United States Patent [19]

Ball

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[54] **MASS SPECTROMETERS**

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[52] **U.S. Cl** **250/294**

[51] **Int. Cl.** **H01j 39/34**

[58] **Field of Search** ..... 250/41.9 DS; 117/201

[56] **References Cited**

UNITED STATES PATENTS

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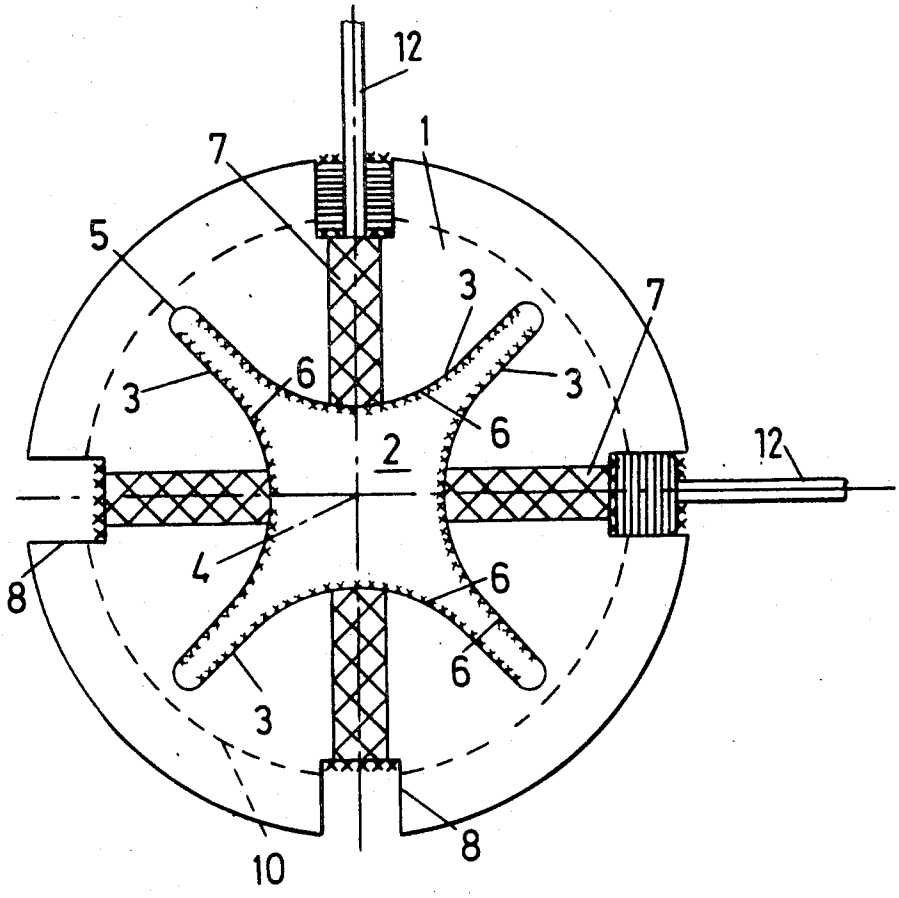
[57] **ABSTRACT**

A mass spectrometer having an ion filter comprising a cylindrical ceramic body with an axial passage. The sides of the passage are four hyperbolic surfaces the axial edges of adjacent hyperbolic surfaces being joined. A metallic plating is formed on each hyperbolic surface but is not connected electrically to the platings on the adjacent hyperbolic surfaces. The ends of each plating are connected as are opposite platings.

13 Claims, 4 Drawing Figures



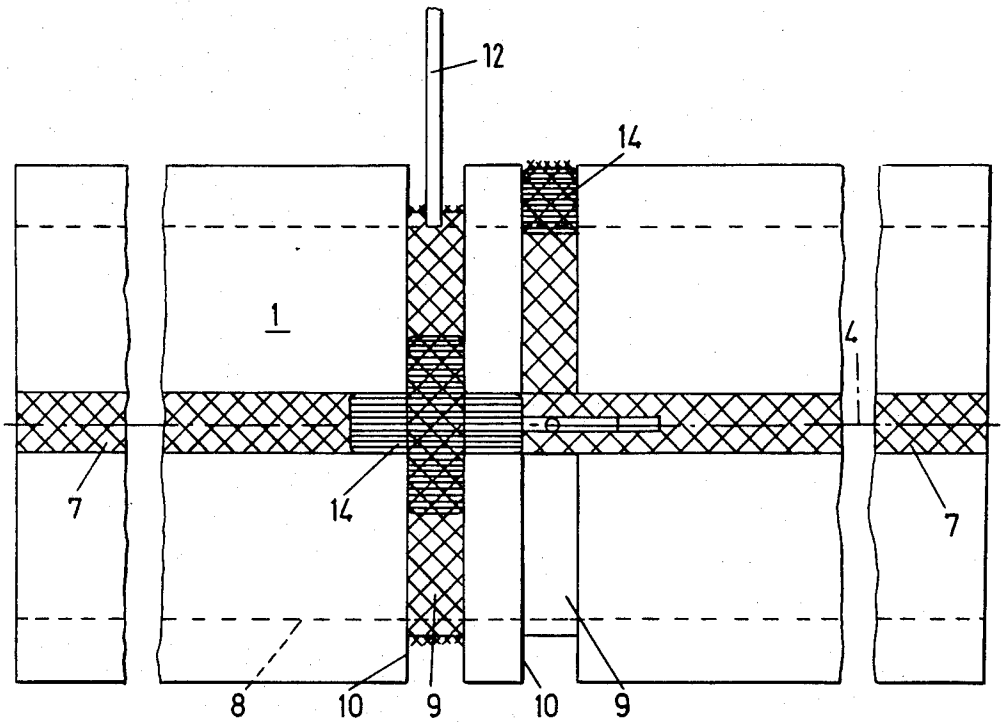


FIG.1

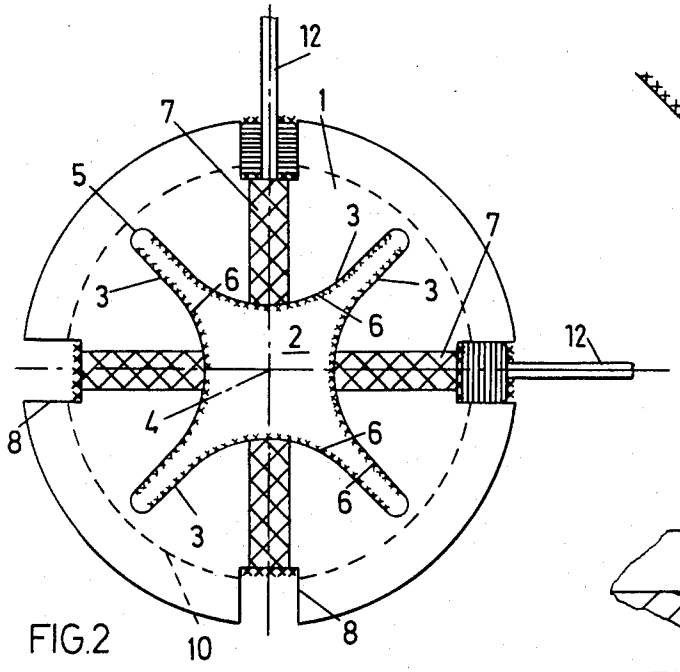


FIG.2

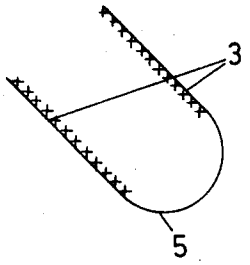


FIG.3

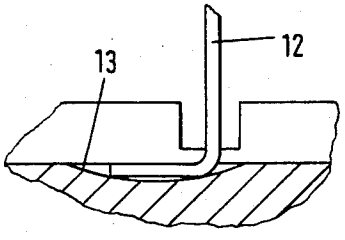


FIG.4

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MASS SPECTROMETERS

This invention relates to mass spectrometers.

A mass spectrometer comprises an ion source, an ion filter, and an ion detector; gas at low pressure to be analysed is introduced into the ion source which ionises the gas into ions which are then selected by the ion filter and passed to the ion detector. The ion filter selects ions having a particular *e/m* ratio which may be varied to analyse the gas.

It is an object of this invention to provide a mass spectrometer having an improved ion filter.

According to this invention there is provided a mass spectrometer having an ion filter comprising a cylindrical ceramic body having an axial passage, the sides of the passage being defined by four hyperbolic surfaces symmetrically disposed with respect to the axis of the ceramic body, the axially extending edges of each pair of adjacent hyperbolic surfaces being joined, each hyperbolic surface being plated with a metallic material which is not electrically connected to the platings of the adjacent hyperbolic surfaces.

Preferably the ends of each plating are joined by a metallic strip which extends from one edge of the corresponding hyperbolic surface at one end of the passage along the corresponding end of the cylindrical body, along the external surface of the cylindrical body and along the other end of the cylindrical body to the other edge of that hyperbolic surface.

Preferably each metallic strip is disposed in an axially extending groove which extends along the external surface of the cylindrical body.

Preferably opposite metallic strips are connected by metallic strips disposed in annular grooves.

Preferably each metallic strip is an annular groove extends over but is insulated from at least one of the other two axially extending metallic strips by ceramic material disposed in the annular groove on top of that axially extending metallic strip.

An embodiment of this invention will now be described, by way of example only, with reference to the accompanying drawings of which:

FIG. 1 is a plan view of parts of an ion filter in accordance with this invention;

FIG. 2 is an end view in the ion filter shown in FIG. 1;

FIG. 3 is an enlarged fragmentary view of part of the end view shown in FIG. 2; and

FIG. 4 is an enlarged fragmentary sectional view.

The ion filter of which a part is shown in the drawings is intended to be incorporated in a mass spectrometer.

The ion filter is in three sections a pre-filter, a central filter, and a post-filter RF alone is applied to the pre-filter and the post-filter whereas RF and DC are applied to the central filter. If the pre-filter and post-filter were not provided end effects at the entry and exit of the central filter would tend to reject ions having the required *e/m* ratio. The pre-filter tends to attract all ions into the central filter and the central filter rejects all ions other than those having the required *e/m* ratio. The post-filter allows all ions to leave the central filter and were it not to be provided some ions having the required *e/m* ratio would not leave the central filter.

Each of the three filter sections has a cylindrical body but the main filter is considerably longer and it is the main filter which will be described. In other respects the three filters are identical.

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The filter shown in the drawings comprises a cylindrical body of high (e.g. 98 percent) alumina ceramic having an axial passage **2**. The axial passage **2** is bounded by four symmetrically disposed surfaces **3** which are hyperbolic with respect to the axis **4** of the body. The adjacent elongated edges of each adjacent pair of surfaces **4** are joined by a surface **5** (FIG. **3**) which is semicircular in end-view.

Each elongated surface **3** is formed with a gold plating **6** which is not in electrical contact with the gold platings **6** on the adjacent surfaces **3.** The axial ends of each gold plating **6** are joined by a gold plating strip **7** which extends from the end of the plating **6** at the axial end of the corresponding surface **3** along one axial end of the cylindrical body **1,** along a groove **8** in the external cylindrical surface of the cylindrical body **1,** and along the other end of the cylindrical body **1** to the other axial end of the plating **6.** The four gold strips **7** and the four grooves **8** are, of course, at right angles to each other in the end view shown in FIG. **2.** Between each pair of adjacent strips **7** on the external surface of the body **1** an axial extending groove **8** is formed. Opposite plates **6** are connected to each other by gold strips **9** in circular grooves **10** which are not as deep as the grooves **8.** Each gold strip **9** extends through half its groove **10** to join the two strips **7** it is intended to connect although not clearly shown, the two gold strips **9** being offset in relation to each other by 90°. Each groove **10** does cross one groove **8** where there is no connection required between the strip **9** and the strip **7.** The strips **7** are formed first and, at these two points, frit pads **14** of glass and ceramic are fired in situ. Subsequently the strips **9** are formed and, at these two points, extend over the first pads **14** so as to be insulated from the strips **7.** An electrical connection has to be made to each pair of opposed platings **6** and this is done by inserting the end of a wire **12** (FIG. **4**) in recess **13** in either groove **8** or in the connecting groove **10**; the end of the wire **12** is covered with gold.

In production the body is extruded oversize with its recess **2** and is hydrostatically pressed in a machine tool. The channels **8** and **10** are then machined and subsequently the body **1** is fired in a gradient temperature controlled tunnel kiln to give a steady shrinkage without distortion or cracking. The gold strips **7** and **9** are painted on or vacuum deposited and and then fired into the ceramic before the gold platings **6** are formed by painting or vacuum deposition.

The filter shown and the pre- and post-filters are mounted within a housing so as to be coaxial with only short distances between the pre-filter and the filter shown and between the filter shown and the post-filter.

I claim:

1. A mass spectrometer having an ion filter comprising a cylindrical ceramic body having an axial passage, said body having at the passage four hyperbolic surfaces symmetrically disposed with respect to the axis of the ceramic body, the axially extending edges of each pair of adjacent hyperbolic surfaces of the ceramic body being joined, each hyperbolic surface of the ceramic body being plated with a metallic material which is not electrically connected to the platings of the adjacent hyperbolic surfaces.

2. A mass spectrometer as claimed in claim **1** wherein the ends of each plating are joined by a metallic strip which extends from one edge of the corresponding hyperbolic surface of the ceramic body at one end of the

passage along the corresponding end of the cylindrical ceramic body, along the external surface of the cylindrical ceramic body and along the other end of the cylindrical ceramic body to the other edge of that hyperbolic surface of the ceramic body.

3. A mass spectrometer as in claim 1, further comprising electrical means connected to said plated materials for applying ion-filtering voltages to said materials.

4. A mass spectrometer having an ion filter comprising a cylindrical ceramic body having an axial passage, said body having at the sides of the passage at least one convex hyperbolic ceramic surface which is plated with a metallic material which is not electrically connected to any other platings on the ceramic surfaces within the passage.

5. A mass spectrometer as claimed in claim 4 wherein the ends of the plating are joined by a metallic strip which extends from one edge of the hyperbolic surface at one end of the passage along the corresponding end of the cylindrical body, along the external surface of the cylindrical body and along the other end of cylindrical body to the other edge of the hyperbolic surface.

6. A mass spectrometer as claimed in claim 4 wherein the ceramic body is produced by extrusion and is then compressed and fired.

7. A mass spectrometer as in claim 4, further comprising electrical means connected to said plated metallic material on said hyperbolic surface of said ceramic body for applying ion-filtering voltages to said plated material.

8. A mass spectrometer as claimed in claim 4 wherein the ceramic body includes a plurality of hyperbolic surfaces along the axial passage, the number of hyperbolic ceramic surfaces being divisible by four, each of the hyperbolic surfaces being plated with a metallic material which is electrically insulated from other platings within the passage, and the hyperbolic surfaces being symmetrically disposed with respect to the axis of the ceramic body, the axially extending edges of each pair of adjacent hyperbolic surfaces being joined.

9. A mass spectrometer as in claim 8, wherein said electrical means are connected to each of the plated metallic materials on each of said hyperbolic surfaces of said ceramic body for applying ion-filtering voltages to each of the materials upon each of the hyperbolic surfaces.

10. A mass spectrometer as claimed in claim 8 wherein the ends of each plating are joined by a metallic strip which extends from one edge of the hyperbolic surface at one end of the passage along the corresponding end of the cylindrical body, along the external surface of the cylindrical body and along the other end of cylindrical body to the other edge of the hyperbolic surface.

11. A mass spectrometer as claimed in claim 10 wherein each metallic strip is disposed in an axially extending groove which extends along the external surface of the cylindrical body.

12. A mass spectrometer as claimed in claim 11 wherein opposite metallic strips are connected by metallic strips disposed in annular grooves.

13. A mass spectrometer as claimed in claim 12 wherein each metallic strip in an annular groove extends over but is insulated from at least one of the other two axially extending metallic strips by ceramic material disposed in the annular groove on top of that axially extending metallic strip.

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