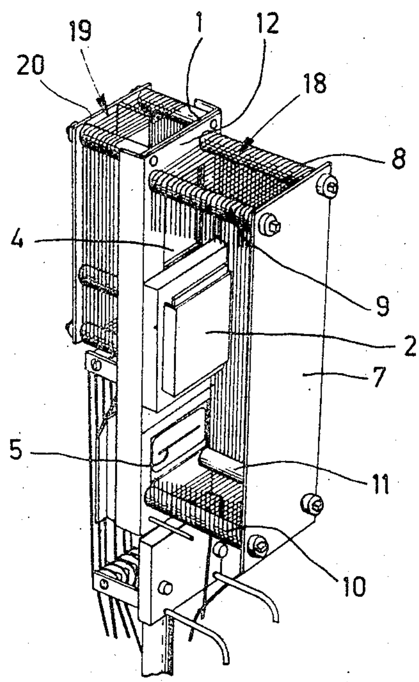

FIG.1

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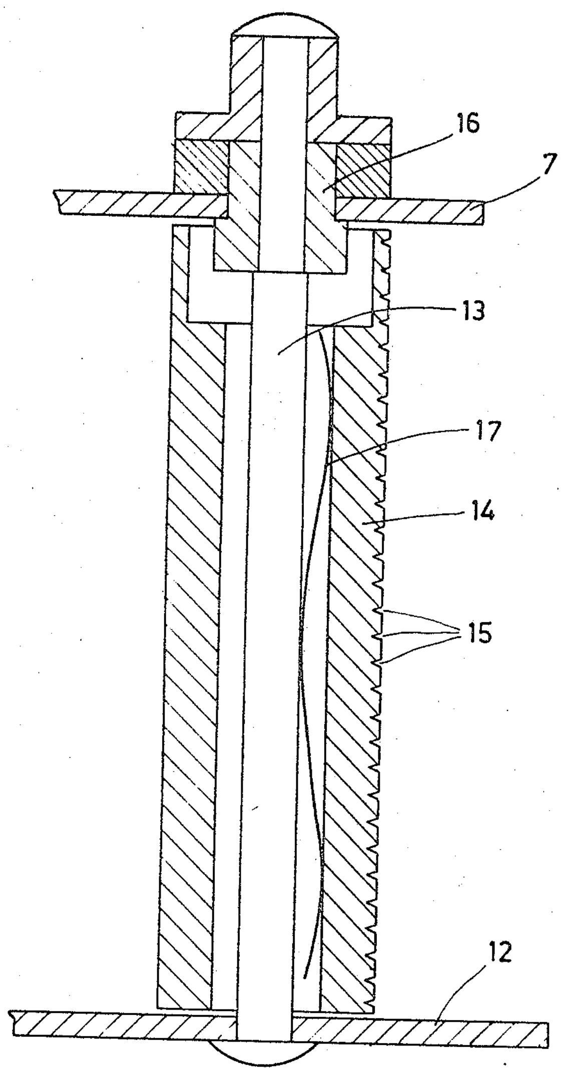

FIG.2

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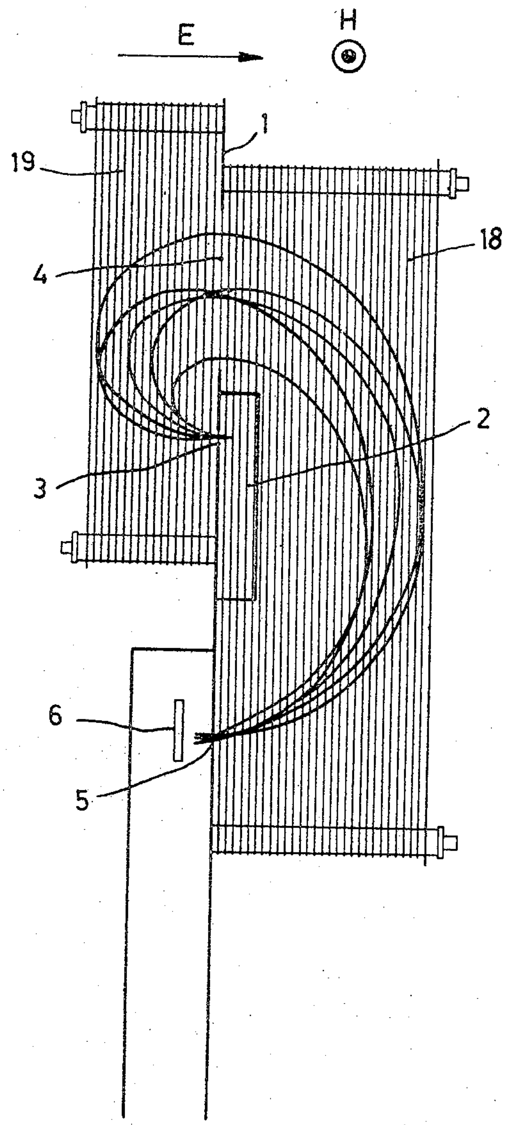

FIG.3

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CYCLOIDAL MASS SPECTROMETER EMPLOYING CROSSED UNIFORM MAGNETIC AND ELECTRIC FIELDS

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U.S. Cl. 250—41.9 5 Claims

Int. Cl. H01j *39/34;* B01d *59/44*

ABSTRACT OF THE DISCLOSURE

A cycloidal mass spectrometer employing crossed uniform magnetic and electric fields in which ions cover cycloidal paths, the electric field being produced by a high resistance wire wound around a region in which ions cover their paths, a potential difference being applied to the ends of the wire.

The present invention relates to a mass spectrometer, more particularly to a so-called cycloidal mass spectrometer, in which ions leave an ion source through a gap and cover cycloidal paths in crossed uniform electric and magnetic fields and finally reach a collecting electrode through a gap.

In the known cycloidal mass spectrometers, the uniform electric field is obtained by providing a plurality of parallel flat plates each applied to a fixed voltage and provided with apertures for passing the ions.

In these mass spectrometers, it is extremely difficult to attain and maintain the high-vacuum required for a satisfactory operation. Due to the flat metal plates constituting large trapped surfaces, it is difficult to achieve a sufficient outgassing even if a prolonged baking-out process is carried out at 450° C. Moreover, each plate requires a separate electrical connection through the vacuum envelope.

The object of the invention is to provide an improvement of cycloidal mass spectrometers obtained by a novel structure for producing the uniform electric field in a mass spectrometer which permits readily outgassing of the spectrometer.

In a cycloidal mass spectrometer, the uniform electric field is produced according to the invention by means of a wire which is helically wound around a region in which the ions cover their paths, voltage difference being applied between the ends of this wire.

The overall electric field can be produced by means of more than one wire helix, for example, by means of two wire helices each located on one side of a central plate. In a favorable embodiment of the invention, the wire of each helix is wound around posts having a metal core surrounded by a ceramic sleeve. Adjacent at least one of these posts, a leaf spring lying between the core and the sleeve pushes the sleeve towards the outer side of the wire helix. Thus, the wire is stretched and slackening of the wire due to heat developed by the resistance of the wire is neutralized.

Use may be made, for example, of four posts arranged as the ribs of a rectangular parallelepipedon.

A cycloidal mass spectrometer having one or more wire helices by means of which the electric field is produced may be readily outgassed and requires a minimum number of electrical connections for producing the electric field.

The invention will now be described more fully with reference to the accompanying drawing, in which:

FIG. 1 is a perspective view of part of a mass spectrometer,

FIG. 2 is a sectional view of one of the posts around which the wire helix is wound,

FIG. 3 is a schematic sectional view of FIG. 1 taken on the axis of the wire helix and at right angles to the magnetic field in which a few ion paths are outlined.

The structure shown in FIG. 1 is mounted on a flange and is located within a vacuum envelope consisting of a tube of stainless steel. The flange, the vacuum envelope and various electrical connections are not shown in the figure, since these form no part of the invention.

The structure includes a central plate **1**, which supports the ion source **2** having a gap (**3**, FIG. 3) in its side (not shown in FIG. 1) from which the ions emanate. The ion beam can reach through an aperture **4** in the central plate **1** and through a gap **5** the collecting electrode (**6**, FIG. 3) behind the gap **5**. A plate **7** is secured by four posts **8**, **9**, **10** and **11** to a detachable frame **12** clamped to the plate **1**. Since **12** is detachable, the ion source is readily accessible.

In FIG. 2, one of the posts is shown on an enlarged scale. This post consists of a metal core **13** and a ceramic sleeve **14** provided with notches **15**. **16** serves for spacing purposes. The core **13** is bolted to the plate **7** and the frame **12** but the sleeve is capable of performing a rotation and a limited translation. The sleeve **14** is spaced apart from the core **13** by a leaf spring **17**. Two diagonally opposite posts are constructed in this manner. The other pair of posts each consist of a metal core, a ceramic sleeve serving the purpose of **16** and the outer sleeve with notches which is not capable of performing a translation. A wire having a diameter of 0.025 mm. and a resistance of 2200 Ω/m. is wound around the four posts **8**, **9**, **10** and **11**. In FIG. 1, this wire helix **18** is partly broken away for the sake of clarity. The wire extends through the notches spaced apart by 0.5 mm. The expansion coefficient of the wire is equal to that of the plate **7** and of the frame **12** so that the wire is not displaced during outgassing. Slackening of the wire due to the heat developed by its resistance is counteracted by the leaf springs. This structure is capable of withstanding electric fields of 10^4 v./m. The ceramic sleeves are coated with a thin layer of tin oxide having a resistance of the order of 10^6 Ω/per square, which value is sufficiently high to prevent the potential distribution established by the wire from being disturbed and sufficiently low to prevent surface charge from being concentrated on the insulators.

FIG. 1 shows a second wire helix **19**. This helix is mounted between the plate **20** and the plate **1** like the first wire helix between the plate **5** and the plate **1**. The beginning of the first wire helix is connected to the plate **5** having a negative potential. The end of the first helix and the beginning of the second helix are connected to the earthed plate **1**. The end of the second helix is connected to the plate **20** having a positive voltage. Thus, only three electrical connections through the vacuum envelope are required for producing a uniform electric field having a direction parallel to the axis of the helices. Moreover, uniformity deviations may be compensated for to a certain extent, since the plate **7** is adjustable independently of the earthed frame **12**.

FIG. 3 is a schematic sectional view of FIG. 1 taken on the axis of the turns and at right angles to the magnetic field. The figure indicates the direction of the magnetic field H of the order of 2,000 gauss and that of the electric field E and outlines a few paths of ions focussed in the gap **5** before the collecting electrode **6**.

What is claimed is:

1. A cycloidal mass spectrometer employing substantially perpendicular magnetic and electric fields comprising an ion source, a collector electrode for ions leaving

said source, means for producing substantially perpendicular magnetic and electric fields in which ions from said source cover cycloidal paths before reaching the collector electrode, said electric field means comprising a high resistance wire helically wound around a region in which ions cover their paths, said helically wound wire producing a uniform electric field in a direction parallel to the axis of the helically wound wire when a potential is applied between the ends of the wire, said helically wound wire being wound about posts, having ceramic sleeves, at least one of which is spring loaded away from the center of the helix to take up wire slack caused by ohmic heating during operation of the spectrometer, and means to apply a potential difference between the ends of said wire to produce an electric field.

2. A mass spectrometer as claimed in claim **1** in which the overall electric field is produced by more than one wire helix.

3. A mass spectrometer as claimed in claim **2**, in which the overall electric field is produced by two wire helices each located on opposite sides of a central plate having an aperture through which said ions travel.

4. A mass spectrometer as claimed in claim **3**, in which each wire helix is wound around four posts arranged like ribs of a rectangular parallelepipedon.

5. A mass spectrometer as claimed in claim **3**, in which the ceramic sleeve of each post is provided with notches which hold the wire in place and is coated with a thin layer of tin oxide.

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