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Brunnee et al.

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[54] DEVICE FOR CONTROLLING THE SLIT WIDTH OF ADJUSTABLE SLIT ELECTRODES IN MASS SPECTROMETERS

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

[58] **Field of Search** ..... 250/41.9 S, 41.9 G, 41.9 D; 315/5.23

[56] **References Cited**

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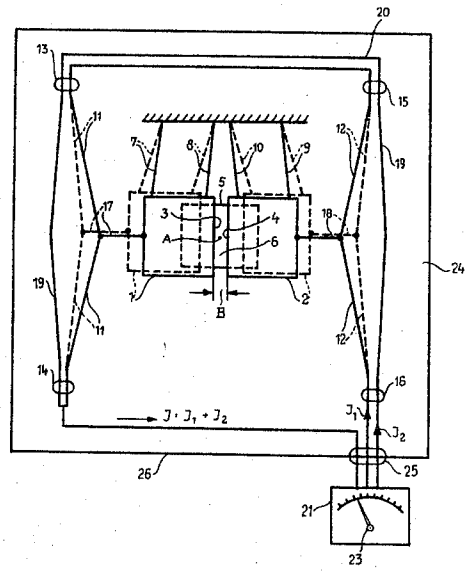
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Assistant Examiner—C. E. Church
Attorney—Wolf, Greenfield & Sacks

[57] **ABSTRACT**

The slit width defined by a pair of slit electrodes in a mass spectrometer is controlled by means of a pair of hot wires, one being coupled to each slit electrode. Each wire extends about two spaced supporting elements and a tensile bar is used to couple a midpoint of each hot wire to its respective electrode. A temperature control arrangement is also used and includes a heating wire coupled to all supporting elements to maintain the temperature of the supporting elements constant as the current in the hot wires is changed to vary the slit width. This type of operation is provided by connecting both the hot wires and heating wire to an electrical regulating device that maintains the sum of the currents in these wires at a constant value.

5 Claims, 2 Drawing Figures



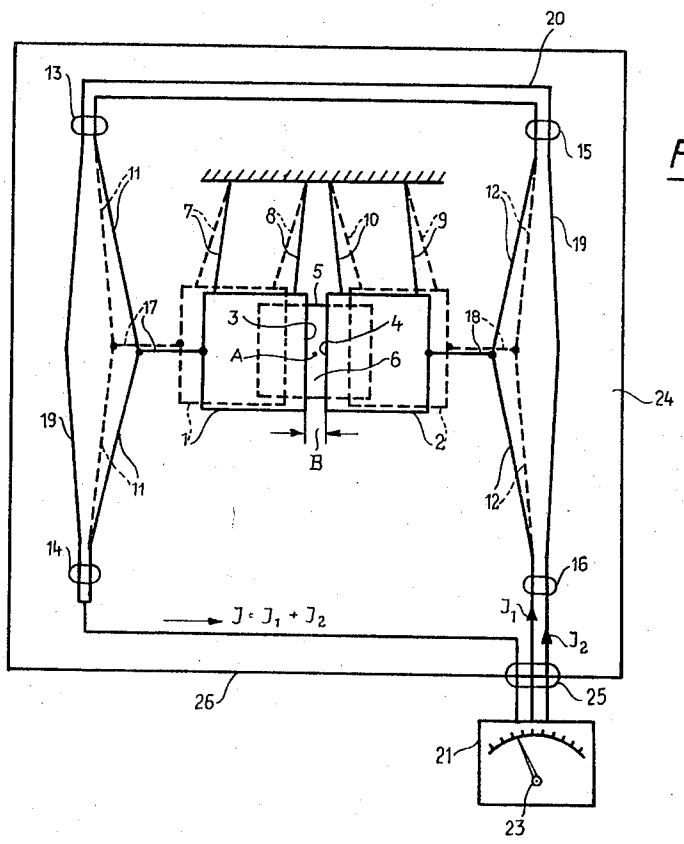

20
13
15
11
12
7
8
10
9
19
5
17
3
4
18
A
6
24
19
1
2
B
11
12
14
16
J = J1 + J2
J1
J2
26
25
21
23

Fig.1

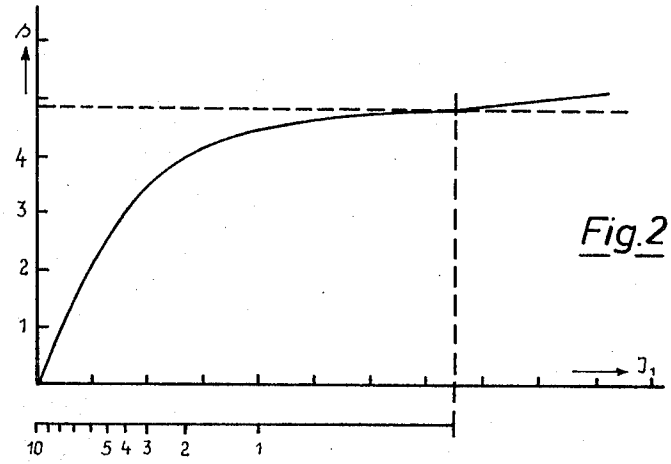

Δ
4
3
2
1
J1
10
5
4
3
2
1

Fig.2

DEVICE FOR CONTROLLING THE SLIT WIDTH OF ADJUSTABLE SLIT ELECTRODES IN MASS SPECTROMETERS

The invention relates to a device for controlling the slit width of adjustable slit electrodes in mass spectrometers by means of an adjusting part.

BACKGROUND OF THE INVENTION

In known devices of this kind the adjusting part is connected to a sliding gear or traversing gear. This construction is expensive and complicated and is unfit for obtaining the desired accuracy of adjustment. A motion of the adjusting part from outside necessitates a transmission of motion from outside to inside of the vaccuum chamber.

OBJECT OF THE INVENTION

It is an object of the invention to provide a device which has a simple contruction and simultaneously affords a high accuracy of adjustment and in which all movable parts may be enclosed within the vaccuum chamber so that transmissions of motion from outside to inside of the vaccuum chamber are unnecessary.

SUMMARY OF THE INVENTION

The foregoing problem has been solved by providing an adjusting part that consists of a hot wire with an adjustable heating means which hot wire, for transmission of its temperature-dependent length, is coupled to the slit electrode. It appeared that the forces of expansion of such a hot wire are sufficient to effect an accurate adjustment of the slit width by using a suspension of the slit electrode which moves easily.

Using a hot wire for adjustment of the slit width has the important advantage of low inertia so that not only high accuracy but a high velocity of adjustment is possible because the temperature and therewith the length of the hot wire will follow variations of the heating current almost inertialessly.

An exceptional high sensitivity combined with low inertia may be obtained by designing the system including the slit electrode and the adjusting part like a hot-wire instrument in which the adjusting part extends from a first to a second supporting element of its support and at its centre point is connected to the slit electrode in such a manner that the hot wire is continuously stretched in V-form by a retracting spring connected to the slit electrode.

A thermostatic arrangement may be provided for temperature control of the two supporting elements in order to avoid unintentional adjustments and therewith adjustment abberations by a change in temperature of the two supporting elements. For this purpose the supporting elements may be connected with a special heating wire through which a heating current is driven which heating current compensates for the variations of heating of the two supporting elements caused by the control current flowing through the hot wire.

Accurate thermostatics may be obtained by connecting the heating wire and the hot wire to the supporting elements adjacent to one another in a pyrometric equivalent manner and connecting them to a regulating device for maintaining constant the sum of said control current and said heating current.

A high accuracy of adjustment of small slit widths may be obtained in that the hot wire is coupled to the slit electrode in such a manner that the slit width will decrease with increasing temperature.

Preferably the slit electrode together with the hot wire, its supports and all other parts belonging to the device for controlling the slit width, which parts are located within the vaccuum chamber are adjustable by turning round an axis which is orthogonal to the plane of the slit.

BRIEF DESCRIPTION OF THE DRAWINGS

The drawing shows a preferred embodiment of the invention which is given by way of example.

In the drawing

FIG. 1 is a device for controlling the slit width of an adjustable slit electrode in the vaccuum chamber of a mass spectrometer,

FIG. 2 shows the characteristic of regulation of the device shown in FIG. 1.

FIG. 1 shows a slit electrode consisting of two symmetric halves 1,2 made of rectangular sheets of metal the adjacent edges 3 and 4 of which are parallel to one another and define a slit for passage of ions as is for instance arranged at the exit side of a sector field analyzer in front of a collector electrode 6. Such a slit also could be arranged at the entrace of said sector field analyzer.

In the drawing the slit width is shown enlarge. Practically, the slit width will amount only to a small fraction of the active slit length. Especially with extremely small slit widths of for instance 10 μ it is important to guarantee a high accuracy of adjustment of slit width. Therefore it is important too, to guarantee an accurate parallelism over all adjustable widths. If the slit as may be desired in mass spectrometers shall be turned round an axis A which is vertical to the plane of the slit, this may be performed by the whole device located totally within the vaccuum chamber 24 being turned around the axis A, and the electric connection to the outside arranged power supply is formed by a flexible cable.

The two halves 1,2 of the slit electrode are shiftable parallel to one another and for this purpose are supported by parallel leaf springs 7, 8 and 9,10 respectively which are arranged transversely to the direction of adjusting movement of the slit electrode.

The adjusting part for the two halves 1,2 of the slit electrode consists of a hot-wire 11 and 12 for each half. Said hot wires 11 and 12 are expanded between fixed support elements 13,14 and 15,16 respectively and a tensile bar 17, 18 one end of which is connected to the centre point of the corresponding hot wire whereas the other end is connected to the corresponding half 1,2. The leaf springs 7,8 and 9,10 are prestressed in such a manner that a tension is transmitted continuously by the tensile bars 17,18 to the hot wires 11,12 in the direction of a diminution of the slit width as is indicated by the arrows in FIG. 1.

The mounting of hot wires 11,12 consisting of the supporting elements 13,14,15,16 is constantly kept at an even temperature in order to avoid movements of the hot wire by thermal expansion of the supporting elements. To this end each of the supporting elements is connected to a heating wire 19 through which a compensating current J_2 is driven which compensates for the variations of heating of the support element by the slit width adjusting current J_1 flowing through the hot wires 11,12. This heating wire 19 for the four support elements of the hot wire mounting forms a continuous wire 20 which is connected to an electrical regulating device 21. The hot wires 11,12, too, form a continuous wire 22 connected to said regulating device 21. Hot wire and heating wire are layed side by side through the supporting elements so that they influence the temperature of the supporting elements in a pyrometric equivalent manner. This allows one to keep the temperature of the supporting elements constant since the sum $J = J_1 + J_2$ of adjusting current J_1 and compensating current J_2 is stabilized. This is a simple means to stabilize very accurately the temperature of the supporting elements 13, 14, 15, 16.

The adjustment of the slit width is effected by variation of the adjusting current by an adjustment knob 23.

It is remarkable that the mounting of the two halves 1,2 of the slit electrode by the parallel leaf springs 7,8,9,10 will guarantee not only an accurate parallelism of the slit edges 3,4 but simultaneously will require only very small displacement forces and will give an adjustability which is practically free from hysteresis.

All movable parts of the described device are included in the vaccuum chamber 24 of the mass spectrometer so that merely a cable passage 25 through the wall 26 of the mass spectrometer is necessary for the connection to the regulating device 21 outside the vaccuum chamber 24.

The slit electrode together with the hot wire arrangement and the mounting of the slit electrode and the hot wire arrangement is turnable around an axis orthogonal to the plane of the flat halves 1,2, the cable connecting the device inside to the cable passage being sufficiently flexible to allow said rotating motion. Thereby an angular adjustment is possible the accuracy of which is not at all effected by the adjustment of the slit width and vice versa.

In the above described device the hot wire is coupled to the slit electrode in such a manner that the slit width will decrease with increasing temperature. Fig. 2 is shows the corresponding characteristic $s = f(J_1)$ in which s is the hub as a function of the adjusting current J_1. The course of this characteristic represents a curve the inclination of which is diminishing with growing adjusting current J_1. This course is conditioned not merely by the fact that the thermal radiation is increasing proportional to the cube of the current J_1 but besides is conditioned by the geometry of the device as is shown in FIG. 1. Thereby a scale $B = f(J_1)$ is obtained as is shown in FIG. 2.

It will be understood that other applications of the invention are possible and the embodiment disclosed may be subjected to various changes, modifications and substitutions without necessarily departing from the spirit of the invention. Thus, the adjustment of the slit width could be effected also by moving only one of the two electrode-halves 1 or 2 whereas the other half is unmovable. The device according to the invention may also be useful in connection with apparatuses other than mass spectrometers e.g., optical apparatuses and with slit electrodes which are adjustable not by parallel movement but by any other kind of movement e.g., moving it like a barn-door. The degree of curvature may be made larger than is shown in Fig. 2 in order to obtain a still higher accuracy of adjustment of little slit widths.

We claim:

1. In a device for controlling the slit width of mass spectrometer adjustable slit electrodes having:

resilient means coupled to at least one of the slit electrodes for biasing the slit electrode in one direction;

a heat conductive control wire;

spaced supporting means for fixedly supporting the control wire at at least two points;

means intercoupling the control wire and slit electrode;

and adjustable heating means coupled to the control wire for supplying control current to the wire to thereby cause the slit width to vary;

the improvement comprising;

a temperature stabilizing wire capable of carrying compensating current coupled from the adjustable heating means to the spaced supporting means for maintaining the spaced supporting means at a relatively constant temperature.

2. A device as defined in claim 1 wherein the adjustable heating means provides current for both the control wire and the temperature stabilizing wire,

the current in the temperature stabilizing wire compensating for the variation of heating of the spaced supporting means caused by the control current flowing through the control wire.

3. A device as defined in claim 2 wherein the control wire and the temperature stabilizing wire are connected to the supporting means adjacent to one another,

and wherein both wires are connected to the adjustable heating means which maintains the sum of the control current and the compensating current at a constant value.

4. A device as defined in claim 1 including parallel leaf springs for supporting the slit electrode and which are arranged transversely to the direction of adjusting movement of the slit electrode.

5. A device for controlling the slit width of mass spectrometer adjustable slit electrodes comprising:

resilient means coupled to at least one of the slit electrodes for biasing the slit electrode in one direction;

a heat conductive wire coupled to said slit electrode;

spaced supporting means for fixedly supporting the control wire at at least two points;

adjustable heating means coupled to the control wire for supplying control current to the wire to thereby cause the slit width to vary; and

a temperature stabilizing means operable for maintaining the spaced supporting means at a relatively constant temperature,

said temperature stabilizing means including means connected to said spaced supporting means for transferring heat to said spaced supporting means.

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