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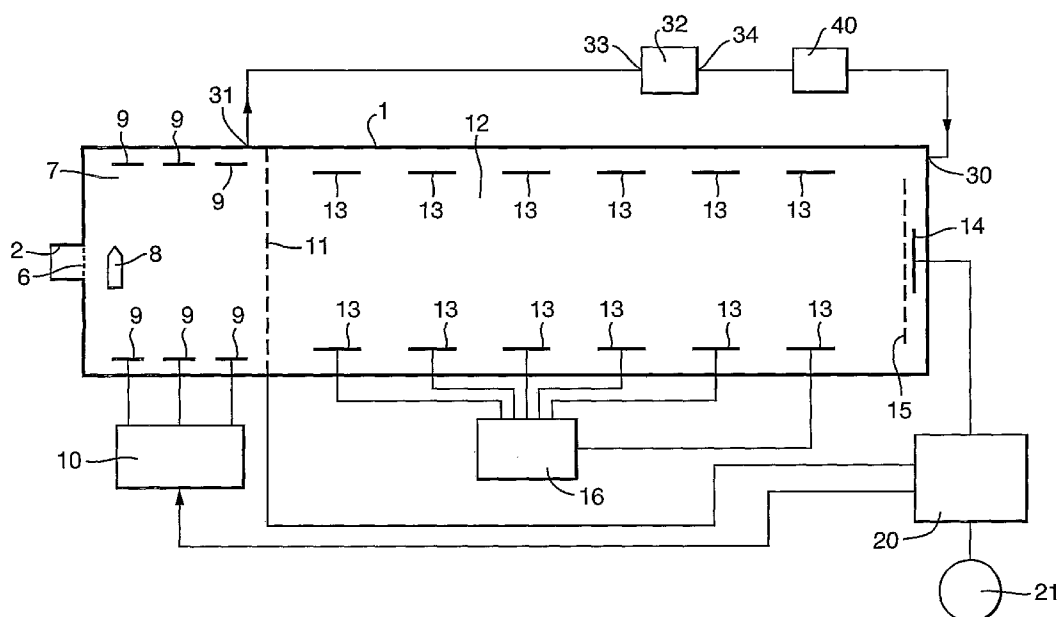
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- as to applicant's entitlement to apply for and be granted a patent (Rule 4.17(ii))
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(54) Title: SPECTROMETER APPARATUS



(57) Abstract: An ion mobility spectrometer has several electrodes (9) spaced along its ion source region (7). Voltages are applied to the electrodes (9) to produce a voltage gradient along the length of the ion source region (7). By varying the voltage gradient, the residence time of ions in the ion source region (7) can be selectively varied. Typically, the spectrometer is arranged to reduce the residence time in response to a decrease in the amplitude, of an ion peak detected at the far end of the drift region (12).

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SPECTROMETER APPARATUS

This invention relates to spectrometer apparatus of the kind having an ion source region arranged to provide ions to an analyser region.

Ion mobility spectrometers or IMS apparatus and FAIMS or DMS apparatus are often used to detect substances such as explosives, drugs, blister and nerve agents or the like. An IMS apparatus typically includes a detector cell to which a sample of air containing a suspected substance or analyte is supplied as a gas or vapour. The cell operates at or near atmospheric pressure and contains electrodes energized to produce a voltage gradient along the cell. Molecules in the sample of air are ionized, such as by means of a radioactive source, UV source or by corona discharge, and are admitted into the drift region of the cell by an electrostatic gate at one end. The ionized molecules drift to the opposite end of the cell at a speed dependent on the size of the ion. By measuring the time of flight along the cell it is possible to identify the ion. A FAIMS apparatus employs a transverse asymmetric field to filter ions.

Examples of IMS apparatus are described in GB 2324407, GB 2324875, GB2316490, GB2323165, US 4551624, US6459079, WO2004/102611 and US 6495824.

In some cases the sensitivity of such apparatus may not be sufficient for reliable detection. Also, the range of analyte concentrations over which a spectrometer apparatus can respond accurately is limited. Depletion of the charge on the reactant ion within the ion source region can cause the apparatus to saturate; this makes it difficult accurately to estimate analyte concentration.

It is an object of the present invention to provide alternative spectrometer apparatus.

According to one aspect of the present invention there is provided spectrometer apparatus of the above-specified kind, characterised in that the apparatus is arranged selectively to vary the residence time of ions within the ion source region.

The apparatus may include an arrangement for establishing a voltage gradient in the ion source region, the variation in residence time being provided by varying the voltage gradient. The arrangement for establishing a voltage gradient preferably includes a plurality of electrodes spaced from one another along the ion source region. The apparatus may be arranged to vary the residence time in response to detection of ions, and may be arranged to reduce the residence time in response to an increase in amplitude of an ion peak and to increase residence time in response to a decrease in amplitude of the ion peak.

According to another aspect of the present invention there is provided spectrometer apparatus having an ion source region arranged to provide ions to an analyser region, characterised in that the apparatus includes an arrangement for applying a voltage gradient along the length of the ion source region and for varying the voltage gradient in response to detection of ions at the far end of the analyser region.

According to a further aspect of the present invention there is provided a method of identifying chemicals in an analyte substance including the steps of subjecting the analyte substance to ionisation for a selectively controlled and variable time, subsequently measuring the mobility of the ions of the analyte substance, and deriving an indication of the nature of the ions from their measured mobility.

IMS apparatus according to the present invention, will now be described, by way of example, with reference to the accompanying drawing, which shows the apparatus schematically.

The system includes an IMS drift cell 1 having an inlet port 2 by which sample air to be analysed is supplied to the apparatus. The port 2 opens into the left-hand end of the interior of the cell 1 via a selective barrier 6 such as a semi-permeable membrane, or of any other form that allows passage of the molecules of interest whilst excluding the majority of other molecules. Alternatively, the barrier 6 could be non-selective, such as a pinhole, as described in WO93/01485. Instead of a barrier, the sample to be analysed may be supplied to the cell 1 by some other interface, such as of the kind described in EP596978.

The barrier 6 communicates with an ion source region 7 including an ionisation source 8 such as a radiation source, UV source or a corona discharge. The ion source region 7 also includes means for producing an electric field directed generally axially of the cell 1. The field is provided by a number of electrodes 9 spaced from one another along the length of the ion source region 7 and connected with a voltage supply 10 in a manner to be described later. To the right of the ion source region 7, a gating grid 11, such as a Bradbury Nielson gate, controls passage of ionised molecules into an analyser region in the form of a drift region 12 formed by a series of drift electrodes 13 driven by a voltage source 16. A collector plate 14 behind a grid 15 at the far, right-hand end of the cell 1 collects ions passed through the drift region 12 and provides an output to a processor 20, which also controls the gate 11, the voltage supply 10 and various other functions of the system. The processor 20 provides an output to a display 21, or other utilisation means, indicative of the nature and concentration of the sample. Usually this is in the form of spectra of peaks of reactant ions of varying amplitudes and widths.

At its right-hand end, the cell 1 has an inlet 30, by which recirculated, cleaned, dried drift gas is supplied to the interior of the cell where it travels from right to left and flows out via an exhaust outlet 31 close to the gating grid 11 in the ion source region 7. Air is supplied to the inlet 30 by means of a pump 32 having an inlet 33 connected to the exhaust outlet 31 and an outlet 34 connected to a molecular sieve 40, which cleans and dries the air exhausted from the drift chamber 12.

The voltage supply 10 controls the voltage applied to the electrodes 9 in the ion source region 7 such as to produce a selectively variable voltage gradient or electric field along the ion source region. This controls the residence time of ions in the ion source region 7. In practice, when no analyte is detected by the collector plate 14, the voltage supply 10 controls the voltage gradient in the ion source region 7 to be a minimum value so that the ions spend a maximum time within the ion source region. In this way, there is a maximum chance of any analyte ions being ionised by the ion source 8. When the concentration of analyte increases, this causes a decrease in amplitude of the detected reactant ion peak because ionized analyte molecules have a greater chance of losing their charge as a result of collision with non-ionized molecules. The processor 20 signals the voltage supply 10 to increase the voltage gradient or

field within the ion source region 7 so that the ions move more quickly away from the ion source 8 to the gating grid 11 and their residence time in the ion source region is reduced. By reducing the residence time of ions in this region 7, there is less chance for the charge on ionized analyte molecules to be depleted by contact with non-ionized molecules, so a greater number of ionized molecules enter the drift chamber 12 and drift to the collector plate 14. This increases the amplitude of ion peaks. The processor 20 may be arranged to identify a particular ion peak of interest and to control the voltage supply 10 so that the field, and hence the residence time, is varied in response to change in amplitude of that peak. Alternatively, the apparatus may be arranged to vary the residence time in response to the amplitudes of a group of several peaks or an average over a part or all of the spectra. Information about the voltage gradient in the ion source region 7 is preferably used by the processor in determining the concentration of the analyte present, in addition to the reactant ions peak amplitudes.

There are other ways in which a voltage gradient could be established along the ion source region 7 without the need for separate electrodes 9. For example, a voltage could be applied between the ion source 8 and the gating grid 11.

The arrangement of the present invention helps to increase the sensitivity of IMS apparatus over an increased range of analyte concentrations, thereby improving its dynamic concentration range.

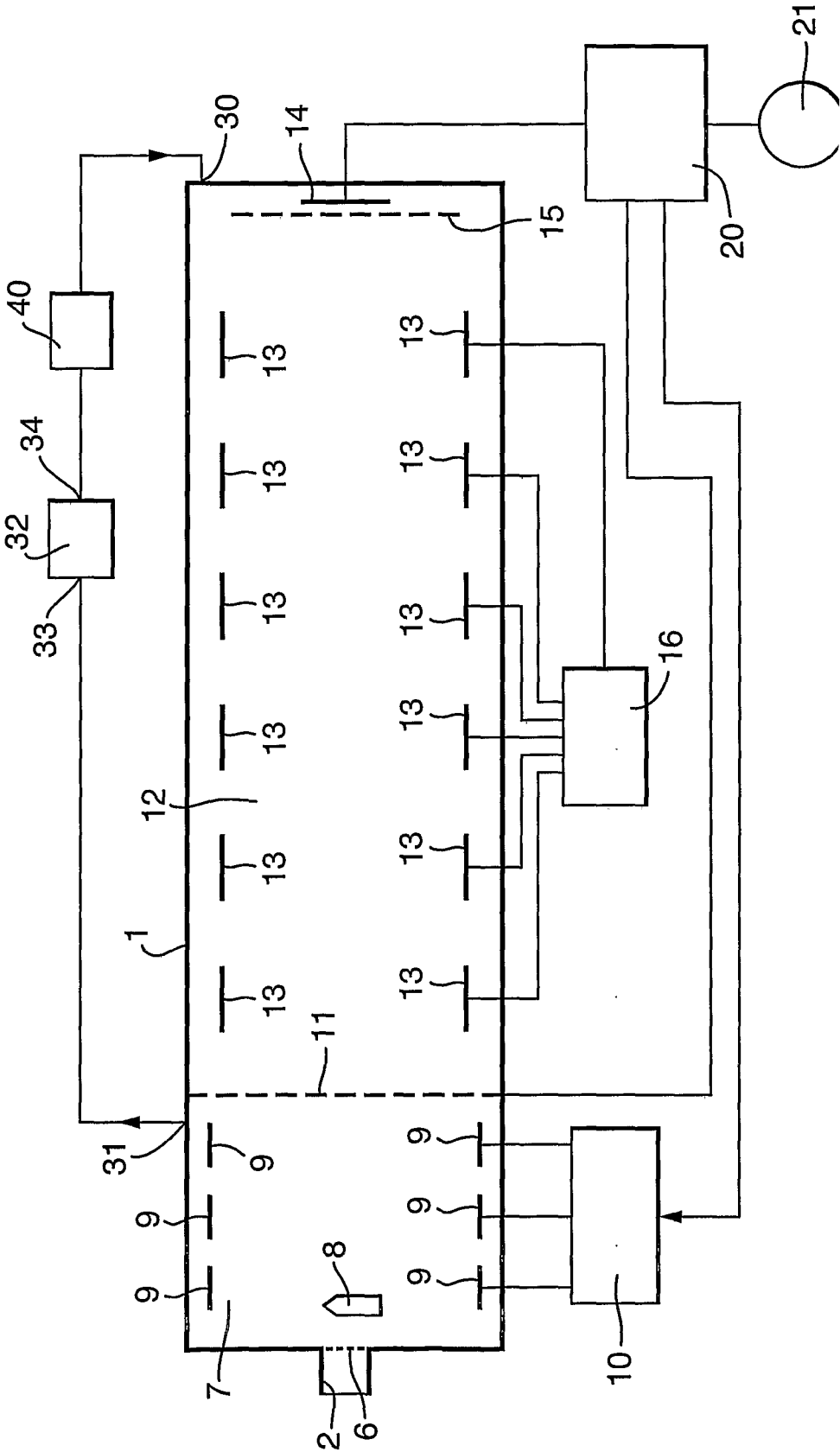
The invention is not confined to apparatus in which the residence time is varied by varying an electrical field since there are other ways in which the residence time can be varied selectively, such as by varying the effective length of the ion source region.

The invention is not confined to IMS apparatus but could be applied to other spectrometer apparatus such as FAIMS or DMS apparatus, such as described in PCT/GB2007/003597.

CLAIMS

1. Spectrometer apparatus having an ion source region (7) arranged to provide ions to an analyser region (12), characterised in that the apparatus is arranged selectively to vary the residence time of ions within the ion source region (7).
2. Spectrometer apparatus according to Claim 1, characterised in that the apparatus includes an arrangement (9) for establishing a voltage gradient in the ion source region (7) and that the variation in residence time is provided by varying the voltage gradient.
3. Spectrometer apparatus according to Claim 2, characterised in that the arrangement for establishing a voltage gradient includes a plurality of electrodes (9) spaced from one another along the ion source region (7).
4. Spectrometer apparatus according to any one of the preceding claims, characterised in that the apparatus is arranged to vary the residence time in response to detection of ions.
5. Spectrometer apparatus according to Claim 4, characterised in that the apparatus is arranged to reduce the residence time in response to an increase in amplitude of an ion peak and to increase residence time in response to a decrease in the amplitude of the ion peak.
6. Spectrometer apparatus having an ion source region (7) arranged to provide ions to an analyser region (12), characterised in that the apparatus includes an arrangement (9) for applying a voltage gradient along the length of the ion source region (7) and for varying the voltage gradient in response to detection of ions at the far end (14) of the analyser region (12).
7. A method of identifying chemicals in an analyte substance including the steps of subjecting the analyte substance to ionisation for a selectively controlled and variable

time, subsequently measuring the mobility of the ions of the analyte substance, and deriving an indication of the nature of the ions from their measured mobility.



INTERNATIONAL SEARCH REPORT

International application No
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A. CLASSIFICATION OF SUBJECT MATTER
INV. G01N27/64

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G01N

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/178975 A1 (GLUKHOY YURI [US]) 18 August 2005 (2005-08-18) paragraphs [0108], [0109]; figures 1,3-6 -----	1-3,7
X	US 3 461 285 A (WERNER HELMUT WILHELM WERNER) 12 August 1969 (1969-08-12) abstract column 2, lines 37-54 column 3, line 25 - column 4, line 45; figure 1 -----	1-3,7
Y	US 5 227 628 A (TURNER BRIAN R [GB]) 13 July 1993 (1993-07-13) abstract; figure 1 column 4, lines 10-48 ----- -/--	1-3,7

☒ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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- *G* document member of the same patent family

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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INTERNATIONAL SEARCH REPORT

Information on patent family members

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