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2,499,320

ION GENERATOR

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Fig. 1

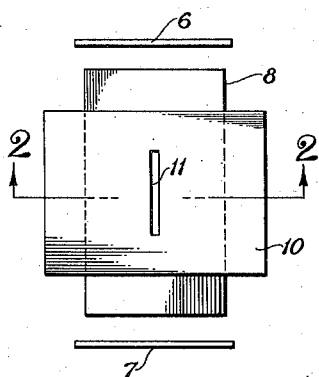


Fig. 2

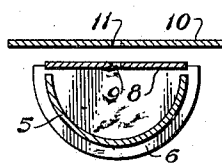
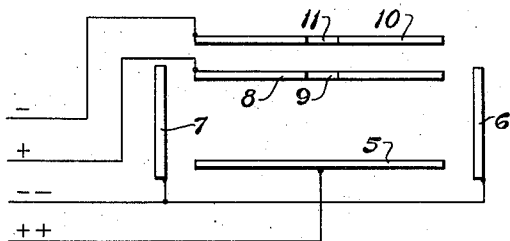


Fig. 3



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ION GENERATOR

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3 Claims. (Cl. 250-41.9)

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This invention relates to ion generators, and more specifically to an ion generator particularly adapted to operate in a highly evacuated space.

Prior patents granted to F. M. Penning (No. 2,146,025) and to W. Bleakney (No. 2,221,467) disclose cold cathode ion generators capable of producing ions in an evacuated space. As disclosed in these patents a magnetic field acting substantially normal to the established electric field is utilized to elongate the electron path thereby increasing the amount of ions produced.

The instant invention, in addition to embodying the principles of ion generation presented in the above cases, further provides means to expel the generated ions from the generator proper in the form of a sharply focused beam, even though said generator be operated in a highly evacuated space.

It is therefore an object of this invention to provide an ion generator with the ability to produce an intense ion beam within a highly evacuated space.

Another object of this invention is to provide an ion generator capable of producing the center of ion concentration in approximate coincidence with the ion exit slit.

A further object of this invention is to produce a focused ion beam.

A still further object of this invention is to provide an ion generator capable of producing an ion beam of controlled latitudinal dimensions.

In order to facilitate explanation and promote an understanding of the construction and operation of this invention three drawings are presented: Figure 1 being a diagrammatic representation of one specific mechanical configuration of the invention in plan view; Fig. 2 being a sectional view of Fig. 1, taken along plane 2-2; and Fig. 3 being a schematic diagram of the associated electrical connections.

Considering Figs. 1 and 2 in detail it may be noted that the ion generating chamber is defined by a semicylindrical anode 5, and two discs 6 and 7, one positioned at a distance from each open end of said anode 5, and a flat metallic front anode 8, covering the concave portion of said rear anode 5, although not in electrical contact with it. This front anode 8 has a slit 9 formed therein, said slit being positioned in such a manner that its greatest dimension lies along the longitudinal axis of the semicylindrical rear anode 5.

In addition to this front anode 8 there is provided an accelerating plate 10, disposed external to said front anode 8 and electrically insulated from it. The accelerating plate 10 also has a

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slit 11 formed therein, said slit 11 being positioned laterally and longitudinally in coincidence with the slit 9 of the front anode 8.

The mechanical features then may be summarized as: a semicylindrical rear anode 5; a flat front anode 8 positioned in proximity with, but not contacting said rear anode 5, and having a longitudinal slot 9 formed therein; an accelerating plate 10 situated adjacent and parallel to the front electrode, spaced from it, and having a slit 11 formed therein in alignment with the slit 9 of the front electrode 8, and two discs 6 and 7, one at each end of said anode 5.

Referring now to the electrical connections as depicted schematically in Fig. 3, a high voltage is impressed between the cathodes 6 and 7 and the rear anode 5, with the cathodes being negative and the rear anode 5 being highly positive. The front anode 8 is maintained at a somewhat lesser positive potential than the rear anode 5, and the accelerating plate 10 is maintained at approximately ground potential, thus being negative with respect to the anode parts 5 and 8.

In addition to the components previously described there is provided a magnetic field, not shown, applied so as to produce lines of force longitudinally through the rear anode 5 and perpendicular to the cathodes 6 and 7. This magnet field may be produced in a variety of ways depending upon the application of this invention and therefore its originating agency is not depicted.

Having now presented the mechanical details and electrical connections of the invention the operation and theory will be considered. In order for an ion generator to operate satisfactorily in an evacuated space a high percentage of the ions formed must be utilized. This is due to the fact that the pressure reduction results in a decreased number of gas molecules in a given space and thus the number of collisions between these molecules and free electrons decreases, thereby reducing the number of ions formed. Therefore in order for an ion generator to produce an intense ion beam while operating in a vacuum it is necessary to make special provisions to control the removal of a great percentage of the ions formed. In the present invention this is accomplished by two separate means operating in conjunction.

In the case of an ionization chamber defined by a cylindrical anode the center of ion concentration would be along the axis of said cylinder, and furthermore, as the main attractive force urging ions from said chamber must be initiated

exterior to the cylinder wall it is obvious that a distance at least equal to the radius of said cylinder must separate the center of ion concentration from the source of said force. As a first means of overcoming the limitations imposed by the hypothetical case described above, the present invention utilizes an ionization chamber bounded by a semicylindrical anode having one flat wall. It is obvious that in an ionization chamber so constructed the center of ionization will be displaced from the axis of said semicylinder in a direction away from said flat wall, and yet it is equally apparent that despite said displacement, the center of ion concentration is closer to the anode wall and thus to the source of the force accelerating the ions from said chamber than in the case of a cylindrical anode. In addition to the present mechanical configuration as hereinabove described a second means utilizing the force of an electric field resulting from the potential difference between anode portions 5 and 8 is incorporated to further displace the center of ion concentration toward the ion exit slit.

The net result of the use of this configuration of the ionization chamber, and the potentials applied to the parts defining said chamber, is to place the center of ion concentration extremely near the ion exit slit 9. As the ion accelerating potential is applied directly exterior to the ion exit slit 9, a large percentage of the ions formed are forced through the exit slit thereby producing an intense ion beam.

Furthermore, due to the configuration presented herein a very favorable focusing action may be produced by applying the proper biasing potential to the front anode 8. A slight variation of the front anode potential results in a large variation in the latitudinal dimensions of the ion beam. Under these conditions the beam may be made very narrow, thus immeasurably increasing its value where used in conjunction with such an apparatus as a mass spectrometer.

Proceeding further with a description of the operation, it will be noted that as a potential is applied between the cathodes 6 and 7, and the rear anode 5, electrons are discharged from the cathodes in the direction of the anode. The action of the magnetic force upon these electrons however prevents them from coming directly in contact with the anode 5. Due to the interaction of the electric field and the magnet field the electrons follow a roughly helical path through the anode space until they approach sufficiently near the oppositely charged anode to be repelled, at which time they reverse direction. Thus the electron travels back and forth between the cathode 6 and 7 describing an approximately helical path about a magnetic line of force. As the electrons are passing back and forth in the anode space collisions occur between said electrons and any gas molecules present in the region, and thus produce ions. Of these ions formed a number impinge directly upon the cathodes resulting in secondary electron emission, thus adding to the number of electrons present and increasing the probability of further ion forming collisions. However, the ma-

jority of ions are attracted by the electric fields about the accelerating plate 10, but do not impinge upon said plate due to the force of repulsion supplied by the field about the front anode 8. Therefore, the ions pass through the exit slit 9 in the front anode 8 and on through the slit 11 in the accelerating plate 10, emerging as a high intensity ion beam of any desired latitudinal dimension.

Although the details of the invention have been discussed with reference to one specific embodiment it will be obvious to those skilled in the art that many modifications are possible within the spirit and scope of the invention and thus the invention is not to be limited to the details shown except as defined in the following claims.

What is claimed is:

1. An ion generator comprising means for establishing a magnetic field, a tubular anode having a generally semicircular cross-section positioned in and parallel to said magnetic field, said tubular anode having an aperture formed in the flat wall thereof, the curved portion of the wall of said anode being electrically insulated from the remainder of said wall and at a positive potential with respect thereto, a pair of cathodes disposed adjacent the open ends of said anode and at a negative potential with respect thereto whereby an electrical discharge is produced in the region defined by said anode, and means for withdrawing ions from said region through said aperture.

2. An ion generator comprising means for establishing a magnetic field, a tubular anode having a generally semicircular cross-section positioned in and parallel to said magnetic field, said tubular anode having an aperture formed in the flat wall thereof, the curved portion of the wall of said anode being electrically insulated from the remainder of said wall and at a positive potential thereto, a pair of cathodes disposed adjacent the open ends of said anode and at a negative potential with respect thereto whereby an electric discharge is produced in the region defined by said anode, and means external to said anode providing with said anode an electric field whereby ions are attracted from said region through said aperture.

3. An ion generator comprising means for establishing a magnetic field, a tubular anode having a generally semicircular cross-section positioned in and parallel to said magnetic field, said tubular anode having an aperture formed in the flat wall thereof, the curved portion of the wall of said anode being electrically insulated from the remainder of said wall and at a positive potential with respect thereto, a pair of cathodes disposed adjacent the open ends of said anode and at a negative potential with respect thereto whereby an electric discharge is produced in the region defined by said anode, and an electrode external and adjacent the flat wall of said anode having an aperture formed therein in alignment with said anode aperture, said electrode being at a negative potential with respect to said anode.

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No references cited.