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METHOD AND DEVICE FOR GENERATING A BEAM OF IONS OF HIGH VELOCITY

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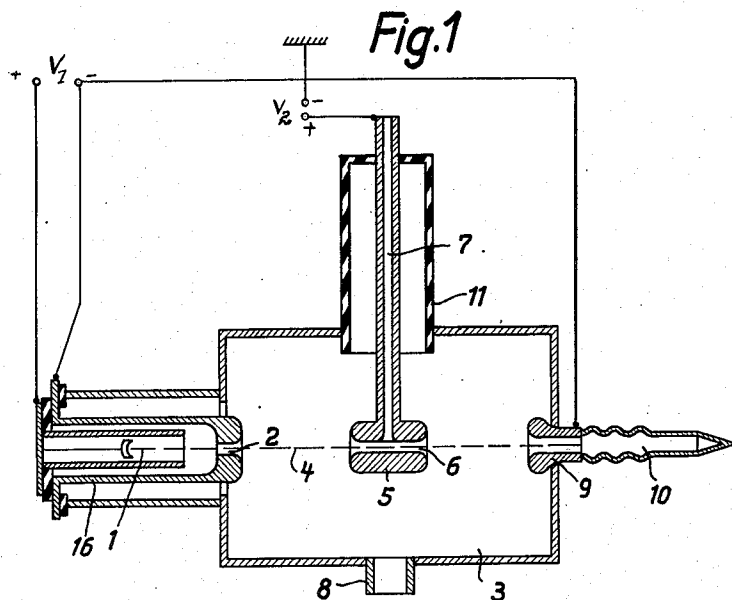


Fig.2

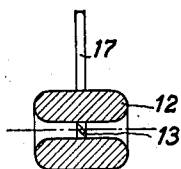


Fig.3

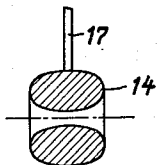
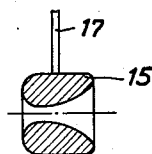


Fig.4



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METHOD AND DEVICE FOR GENERATING A
BEAM OF IONS OF HIGH VELOCITY

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13 Claims. (Cl. 250—27)

This invention relates to a method and device for generating beams of ions of high velocity.

It is known that in a vacuum tube positive ions can be neutralised by slight collisions with a gas molecule. This process takes place with only very little loss of kinetic energy. Therefore the formed neutral particles have nearly the same velocity as the positive ions. By a similar process these neutral particles can capture an electron and then form negative ions which again have nearly the same velocity as the aforesaid positive ions. The reversed process may also take place. Negative ions are transformed into neutral particles by an electron and those neutral particles then are transformed into positive ions by a second electron. This process too goes on with only very little loss of velocity.

Further it is known that ions of high velocity can be generated by multiple acceleration of positive ions in the following way. Positive ions are accelerated by a certain voltage whereafter they are neutralised. Those neutral particles, the velocity of which corresponds to the accelerating voltage now pass through the same voltage, however with the reversed sign. Thereon the neutral particles are again ionised and accelerated another time. By repeating this process several times, positive ions of very high velocity are finally generated. However, the intensity of the beam consisting of positive ions is very much reduced by the repeated transformation of positive ions into neutral particles, as this process is a rather improbable one at high voltages. The gain of this transformation often amounts to about 0.1% only.

The neutralisation of negative ions and the ionisation of the neutral particles however, are essentially more probable processes at high voltages. Under favourable circumstances and at sufficiently high voltages most of the negative ions can be transformed into positive ones. Therefore the device according to the present invention employs negative ions generated by a special ion source or created by electron capture of positive ions and neutral particles. These negative ions of low velocity are accelerated by an electrostatic field to negative ions of high velocity, thereon in the aforementioned way they are transformed into positive ions without practically any loss of velocity. These positive ions having the same velocity as the accelerated negative ions are likewise accelerated to ions of still higher energy by a similar electrostatic field. It is practical to make the amount of the accelerating voltage of the positive ions just equal to

the accelerating voltage of the negative ions. In this case the voltage used for accelerating the positive ions is the same as that used for accelerating the negative ions, the field in the latter case, however, having the reversed sign. The electrode on which the positive ions impinge thus has the same potential as the aforementioned source of negative ions.

As the source of negative ions and the collecting electrode for the positive ions are at the same potential it is practical to connect them both to ground. Sometimes it also will be practical to ground the walls of the vacuum tube. The positively charged electrode is introduced into the vacuum tube by means of an insulating bushing.

The transformation of negative ions into positive ions is effected either by passing the negative ions through a space of sufficiently high pressure or by passing the negative ions through a thin foil or by grazing engagement of negative ions on a suitable surface.

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

Fig. 1 is a diagrammatic representation of apparatus embodying the principles of the invention; and

Figs. 2, 3 and 4 are diagrammatic representations of modified forms of electrodes suitable for use in the apparatus of the invention.

Fig. 1 of the accompanying drawing schematically shows an example of the invention. The positive ions generated in the ion-source 1 by passing through a bore 2 are transformed into negative ions, which then enter the space of the accelerating field. The beam of negative ions 4 is accelerated by the potential between the end of bore 2 and the positively charged electrode 5. These accelerated negative ions enter a bore 6 of the electrode 5. The pressure in the middle part of bore 6 is somewhat higher than in the surrounding space of the apparatus, as a stream of gas continually flows into the bore through a pipe 7 of small cross-section. This gas, of course, also flows through bore 6 into the surrounding space 3 of the apparatus. But the pressure in this space of the apparatus is very low, as the tube is continually evacuated by a strong vacuum pump connected to pipe 8. In the bore 6 the negative ions are transformed into positive ions and many of them leave the bore 6 as positive ions having nearly the same velocity as the thus negative ions. Between the end of the bore 6 and the collecting electrode 9 the positive ions are also accelerated, since the thus field between 5 and 9 is of reversed sign from the electrostatic

field between 2 and 5. By this arrangement the ions impinging on the reaction surface 10 having a kinetic energy corresponding to a voltage which is twice the voltage applied between electrode 5 and parts 2 and 9.

Besides this doubling of energy the arrangement according to the invention has the advantages that only one high tension insulator is necessary and that both the source of negative ions as well as the collecting electrode are grounded.

Fig. 2 is another embodiment for transformation of negative ions into positive ions within the high voltage electrode 5. The cylindrical hollow electrode 12 fixed to the metal rod 17 contains a foil 13 in the middle of the bore. This foil is so thin, that the impinging negative ions can pass it without any substantial loss of kinetic energy, however by passing through the foil most of the negative ions are transformed into positive ions and these positive ions leaving the bore are again accelerated in the described manner. Figs. 3 and 4 illustrate two further examples for transforming negative ions into positive ions by grazingly engaging on a suitable surface. The shape of the bore within the electrode 14 and 15 is so chosen, that as many negative ions as possible are transformed into positive ions.

What we claim as new and desire to secure by Letters Patent of the United States is:

1. A method for generating a beam of ions of high velocity which comprises subjecting a beam of negative ions to the acceleration of a strong electrostatic field, thereafter converting at least a portion of the negative ions in said beam to positive ions by collision and further accelerating the positive ions thus produced by a further strong electrostatic field.

2. A method for generating a beam of ions of high velocity which comprises subjecting a beam of negative ions to the acceleration of a strong electrostatic field, thereafter passing said beam of negative ions into a region of sufficiently high gas pressure to convert at least a portion of the negative ions in said beam to positive ions by collision and further accelerating the positive ions thus produced by a further strong electrostatic field.

3. A method for generating a beam of ions of high velocity which comprises subjecting a beam of negative ions to the acceleration of a strong electrostatic field, thereafter passing said beam of negative ions into grazing engagement with a surface whereby to convert at least a portion of the negative ions in said beam to positive ions by collision and further accelerating the positive ions thus produced by a further strong electrostatic field.

4. A method for generating a beam of ions of high velocity which comprises subjecting a beam of negative ions to the acceleration of a strong electrostatic field, thereafter passing said beam of negative ions through a thin foil whereby to convert at least a portion of the negative ions in said beam to positive ions and further accelerating the positive ions thus produced by a further strong electrostatic field.

5. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named

electrode and providing means for accelerating the positive ions.

6. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode.

7. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said collecting electrode being at ground potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode.

8. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said casing, said negative ion source and said collecting electrode being at ground potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode.

9. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode, said first-named electrode comprising a member permeable to high velocity ions and means supporting said member in the path of the negative ions.

10. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode, said first-named

electrode comprising a perforated member and means supporting said member so that the perforation therein is in the path of the negative ions.

- 5 11. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative
10 ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said
15 collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode, said first-named electrode comprising a perforated member and
20 means supporting said member so that the perforation therein is in the path of the negative ions, said supporting means providing a conduit whereby gas may be supplied to the perforation in said member.
- 25 12. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative
30 ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named

electrode and providing means for accelerating the positive ions, said negative ion source and said collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source
5 and the collecting electrode, said first-named electrode comprising a perforated member and means supporting said member so that the negative ions from said source pass in grazing engagement with the walls of said perforation.
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13. A device for generating a beam of ions of high velocity comprising an evacuated casing, and enclosed within said casing, a source of negative ions, an electrode spaced from said source and providing means for accelerating negative
15 ions from said source and for converting accelerated negative ions into positive ions, and a collecting electrode spaced from said first-named electrode and providing means for accelerating the positive ions, said negative ion source and said
20 collecting electrode being at the same potential and said first-named electrode being at a high potential with respect to the negative ion source and the collecting electrode, said first-named electrode comprising a perforated member, a thin
25 foil transversely positioned in said perforation and means supporting said member so that the perforation therein is in the path of the negative ions.

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