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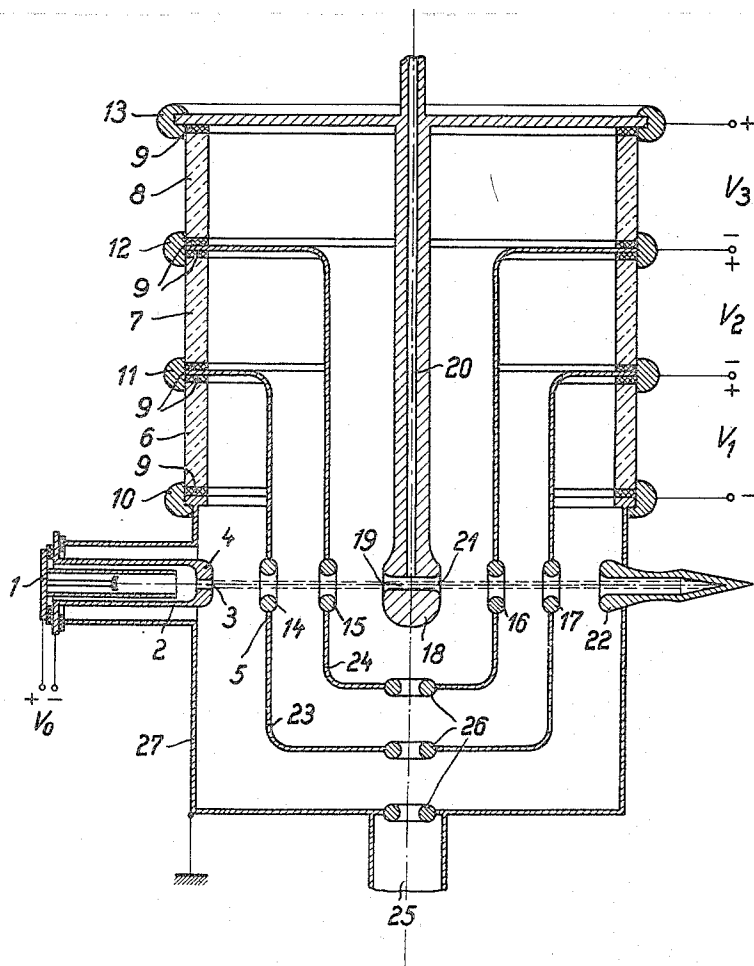
2,272,374

DEVICE FOR GENERATING A BEAM OF IONS

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2 Sheets-Sheet 1

Fig. 1



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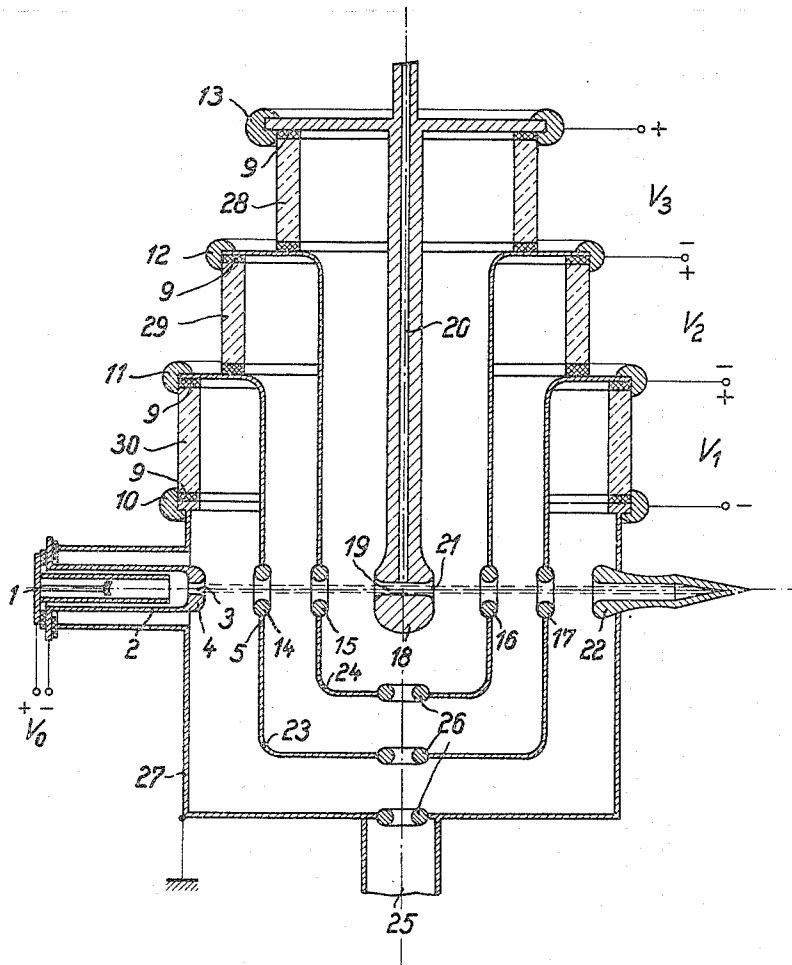
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Fig.2



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UNITED STATES PATENT OFFICE

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DEVICE FOR GENERATING A BEAM OF IONS

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6 Claims. (Cl. 250—84)

It has already been suggested to produce an intense beam of ions of a very high velocity by accelerating negative ions by means of an electric field and by converting the thus produced high speed negative ions into positive ions and by then further accelerating these latter ions by means of an electric field.

The present invention relates to a particularly advantageous device for carrying out the above described procedure in which the acceleration of the ions is effected in steps with the aid of electrodes of pot-like shape each of which is provided with two diametrically oppositely located apertures through which the beam of ions enters into the respective electrode and leaves it. The several acceleration-electrodes are inserted into one another in such a manner that the negative ions pass through the apertures in the side-walls of the electrodes successively and are then converted into positive ions inside the central electrode and then, as positive ions, they successively leave the individual electrodes through the exit apertures.

With this arrangement, first the negative ions are accelerated from step to step and after they have been converted into positive ions these latter are again accelerated by the same potentials. The beam of ions passes through the individual electrodes in the direction of their diameters. The total path of the ions within the influence of the acceleration-electrodes is, therefore, only about as long as is the diameter of the outer acceleration-electrode. That path is independent of the size of the insulators by which the individual pot-shaped electrodes are insulated from one another. Consequently, it is, possible to arrange the electrodes in such a manner with respect to one another that the beam of ions successively passes through all apertures of the electrodes. This would be by far more difficult if, for instance, the individual acceleration-electrodes were designed as flat members separated from one another by cylindrical insulators, and the beam of ions would have to pass along the direction of the axis of the insulators.

The invention is illustrated diagrammatically and by way of example on the accompanying drawings on which Figure 1 is a vertical axial section through a device designed according to this invention, and Figure 2 is a similar representation showing a modified constructional form. The acceleration is, in both cases, effected in only two times three stages, but it is apparent that the invention also permits the employment of a considerably larger number of stages.

The negative ions are produced by a canal-ray tube consisting substantially of the electrodes 1 and 2. Said ions are produced, with this arrangement, in the proximity of the aperture of the channel 3, and they are accelerated by the field existing between the electrodes 4 and 5. The individual electrodes are insulated from one another by the insulators 6, 7 and 8, and the joint between the insulators is sealed with the aid of air-tight rings 9, for instance rubber. Sparking protection bodies 10—13 are provided in order to reduce exterior sparkover. The apertures of the electrodes are provided with protection rings 14—17 to avoid sparking in the interior. The bodies 10—13 and 14—17 consist of or are coated with conducting material. Their well rounded shape serves to protect the sharp edges of the apertures in the electrodes 23 and 24 and the edges of insulators 6, 7 and 8 where sparking is most likely to occur. Their utility depends upon their location as well as upon their rounded shape and conductivity. The acceleration of the negative ions entering through the electrode ring 14 is effected by the field existing between this ring and the ring 15 of the next following electrode. The negative ions passing through the ring 15 are again accelerated by the field existing between the central electrode 18 and the ring 15. Inside the channel 19 of the electrode 18 they are converted into positive ions. This conversion can be effected, for instance, by continuously introducing a sufficient amount of a suitable gas through the bore 20. When negative ions collide with gas molecules they are mostly converted into positive ions.

This conversion can be effected also by causing the negative ions to pass through a thin foil which may be provided in the interior of the electrode 18 across the channel 19. In this case it is not necessary to provide the bore 20 for the introduction of a gas into said electrode. The positive ions leaving the channel 19 at 21 are again accelerated by the field existing between the electrode 18 and the ring 16. Further acceleration is effected by the fields existing between the electrode parts 16 and 17, and between 17 and the ion-collector 22 respectively. The whole apparatus has to be evacuated which is effected by means of a vacuum pump joined to the device at 25. In order to facilitate the evacuation of the interior of the electrodes 23 and 24 it is advisable to provide the electrodes with additional apertures. In order to prevent sparkover it is, in general, advisable to provide these

apertures with bodies 26 similar bodies 10—13 and 14—17.

With this arrangement the wall 27 may be grounded if it consists of a conductive material or is covered with conductive material. If, for instance, the individual accelerating potential differences V_1 , V_2 and V_3 amount to 400,000 volts each, the acceleration is equal to

$$2(V_1 + V_2 + V_3) = 2,400,000$$

volts. In spite of this the ion collector, as well as the source of the negative ions, is at earth-potential, or at a potential (V_0) differing only little from the earth-potential. With this example the diameter of the lower pot 27 may amount to only 50 cm. in spite of the acceleration of 2.4 millions of volts. The insulators 6—8 must, of course, be dimensioned with proper consideration of the high potential of 400,000 volts. As, however, every electrode is twice utilized, the total length of all insulators is only one half of what it would be with the arrangements hitherto used to produce the same final speed of the ions. On the drawings the + and - signs applied to the lead wires of the electrodes indicate the relative potentials of these electrodes. For instance the lead wire to the member 27 is marked - to indicate that it has a negative potential with respect to the lead wire of electrode 23. V_1 indicates the value of this potential difference. The lead wire of electrode 23 has a + sign on the side toward the lead wire to member 27 to show that it has a positive potential to the latter. The lead wire to electrode 23 also has a - sign above it to show that it has a negative potential with respect to the lead wire to electrode 24 and V_2 indicates the value of this potential difference, and so on.

Another advantage of the present arrangement is that the insulators can be mounted in such a manner that their longitudinal axis stands vertical. The entire arrangement can, therefore, be housed in a sort of tower of a comparatively small diameter, nothing else being necessary than to provide means preventing spark-over from the high tension electrodes to the walls of said tower. The modification shown in Fig. 2 differs from Fig. 1 in that the diameters of the insulators 29 and 30 are successively smaller. This arrangement presents the advantage that the weight of the device and the volume of the space in which the device is to be housed can also be made correspondingly smaller than those of the device shown in Fig. 1. A further reduction of the size of said space is possible if this space is filled with a material having a larger breakdown strength than air. That space may, for instance, be filled with a suitable oil or a suitable compressed gas, preferably a gas having a large breakdown strength or a non-combustible liquid having a large breakdown strength.

We claim:

1. A device for generating and accelerating a beam of ions, comprising a casing containing a

source of negative ions and an ion-collector in its opposite walls, a plurality of accelerating electrodes spaced from said casing and from one another, a central insulated electrode containing means for converting negative ions into positive ions, said accelerating electrodes being provided each with an aperture permitting the passage of the negative ions from said source toward said central electrode and an aperture permitting the passage of the positive ions converted from the negative ions by the central electrode toward said ion collector, and annular insulators separating said electrodes from said casing, and from one another.

2. A device as defined a claim 1 in which the accelerating electrodes are pot-shaped and the apertures for the passage of the ions are provided in the side-walls thereof.

3. A device as defined a claim 1 in which the edges of the apertures in the accelerating electrodes are provided with conductive, rounded coverings against sparking.

4. A device as defined a claim 1 in which the accelerating electrodes are pot shaped and are provided with apertures to facilitate evacuation of the interior of said electrodes.

5. A device for generating and accelerating a beam of ions, comprising a casing containing a source of negative ions and an ion-collector in its opposite walls, a plurality of accelerating electrodes arranged within one another and within said casing and insulated from one another and from said casing by annular insulating members, and a central insulated electrode containing means for converting negative ions into positive ions, the walls of said accelerating electrodes being provided each with an aperture permitting the passage of the negative ions from said source toward said central electrode and an aperture permitting the passage of the positive ions converted from the negative ions by the central electrode toward said ion collector.

6. A device for generating and accelerating a beam of ions, comprising a casing containing a source of negative ions and an ion collector in its opposite walls, a plurality of annular accelerating electrodes spaced from said casing and from one another, a central electrode spaced from said accelerating electrodes containing means for converting negative ions into positive ions, the walls of said accelerating electrodes each being provided with an aperture permitting the passage of the negative ions from said source toward said central electrode and an aperture permitting the passage of the positive ions converted from the negative ions by the central electrode, toward said ion collector and annular insulators separating said electrodes from said casing and from one another, the diameter of the insulator of said central electrode being smallest and the diameters of the insulators of said accelerating electrodes being successively larger.

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