Feb. 28, 1950 J. G. BACKUS 2,499,289

ION GENERATOR

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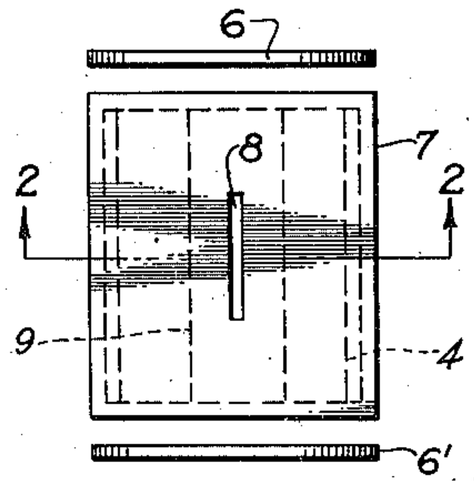

FIG 1

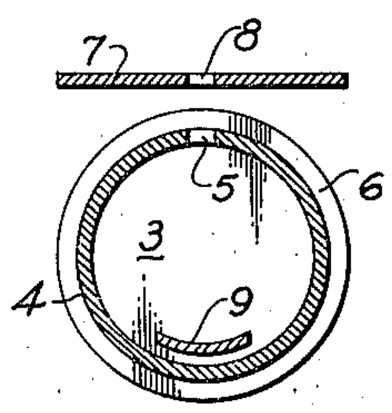

FIG 2

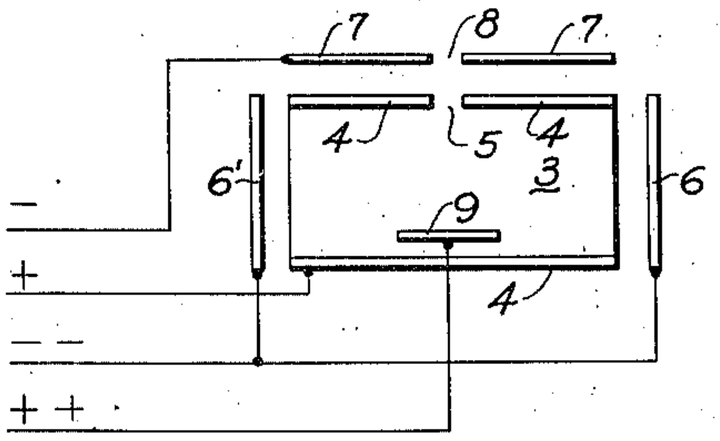

FIG 3

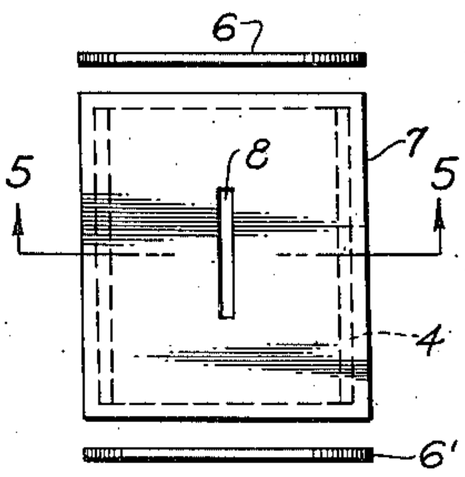

FIG 4

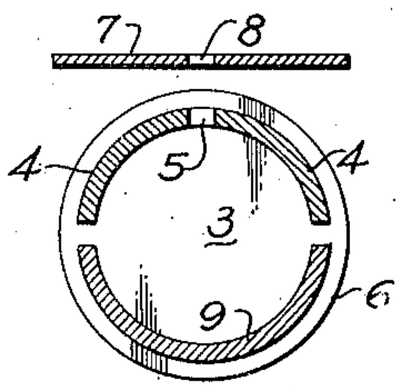

FIG 5

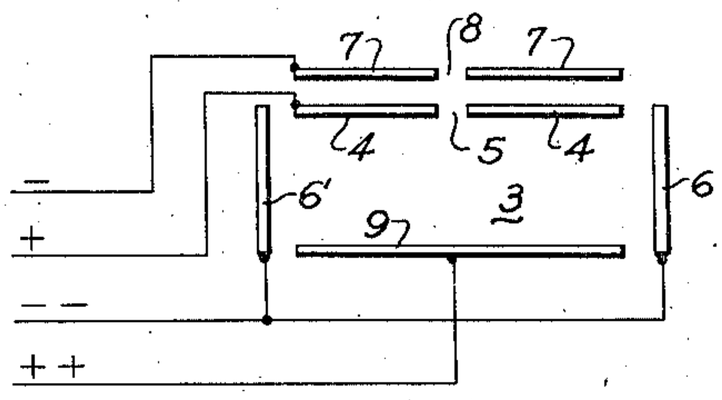

FIG 6

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ION GENERATOR

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5 Claims. (Cl. 250—41.9)

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This invention relates to ion sources and more specifically to an ion source which is capable of producing a relatively high intensity beam of ions while operating in a very low pressure space.

Various recent inventions have combined an ion source with a mass spectrometer, said combination operating in a very low pressure space. The successful operation of such a combination requires an intense ion beam be passed through the mass spectrometer. However, due to the low operating pressure the amount of ions formed is necessarily small and thus a large percentage of those ions formed must be expelled from the ion source in a usable beam.

As pointed out by F. M. Penning in Patent No. 2,146,025 the electron path in a cold cathode ion source may be lengthened by including a magnet field acting perpendicular to the established electric field, consistent with the mechanical configuration presented therein. Further, the incorporation of this principle with means for removing the ions from the ionization chamber as presented by Walter Bleakney in Patent No. 2,221,467 provides an apparatus for the focusing and separation of ions.

The above mentioned cases provide a very suitable source of ions. However, as will be readily appreciated by those familiar with the art, the necessity has arisen to provide means to project an intense ion beam from such a source. The present invention utilizes the actual ion generating principles presented in the above mentioned cases with means to remove a sufficiently large percentage of the ions from the ionization chamber in the form of an intense ion beam to make these ions available for further usage.

It is therefore an object of this invention to provide an ion generator capable of producing an intense beam of ions.

Another object of this invention is to provide an ion generator capable of producing a relatively intense ion beam within a highly evacuated space.

A further object of this invention is to provide an ion generator having the ability to maintain an intense ion beam regardless of operating pressure reductions without a corresponding potential increase.

Further objects and advantages of the present invention will become apparent to those skilled in the art from the following description of construction and operation.

In order to facilitate an understanding of the following description a number of drawings have been included, of which Figure 1 is a plan view

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of one preferred embodiment, Fig. 2 is a sectional view of Fig. 1 taken as indicated, and Fig. 3 is a schematic representation of the electrical connections and potentials associated with the parts shown in Figs. 1 and 2. A further embodiment is depicted in the remaining figures of which Fig. 4 is a plan view of this specific embodiment, Fig. 5 is a sectional view of Fig. 4 taken as indicated, and Fig. 6 is a schematic layout of the relative electrical potentials associated with this embodiment.

Considering Figs. 1 and 2 in conjunction and in greater detail, it will be appreciated that the ionization chamber **3** is defined by a metallic hollow cylinder **4** acting as an anode, and two metallic discs **6** and **6'** functioning as cathodes. The anode cylinder **4** has a slit **5** formed therein, parallel to the axis of said cylinder. The cathodes **6** and **6'** are of approximately the same diameter as the anode cylinder **4** and are placed perpendicular to the axis of said cylinder, their centers lying on an extension of said axis. In addition the cathodes **6** and **6'** are situated at a short distance from said anode cylinder so as to be electrically insulated from it and to allow a free access for air or gas into the ionization chamber **3**. There is also provided on accelerating plate **7** external to said anode cylinder **4** and having a slit **8** formed therein; said slit being parallel and adjacent to the slit **5** of the anode cylinder **4**.

Within the anode cylinder **4** there is placed a metal pusher electrode **9** of arcuate cross section mounted parallel to said cylinder wall. Said pusher electrode **9** is placed near the wall of the anode cylinder **4** opposite the slit **5** and is electrically insulated from the anode cylinder **4**.

Considering the electrical connections of the parts described above, Fig. 3 indicates the relative polarities of the elements. As may be seen in Fig. 3 a negative potential is applied to the cathodes **6** and **6'** and a positive potential impressed upon the anode cylinder **4**. The accelerating plate **7** is at substantially ground potential, thus being at a negative potential with respect to the anode **4**, and the pusher electrode **9** is at a positive potential with respect to the anode **4**.

Having now covered the mechanical and electrical details of the ion generator, the operation will be considered. However, it is to be noted that in addition to the details shown and hereinabove described there is present a magnetic field acting through the ionization chamber and having lines of force parallel to the axis of the anode cylinder **4**. As the magnet field may be produced by a variety of magnet types and as only the

effect of the force is of importance no magnet has been depicted in the drawings.

Proceeding with the operation, assume a sufficient potential applied between the anode 4 and cathodes 6 and 6' to initiate an electron discharge between said elements. Due to the magnet field influence the discharge electrons do not travel directly from the cathode to the anode but are constrained to pass through the anode cylinder substantially parallel to the magnetic lines of force.

The interaction of the magnetic and electric fields produces a resultant helical electron path through the anode cylinder 4, and thus the electrons oscillate between the cathodes thereby producing an extended electron path. And as ions are formed by collisions between discharge electrons and gas molecules within the ionization chamber 3, the number of ions formed increases as the electron path increases.

In order to remove the ions from the ionization chamber 3 the accelerating plate 7 is maintained at a negative potential with respect to the anode 4. Thus an attractive force is exerted on the ions within the chamber 3 which imparts to them a velocity toward the accelerating plate 7. However, aside from the area directly opposite the slit 5 in the anode cylinder 4, the accelerating plate 7 is entirely shielded from the ionization chamber 3 by said anode cylinder 4. Thus the ions are forcibly propelled through the slit 5 in the anode cylinder and further through the slit 8 in the accelerating plate 7 emerging as a concentrated ion beam.

As the operating pressure is reduced the concentration of gas molecules decreases thus reducing the amount of ions formed. Due to this fact it is necessary to provide means to utilize a greater percentage of the ions formed if the ion beam produced is to be maintained undiminished. For this purpose the pusher electrode 9 is provided. As this electrode 9 has a more positive potential than the anode 4 it will produce an electric field repelling the ions within the chamber. As it has been previously verified that normally the center of concentration of the ions lies along the axis of the anode cylinder 4, this repulsive force from the pusher electrode 9 will displace the center of ion concentration in the direction of the ion exit slit 5. Thus a greater number of ions will be closer to the attractive force of the accelerating plate 7 and a resulting greater ion beam will result. With a constant operating pressure the ion beam actually is intensified by the use of this additional electric field from the pusher electrode and in the case of a reduction in ambient pressure the ion beam intensity is maintained substantially constant by this electric field.

Examining the further embodiment presented in Figs. 4, 5 and 6 it will be noted that all parts having the same function in each embodiment are identified by identical numbers. As viewed in Fig. 4 the ion generator appears practically identical to that shown in Fig. 1, however the view presented in Fig. 5 clearly identifies the mechanical differences. In this latter embodiment the cylindrical anode is divided longitudinally into two equal parts, each of hollow semicircular cross section. These cylinder parts are identified in Fig. 2 and Fig. 5 as an anode 4 and pusher electrode 9. Thus the pusher electrode 9 and anode 4 as shown in Fig. 5 exhibit different mechanical forms than the units similarly named in the first embodiment, however aside from this variation, the mechanical configuration of this embodiment of the ion generator is identical to the first presented.

With regard to the electrical connections and potentials as shown in Fig. 6 it will be noted that potentials of the same order are applied to analogous parts in each embodiment. A negative potential is applied to each of the cathodes 6 and 6' while a positive potential is applied to the anode 4. A more positive potential is applied to the pusher electrode 9 than to the anode 4, thus permitting it to carry out the function attributed to it in the previous description of the first embodiment and a negative or ground potential is applied to the accelerating plate 7.

The operation of this embodiment is identical to that presented for the embodiment covered by Figs. 1, 2 and 3. The differences are entirely mechanical, resting entirely in the use of the bottom half of the anode cylinder as a pusher electrode instead of an extra electrode being inserted in the cylinder for that purpose.

Although this invention has been depicted in only two specific embodiments 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 disposed in and parallel to said magnetic field, said tubular anode having an aperture formed in a wall thereof, 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, an arcuate electrode disposed internally of and concentric with said anode, opposite said anode aperture, and at a positive potential with respect to said anode, and an electrode disposed adjacent said anode aperture external to said anode, and at a negative potential with respect thereto.

2. An ion generator comprising means for establishing a magnetic field, a tubular anode disposed in and parallel to said magnetic field, said tubular anode having an aperture formed in a wall thereof, 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, means external to said tubular anode providing an electric field whereby ions are attracted from said region through said aperture, and means interior to said anode providing a further electric field whereby ions are repelled through said aperture.

3. An ion generator comprising means for establishing a magnetic field, a tubular anode disposed in and parallel to said magnetic field, said tubular anode having an aperture formed in a wall thereof, a portion of the wall of said anode opposite said aperture being electrically insulated from the rest of said wall and being at a positive potential with respect thereto, a pair of cathodes disposed adjacent to 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, an electrode external to the region defined by said anode, at a negative potential with respect to said anode, and having an aperture formed there-

in, said aperture being aligned with said anode aperture.

4. An ion generator comprising means for establishing a magnet field, a tubular anode disposed in and parallel to said magnetic field, said tubular anode having an aperture formed in a wall thereof, an electrode situated inside of said anode, opposite said aperture, and at a positive potential with respect to said anode, 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 tubular anode providing an electric field whereby ions are attracted from said region through said anode aperture.

5. In an ion generator the combination comprising a cylindrical ion chamber defined by two semi-cylindrical anode sections, one of said sections having an aperture formed therein and being maintained at a negative potential with respect to the other section, a pair of cathodes disposed adjacent the open ends of said ion chamber and axially aligned therewith, means establishing a magnetic field through and parallel to said cylindrical ion chamber, and means maintaining said cathodes at a negative potential with respect to said anodes whereby electron discharge is initiated therebetween.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,146,025	Penning	Feb. 7, 1939
2,373,151	Taylor	Apr. 10, 1945