

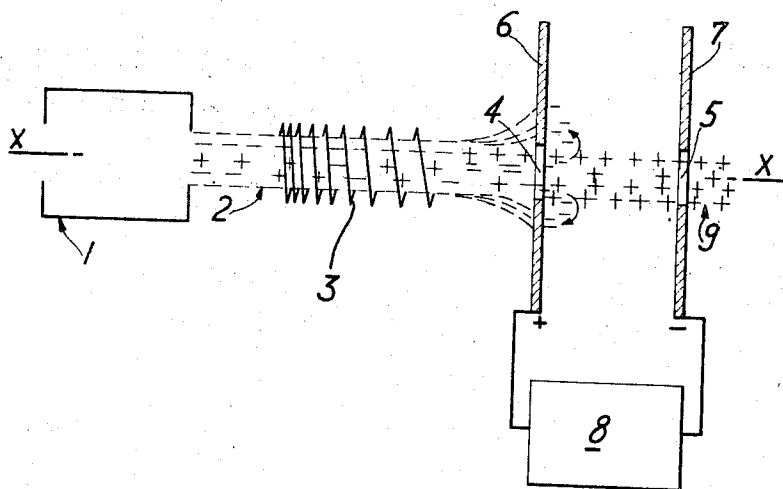
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POSITIVE ION-SOURCE HAVING ELECTRON RETAINING MEANS

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**POSITIVE ION-SOURCE HAVING ELECTRON
RETAINING MEANS**

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2 Claims. (Cl. 315—111)

ABSTRACT OF THE DISCLOSURE

An accelerated jet of positively and negatively charged particles is passed through a coil generating a magnetic field parallel to the long axis of the jet and having its intensity decreasing in the direction of flow to diverge negatively charged particles. The jet then passes through spaced parallel plates having openings in the cross-section of the jet with the upstream plate positively charged and the downstream plate negatively charged so that the upstream plate captures negatively charged particles.

The present invention relates to a source of positively charged particles, and in particular a source of positive ions adapted to generate a very high-energy ion beam.

The known high energy ion sources usually comprises an enclosure provided with a small opening and containing a mixture of neutral gases and an ionized gas, the pressure of said neutral gases being of from 10^{-5} to 10^{-7} atmosphere.

One or several electrodes mounted in register with said opening and raised to negative potentials with respect to said enclosure, permit to extract the ions contained in the latter and to accelerate them. The ionized gas is homogeneously and isotropically distributed in said enclosure, i.e. the velocities of the particles (in particular of the ions) are randomly orientated.

Therefore, whenever an ion passes through the enclosure opening, its velocity (which will be referred to as its initial velocity) can have any direction and is usually low, since the kinetic energy of the plasma contained in the enclosure is of small value. It follows that, in the vicinity of said enclosure, a positive space-charge is created, said space-charge resulting from the presence of a large amount of low initial-velocity ions and having a tendency to interfere with the extraction of ions from said enclosure.

Consequently, the intensity of the ion beam obtained is limited to about 1 ma.-cm.² for an extraction voltage of up to 1000 volts. In addition, the energy of the ions forming such a beam is rather low and can be increased only by carrying out acceleration methods which require voltage sources of several hundred thousand volts.

Moreover, since the pressure of neutral gases is high, the major portion of the extracted ions is lost, due to charge exchanges in the numerous collisions between ions and neutral gases.

The present invention, which is free of the above drawbacks, relates to a source of positively charged particles, and in particular a source of positive ions adapted to generate a very high energy ion beam, said source comprising means for generating an accelerated jet of positively charged particles and of negatively charged particles which is altogether electrically neutral and possessed of a very high energy, at least two electrically conductive parallel plates at right angles to the longitudinal axis of said jet, said plates being provided with openings co-axial to said jet and the areas of which are of the order of that of the cross-section of said jet, and a source of

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direct current adapted to establish an electric field between said plates and so mounted that its positive terminal is connected to that of said plates which is the more upstream of said jet, whereby when said jet has passed through said opening of said upstream plate, the negatively charged particles of said jet, due to said electric field, are slowed down and then sent back towards said upstream plate by which they are captured, whereas the positively charged particles proceed on their way and pass through the opening of the other plate after having been accelerated by said electric field.

According to a specific form of embodiment, said jet of particles is constituted by a plasma emitted by an electro-magnetic accelerator.

Said source of positively charged particles can comprise means located between said means for generating an accelerated jet and said two plates, and adapted to generate a magnetic field which is parallel to the longitudinal axis of said jet and the intensity of which decreases in the direction of flow of said jet, said magnetic field causing the major portion of the negatively charged particles to diverge and thus to hit said upstream plate instead of passing through the opening of said upstream plate.

The features of the present invention will be disclosed hereafter, reference being had to the accompanying drawing which diagrammatically represents a source according to the invention, shown in section along a plane passing through the axis of the jet of particles, said jet being assumed as constituted by an accelerated plasma emitted by an electro-magnetic accelerator.

In the figure, an accelerator of ionized gas or plasma is diagrammatically shown at 1. This accelerator emits a jet of plasma 2 possessed of a very high energy, which is altogether electrically neutral and composed of positive ions and of electrons, the velocity of the positive ions being substantially equal to the component of the electron velocity along the axis XX of the jet.

The electrons of jet 2 follow helical paths whereas the ions, driven by the electronic space charge, move in the direction of axis XX. The energy of the flux of particles forming jet 2 is proportional to the electro-magnetic power of accelerator 1, which is for instance of 300 w., the ion energy being then of the order of 10^2 ev. and the total number of particles emitted per second of the order of 10^{19} .

A coil 3 co-axial to the plasma jet 2 generates a static magnetic field which is parallel to the longitudinal axis of said jet, and the intensity of which decreases in the direction of flow of said jet.

Two circular openings 4 and 5 co-axial to the plasma jet 2 and the areas of which are of the order of that of the cross-section of said jet, are provided in two parallel conductive plates, 6 and 7 respectively, connected to the terminals of a direct current source 8, plate 6 located between coil 3 and plate 7 being connected to the positive terminal of said source 8.

Any electron contained in plasma jet 2 undergoes, when passing through coil 3, the action of the magnetic field generated by said coil, and if this magnetic field, which is co-axial to jet 2, is gradually decreasing, it causes an increase of the radius of the helical path followed by said electron. Therefore the major portion of the electrons which pass through said coil diverge from jet 2 and hit plate 6 instead of passing through opening 4. As stated above, the ions move in the direction of axis XX and therefore in the direction of the magnetic field. Accordingly, the magnetic field exerts no action upon them and they are not deviated and all of the ions pass through opening 4.

The ions are not deviated by the magnetic field, since

their velocities are parallel to said field, and therefore they all pass through opening 4. A first sorting of the ions contained in plasma jet 2 is therefore achieved through the medium of said static magnetic field.

Those electrons which have been able to pass through opening 4, because they have not sufficiently diverged from axis XX to be stopped by plate 6, are immediately submitted to the decelerating field existing between plates 6 and 7 and they are accordingly captured by plate 6, the potential of which is positive.

A second sorting is thus carried out, and beam 9 circulating between plates 6 and 7 no longer contains electrons and is exclusively constituted by ions.

This ion beam is accelerated by the electric field between plates 6 and 7, and thus the energy the ions of jet 2 had on leaving the accelerator is still increased.

The electrons captured by plate 6 are driven by conduction to source 8.

Since the energy of the ions contained in beam 2 is already very high before they pass through opening 4, the space charge created in the vicinity of said opening and due to the presence of numerous electrons captured by plate 6 has no substantial action on ion beam 9.

Accelerator 1 and plates 6 and 7 are located in a tight enclosure (not shown), inside which the air pressure is maintained at about 10^{-8} atmosphere in order to minimize the probability of collisions between neutral gas and positive ions.

The intensity of the ion beam delivered by the source according to the present invention is, for instance, of the order of 30 ma./cm.², the diameter of openings 4 and 5 being 1 cm. and the voltage delivered by source 8 being of 500 v.

Such a source can be used whenever a very high-energy accelerated ion beam is needed, and it is of special interest for thermonuclear fusion.

What is claimed is:

1. A device for separating electrons and positive ions from an accelerated jet of positively charged particles and negatively charged particles which is altogether electrically neutral and possessed of a very high energy, including a source for said jet, at least two electrically conductive parallel plates at right angles to the longitudinal axis of said jet, said plates being provided with openings co-axial to said jet and the areas of which are of the order of that of the cross-section of said jet, a source of direct current adapted to establish an electric field between said plates and so mounted that its positive terminal is connected to that of said plates which is the more upstream of said jet, and a coil located entirely between said means for generating an accelerated jet and said two plates and generating a magnetic field which is parallel

to the longitudinal axis of said jet and the intensity of said magnetic field decreases continuously in the direction of flow of said jet, whereby the major portion of said negatively charged particles is caused to diverge from said longitudinal axis and to hit said upstream plate, and, once said jet has passed through said opening of said upstream plate, the remaining negatively-charged particles of said jet, due to said electric field, are slowed down and then sent back towards said upstream plate by which they are captured, whereas the positively-charged particles proceed on their way and pass through the opening of the other plate after having been accelerated by said electric field.

2. A source of ions adapted to generate a very high energy ion beam, said source comprising an electro-magnetic accelerator adapted to emit a jet of plasma possessed of a very high energy, at least two electrically conductive parallel plates at right angles to the longitudinal axis of said jet, said plates being provided with openings co-axial to said jet and the areas of which are of the order of that of the cross-section of said jet, a source of direct current adapted to establish an electric field between said plates and so mounted that its positive terminal is connected to that of said plates which is the more upstream of said jet, and a coil located entirely between said means for generating an accelerated jet and said two plates and generating a magnetic field which is parallel to the longitudinal axis of said jet and the intensity of said magnetic field decreases continuously in the direction of flow of said jet, whereby the major portion of the electrons of said plasma is caused to diverge from said longitudinal axis and to hit said upstream plate, and, once said jet has passed through said opening of said upstream plate, the remaining electrons of said jet, due to said electric field, are slowed down and then sent back towards said upstream plate by which they are captured, whereas the positive ions of said plasma proceed on their way and pass through the opening of the other plate after having been accelerated by said electric field.

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