act at a distance. A non-vanishing far field is generated across a bipolar grid, for example, either by applying two RF voltages with the same frequency but different amplitudes, or by using a mixture of RF voltages with different frequencies which do not all balance each other out in the near field, resulting in neutralization, or by virtue of the fact that the structural elements are different sizes or different distances from a virtual covering surface of the pole electrode system. There can also be a mixture of different types of RF voltages and structural elements. It is also particularly possible to use, for example, two RF voltages which have the same amplitude and frequency but whose phase difference is something other than 180°, in which case only some of the amplitudes in the dipolar field of the asymmetrically arranged structural element arrays is balanced out, and the rest remains for the far field.

[0024] Thus, according to one embodiment of the invention the smooth rods of current multipole rod systems are replaced with pole electrode systems whose surfaces have a structure with closely packed zero-dimensional (tip-shaped) or one-dimensional (wire-shaped or edge-shaped) structural elements, the edges or tips reproducing the current shape of the smooth surface of the rods. Connecting the structural elements to RF voltages generates a dipole field in the near region, and further away a far field similar to that produced by the rods currently used. In the near region in front of the virtually generated surface the structural elements thus have an alternating electric near field which is more inhomogeneous than it would be if it were formed by the smooth surface of the rods. Heavy ions which approach the pole electrode systems can thus be more strongly driven back while, close to the axis, a multipole field of the current type with a low lower mass limit can be formed.

[0025] In accordance with another embodiment of the invention, solid pole rods are used where the surfaces of the rods are reshaped to form a field of edges or tips with enclosed indentations produced, for example, by milling grooves. Here, as well, the alternating fields which are generated on the edges or tips are more inhomogeneous than they would be the case on smooth surfaces. It is thus possible to produce quadrupole systems whose upper mass limit is 30 to 40 times the lower mass threshold.

BRIEF DESCRIPTION OF THE DRAWINGS

[0026] FIG. **1** shows a quadrupole ion guide according to the prior art with four hyperbolic pole rods (**1**, **2**, **3**, **4**).

[0027] FIG. **2** shows only the two pole rods (**1**) and (**2**) of the quadrupole ion guide in FIG. **1** so that the hyperbolic surfaces are visible.

[0028] In FIG. **3** the hyperbolic surfaces of the pole rods in FIG. **2** are replaced by elongated electrodes in the form of wires, creating the pole electrode systems (**11**) and (**12**) instead of the pole rods. The electrode wires here are fixed parallel to the axis of the ion guide.

[0029] FIG. **4** illustrates the situation when the rod surfaces are replaced by a system of electrode wires arranged at right angles to the axis of the ion guide. This creates the pole electrode systems (**21**) and (**22**).

[0030] FIG. **5** illustrates how the pole electrode systems in FIG. **3** are connected with the voltages U_1 to U_4. The pole electrode system (**11**) has two electrode arrays (**11***a*) and (**11***b*), each at a voltage of U_1 or U_2 and which form a bipolar grid. The pole electrode system (**12**) is also configured as a bipolar grid.

[0031] FIG. **6** illustrates a system of round rods arranged as a dodecapole. A special configuration generates a quadrupole field rather than a dodecapole field, the rod groups (**31**, **32**, **33**), (**34**, **35**, **36**), (**37**, **38**, **39**) and (**40**, **41**, **42**) each representing a pole electrode system as defined in this invention. Between any two neighboring pole rods there is always the alternating voltage difference 2U/3, which generates the dipole fields. The rod pairs (**32**, **38**) with voltage +U and (**35**, **41**) with voltage −U supply the main part of the quadrupole field.

[0032] FIG. **7** illustrates how the voltages for the rod system in FIG. **6** can be generated by a single secondary winding of an RF transformer.

[0033] FIG. **8** represents two opposed pole electrode systems (**53**) and (**56**) constructed of lamellar electrodes. Each system of lamellae comprises two electrode arrays (**51**) and (**52**) which create a type of bipolar grid, but the electrodes of one electrode array (**52**) do not extend as far as the virtually generated surface (**54**). The same is true for the virtual surface (**55**). Due to this geometric asymmetry, the influence of the electrode array (**51**) predominates if two RF voltages of opposite polarity but the same amplitude are applied across the two electrode arrays.

[0034] FIG. **9** illustrates two sheet electrodes which can be assembled to form a quadrupole ion guide which realizes this invention. The two sheet electrodes have an identical shape and are merely rotated through 90° with respect to each other. They can form two electrode arrays, each comprising sheet electrodes (**62**) and (**63**).

[0035] In FIG. **10** the sheet electrodes in FIG. **9** are assembled to form an ion guide. If the two pole electrode arrays are connected to two RF voltages of opposite polarity but the same amplitude, then an attenuated quadrupole field is generated in the interior because the electrodes of both electrode arrays (in a similar way to FIG. **8**) extend to within different distances of the virtually generated surfaces.

[0036] FIG. **11** illustrates the electric field lines of a bipolar wire grid (**71**-**75**) that is fed with the two RF voltages $U5=+A\cos(\omega t)$ and $U6=-(A/2)\cos(\omega t)$. A far field (**76**) is formed which corresponds to all wires being fed with $+(A/2)\cos(\omega t)$, with a dipole field superimposed in the near field region (**77**).

DETAILED DESCRIPTION

[0037] While the invention has been shown and described with reference to a number of embodiments thereof, it will be recognized by those skilled in the art that various changes in form and detail may be made herein without departing from the spirit and scope of the invention as defined by the appended claims.

[0038] A simple but strongly effective embodiment of the invention consists in replacing each of the smooth pole rods used hitherto by a bipolar wire grid and reproducing the surfaces of the pole rods with the grid, as shown in FIGS. **3** and **5**. The electrode wires here are fixed parallel to the axis of the ion guide. The wires of the pole electrode system can, of course, also be replaced by a system of lamellae made of