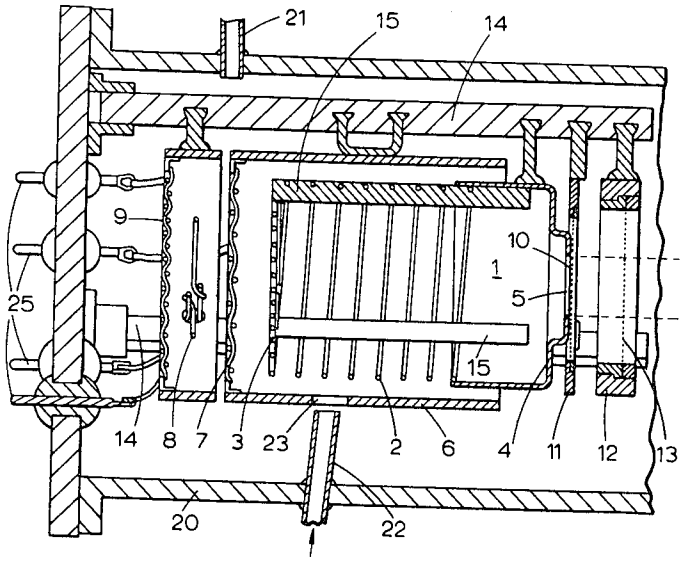
[54] **ION SOURCE**
4 Claims, 6 Drawing Figs.

[52] U.S. Cl. ..... **313/63,** 250/41.9 SB, 324/33
[51] Int. Cl. **H05h 1/00**
[50] Field of Search ..... 250/41.9 SB; 313/63; 324/33

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ABSTRACT: A nonmagnetic, electron impact ion source comprising an evacuated envelope having means for passing ionizing gases through the envelope. Within the envelope, an electron emitting cathode is positioned adjacent a grid-shaped ionization chamber. A conducting wall section of the ionization chamber that is impenetrable to ions has an ion exiting aperture, which is adjacent to a grid-shaped electrode for extracting ions. The extracting electrode is positioned at a distance of a few tenths of a mm. from the ion exiting aperture, and kept at a small negative voltage not exceeding 5 volts relative to the ionization chamber. An acceleration electrode adjacent to the extracting electrode forms ions from the ionization chamber into beams. A screen grid placed between the extracting and acceleration electrodes prevents the high negative voltage of the acceleration electrode from affecting the electric field within the ionization chamber.



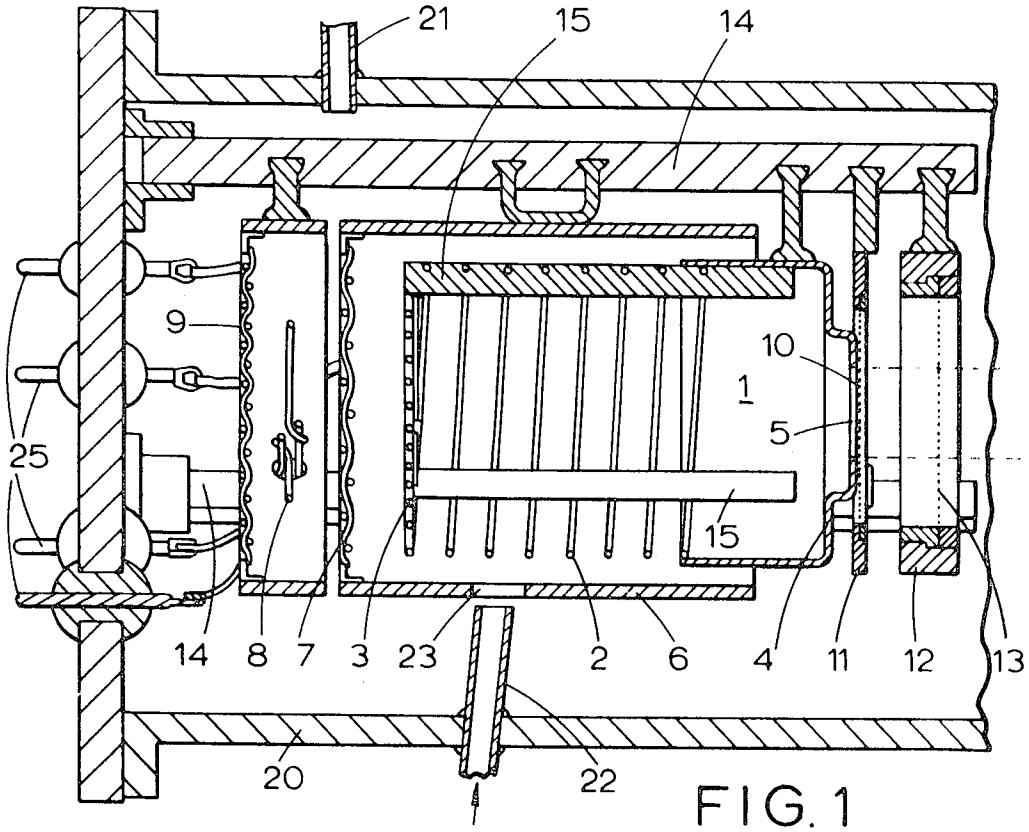


FIG. 1

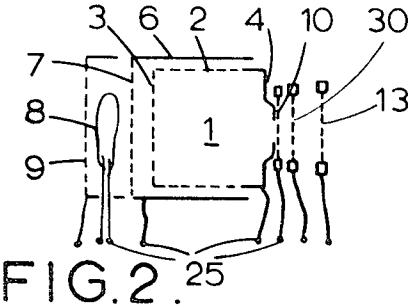


FIG. 2.

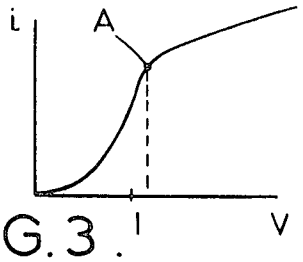


FIG. 3.

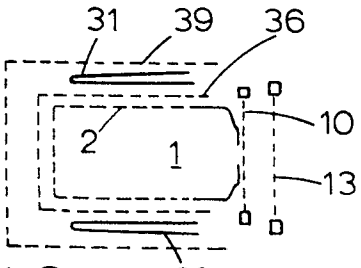


FIG. 4.

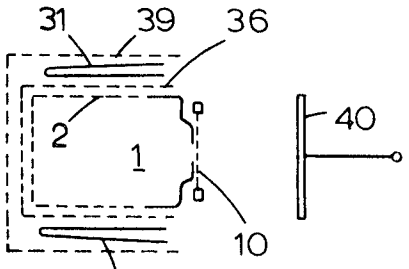


FIG. 5

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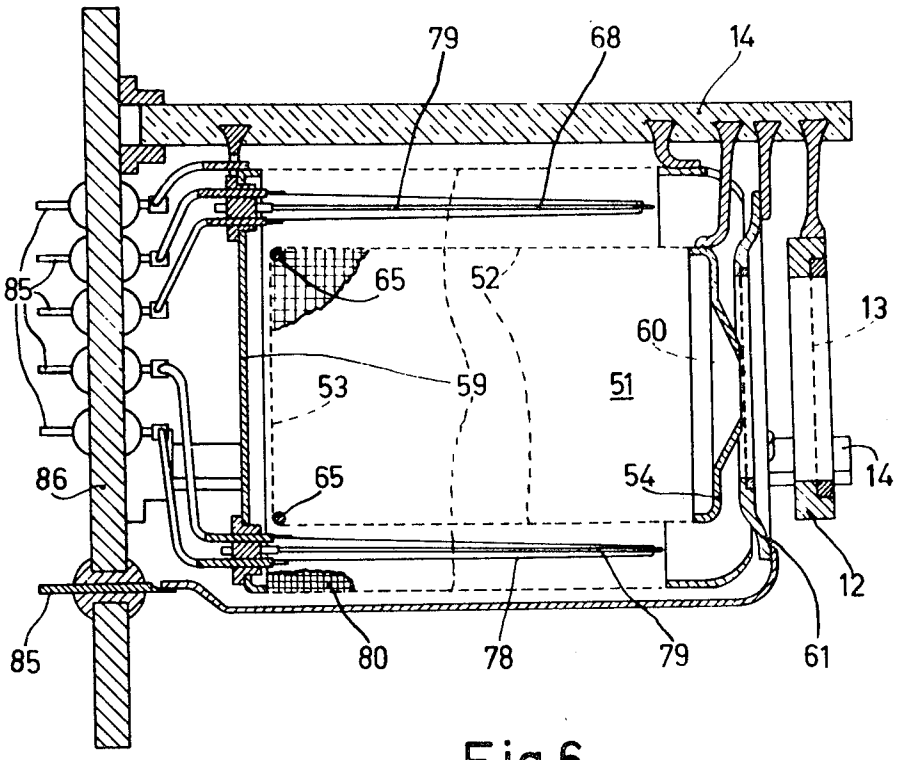


Fig.6

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ION SOURCE

The invention relates to an ion source comprising an ionization chamber into which electrons are injected without using a magnetic field influencing the electrons, for ionizing a gas, and an accelerating electrode, said ionization chamber comprising grid-shaped electrically conductive wall parts and an electrically conductive wall part which is impenetrable to ions and comprises an ion exit aperture.

Such an ion source is known from the article "La sensibilité de la jauge à collecteur caché" in "Le Vide" of July/Aug. 1968, pp. 240–244. The device described in this article is an ion source which is used as an ionization manometer. The use of the device described as an ionization manometer or as an ion source requires in both cases a flow of ions which is as large as possible. Moreover, the use as an ion source requires a small energy spread of the ions in the beam formed.

The operation of such an ion source is as follows. Electrons are injected into the ionization chamber by means of, for example, a filament which is arranged outside the ionization chamber and has a negative voltage relative to the latter. The electrons emitted by the filament are accelerated to the ionization chamber by the electric field between the filament and the ionization chamber and pass the grid-shaped wall parts thereof. The ions formed in the ionization chamber are accelerated to the accelerating electrode—which is provided outside the ionization chamber before the ion exit aperture and has a negative voltage relative to the ionization chamber—by the electric field between the wall of the ionization chamber and the accelerating electrode. The potential field between the accelerating electrode and the wall of the ionization chamber has such a large gradient within the ionization chamber of the known ion source that ions which are formed at various places in the ionization chamber traverse, on their way to the accelerating electrode, various voltage differences so that a large energy spread occurs in the ion beam.

It is the object of the invention to provide an ion source in which a large ion current intensity is associated with a small energy spread.

According to the invention, an ion source comprising an ionization chamber in which electrons are injected without using a magnetic field influencing the electrons, for ionizing a gas, and an accelerating electrode, said ionization chamber comprising grid-shaped electrically conductive wall parts and an electrically conductive wall part which is impenetrable to ions and comprises an ion exit aperture, is characterized in that the ion source comprises a grid-shaped extraction electrode covering the ion exit aperture, said extraction electrode being situated within a distance of a few tenths of a mm. from the wall part with the ion exit aperture and, during operation of the ion source, having a negative voltage of at most 5 volt relative to said wall part.

The invention is based on the recognition of the fact that in the ionization chamber a space charge is formed by the electrons injected into the ionization chamber and the ions formed by ionization. The total space charge is negative by the excess of injected electrons. If the extraction electrode has the same potential as the walls of the ionization chamber, the space charge in the ionization chamber has a potential field of which the potential in any point is lower than on walls of the ionization chamber and of which a point approximately in the center of the ionization chamber has a lowest potential of, for example, −2.5 volt. As a result of this the field strength in any point of the ionization chamber is directed to a point approximately in the center so that the positive ions always experience a force towards that point. So the ions are captured in a potential trough and can only reach points of said trough which do not have a higher potential than the point where they are formed. According to the invention, a grid-shaped extraction electrode is provided immediately in front of an ion exit aperture in the wall of the ionization chamber at a voltage of, for example, −1 volt. This has for its result at the area of the ion exit aperture the potential field has the potential of the extraction electrode. As a result of this the height of the edge of the potential trough at the area of the ion exit aperture has become 1.5 volt instead of 2.5 volt. As a result of this all the ions which are formed in a point of the ionization chamber the potential of which lies between −1 volt and 0 volt can leave the ionization chamber via the grid-shaped extraction electrode. The extracted ion beam consequently has an energy spread of maximally 1 volt. In practice, the energy spread in the direction of the beam is still slightly smaller because the direction in which the ions emanate in general does not coincide with the direction of the beam in which it is accelerated by the accelerating electrode. A part of the energy spread hence influences only the lateral ion speeds. By making the extraction electrode more negative a larger part of the ions formed in the ionization chamber can be extracted. When the extraction electrode is made more negative than the depth of the potential through with extraction electrode at 0 volt, all the formed ions are extracted, in principle. The ion efficiency increased in this manner is, of course, associated with a larger energy spread in the beam.

An ion source according to the invention can advantageously be constructed so that the grid-shaped wall parts of the ionization chamber are surrounded by a reflector electrode. If said reflector electrode is given a small positive voltage of, for example, 1 volt relative to the wall of the ionization chamber, ions which might escape through the meshes of the grid-shaped wall portions are reflected. The use of a reflector electrode hence permits larger meshes of the grid-shaped wall parts of the ionization chamber.

An advantageous construction of the ion source according to the invention is furthermore such that a screen grid is situated between the extraction electrode and the accelerating electrode. It is prevented by means of said screen grid that the electric field of the accelerating electrode can penetrate through the meshes of the extraction electrode, so that the energy spreading would be adversely influenced.

In order that the invention may be readily carried into effect, it will now be described in greater detail, by way of example, with reference to the accompanying drawing, in which

FIG. 1 is a longitudinal cross-sectional view of an ion source according to the invention,

FIG. 2 is a diagrammatic arrangement of the electrodes of an ion source according to the invention having a screen grid between the extraction electrode and the accelerating electrode,

FIG. 3 is a graphical representation of the ion current as a function of the voltage of the extraction electrode,

FIG. 4 is a diagrammatic longitudinal cross-sectional view of an ion source according to the invention with an alternative arrangement of the filament.

FIG. 5 is a diagrammatic longitudinal cross-sectional view of an ion source according to the invention comprising a target plate for ion bombardment.

FIG. 6 is an embodiment having the alternative filament arrangement diagrammatically shown in FIG. 4.

Referring now to FIG. 1, an ionization chamber 1 within an envelope 20 is formed by a coiled grid 2 wound on supporting wires 15, a grid 3 and a plate 4 comprising an ion exit aperture 5. The grids 2 and 3 and the plate 4 are conductively interconnected. A cylindrical metal reflector electrode 6 surrounds the grid 2 and comprises at one end a grid 7 which is conductively connected to the electrode 6. An electron-emitting filament 8 is situated between a grid 9 and the grid 7. A fine-mesh grid 10 which is connected to the extraction electrode 11 is situated immediately in front of the ion exit aperture 5.

An accelerating electrode 12 comprising a grid 13 accelerates the ions emanating through the grid 10. The electrodes are supported by three glass rods 14 of which only two are visible in the drawing. The envelope 20 is evacuated via an exhaust tube 21, the gas to be ionized is supplied to the ionization chamber 1 via an inlet 22 and an aperture 23 in the reflector electrode 6. The gas may also generally be present within the envelope 20 and reach the ionization chamber via all kinds of apertures in the electrode system. The rods 14 are secured

to an end plate which is detachably secured to the envelope 20 and also comprises connections 25 for the electrodes.

During operation of the ion source the filament 8 has a negative voltage of, for example, 50 volt to 150 volt relative to the ionization chamber 1 and emits electrons. The electrons are injected into the chamber 1 via the grid 3 with an energy which is sufficient to ionize gas molecules. The grid 9 is at a negative potential relative to the filament 8 and directs the beam of emitted electrons in the direction of the chamber 1.

The grid 10 of the extraction electrode 11 is at a small negative potential of, for example, 1 volt relative to the wall of the chamber 1 and extracts ions from said chamber. The extracted ions are accelerated by the accelerating electrode 12 which has a potential of, for example, −50 volt to −5 k.volt relative to the chamber 1 and pass the grid 13 of same as a substantially parallel beam.

FIG. 2 diagrammatically shows how a screen grid 30 can be arranged between the grid 10 of the extraction electrode and the grid 13 of the accelerating electrode. The strong accelerating field then is between the grids 13 and 30 and does substantially not penetrate through the meshes of the grid 10 in the chamber 1. The voltage of the screen grid 30 is, for example, from −50 volt to −100 volt relative to the chamber 1 dependent upon the voltage at the grid 13.

In the graphic representation of FIG. 3 it is shown that the ion current *i* with small voltages V of the extraction electrode relative to the wall of the chamber 1 rapidly increases with the voltage. For larger voltages a saturation occurs. Point A is indicated as a suitable adjusting point for sufficient ion current at a sufficiently low voltage and hence small energy spread.

FIG. 4 diagrammatically shows an alternative arrangement for the filament. The filament in the construction shown consists of two parts 31 and 32 which are arranged at the side of the chamber 1. In this case the reflector electrode should also be gridlike and is denoted by a grid 36. A grid 39 is at a negative potential relative to the filaments 31 and 32 and direct the emitted electrons towards the chamber 1.

FIG. 5 diagrammatically shows an arrangement for ion bombardment of a target plate 40.

FIG. 6 shows an ion source, comprising the alternative arrangement for the filament as already shown in FIG. 4. In this ion source penetration of the electron accelerating and reflecting field into the ionization space is reduced by employing fine-mesh electrically conducting material having good screening properties for the permeable walls 52 and 53 of the ionization chamber 51. The mesh is constructed from a metal which can be readily outgassed and can be of woven construction. In one example a woven tungsten wire mesh was employed having approximately 80 apertures per cm. and an electron transparency of approximately 70 percent. The mesh is supported at the edges of the walls 52 and 53 and intermediately where necessary by a wire frame 65 and by the outer rim of the aperture plate 54. Electron emissive hairpin filaments 68, 78 provided with respective supports 79, are located outside the chamber 51 to either side thereof, and are independently connected to respective terminal connections 85 which pass in vacuumtight manner through the mounting and support flange 86. It is convenient to employ both the filaments 68, 78 for heating the metal parts of the apparatus by electron bombardment while outgassing, but only one filament, for example 68, would normally be employed during operation of the ion source. A conducting screen 59, at least a part 80 of which can be of conducting mesh to allow the free passage of gas molecules within the apparatus, is provided and biased in operation slightly negatively with respect to the filament 68. In this way an electron reflecting field is thus provided outside the walls 52, 53 of the chamber 51, so that electron emerging via the walls 52, 53 will be reflected and caused to pass again through the ionization space within the chamber 1 thus improving their ionizing effect. The source shown in FIG. 6 is in nude form being mounted on the flange 86 ready for attachment to apparatus as desired. The remaining construction and arrangement of this embodiment is however substantially the same as that of the embodiment described with reference to FIG. 1.

The dimensions of the embodiment shown in FIG. 1 are as follows: The chamber 1 is 2 cm. long and has a diameter also of 2 cm. The ion exit aperture has a diameter of 5 mm. and the distance between the grid 10 and the plate 4 is 0.1 mm. At a voltage of −1 volt of the grid 10 relative to the plate 4, the current intensity of the extracted ion beam is 100 μa. with an energy spreading of 0.6 ev. With the extraction voltage increasing, for example, the current intensity is 10 ma. with an energy spread of 1.0 ev.

It is to be noted that there exist several alternative methods of producing an ionizing electron beam in addition to all kinds of arrangements of the filament. The invention comprises all said methods. An alternative method is, for example, the mounting of radioactive source in the proximity of the ion source, which emits β-particles into the chamber 1.

It is also to be noted that within the scope of the invention the grids 10 and 13 and 30 can be formed so that they exert a lens effect on the ion beam so as to obtain, for example, an accurate parallel beam.

We claim:

1. A nonmagnetic ion source comprising an evacuated envelope having means for receiving ionizing gases, an electron emitting cathode operating at a negative voltage within said envelope, an ionization chamber adjacent to said cathode and operating at a positive voltage relative to said cathode for containing ions produced by collisions of electrons from said cathode with said ionizing gases, said ionization chamber formed from grid-shaped, electrically conductive walls and an electrically conductive wall section impenetrable to ions, said wall section having an ion exiting aperture, a grid-shaped ion extracting electrode operating at a negative voltage not greater than 5 volts relative to said ionization chamber, said extracting electrode positioned within a distance of a few tenths of a mm. adjacent to said ion exiting aperture, and an accelerating electrode adjacent to said ion extracting electrode and operating at a negative voltage relative to said chamber to form said ions into beams.

2. A nonmagnetic ion source as claimed in claim 1 further comprising a grid-shaped electrode between said cathode and said envelope and operating at a negative voltage relative to said cathode for directing electrons from said filament to said ionization chamber.

3. A nonmagnetic ion source as claimed in claim 1 further comprising a reflector electrode operating at a positive voltage relative to said ionization chamber and surrounding said ionization chamber to prevent ions from escaping through said grid-shaped walls.

4. A nonmagnetic ion source as claimed in claim 1 further comprising a screen grid operating at a negative voltage relative to said ionization chamber and positioned between said extracting and accelerating electrodes to prevent the electric field of said accelerating electrode from penetrating into said ionization chamber through said extracting electrode.

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