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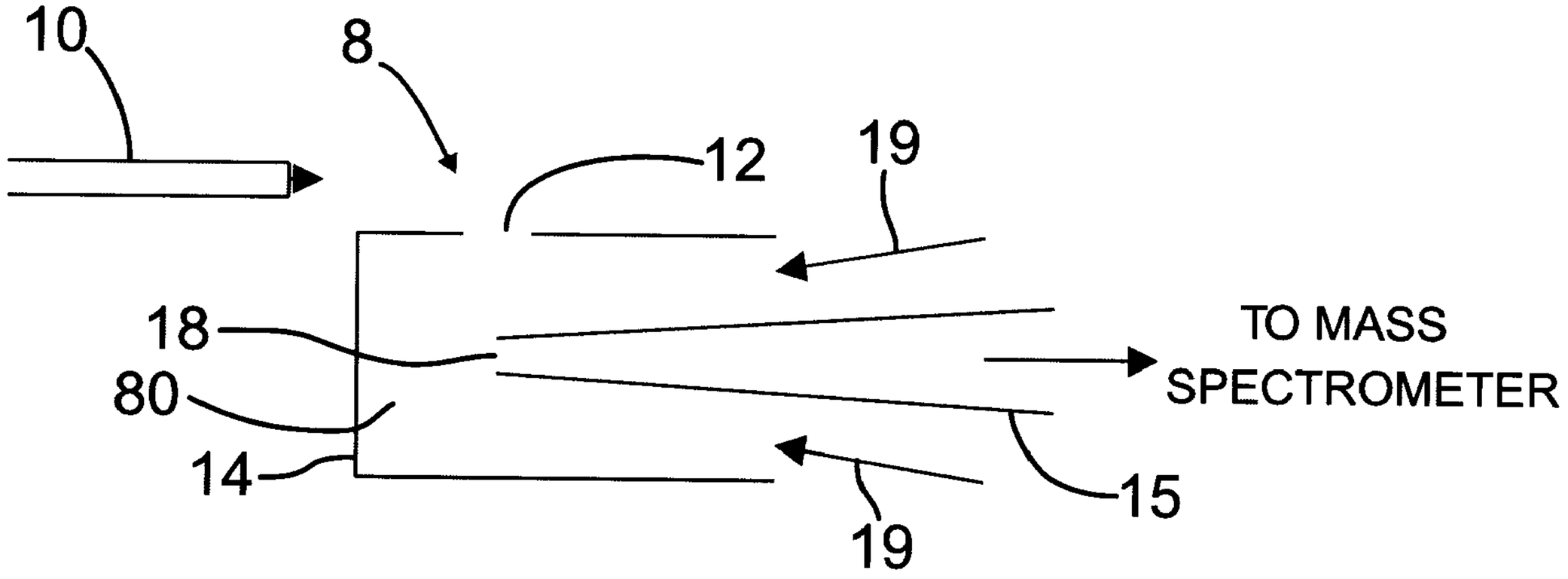
(54) Titre : INTERFACE DE SPECTROMETRE DE MASSE A HAUTE SENSIBILITE POUR SOURCES IONIQUES MULTIPLES

(54) Title: HIGH SENSITIVITY MASS SPECTROMETER INTERFACE FOR MULTIPLE ION SOURCES



(57) Abrégé/Abstract:
An interface for mass spectrometers. The interface uses non coaxial sampling pathways of the analyte ion beam prior to entering the entrance of a mass spectrometer for decreasing chemical background, and can be done in such a way as to permit multiple sprayers, increasing sample throughput and sensitivity for LC/MS (liquid chromatography/MS). The interface includes an ion source having an exit from which a beam of analyte ions are emitted, a curtain plate and an aperture in the curtain plate member, an orifice plate having an orifice therein. The orifice plate is being spaced from the curtain plate member defining a flow passageway therebetween, and the aperture in the orifice plate is aligned with a sample entrance to a first vacuum stage of a mass spectrometer maintained substantially lower than atmospheric pressure. The aperture in the curtain plate member is non coaxially aligned with the orifice in the orifice plate and the interface includes a gas flow mechanism for directing a counter flow gas into the flow passageway.

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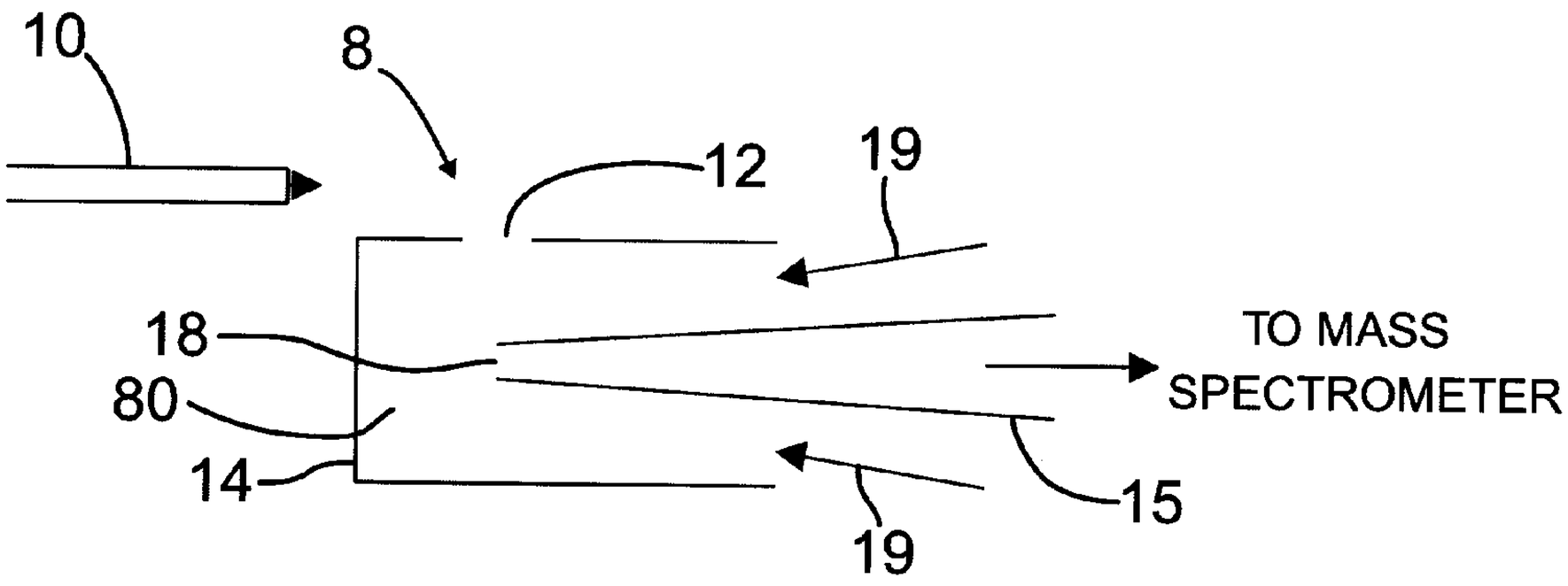
(54) **Title:** HIGH SENSITIVITY MASS SPECTROMETER INTERFACE FOR MULTIPLE ION SOURCES



(57) **Abstract:** An interface for mass spectrometers. The interface uses non coaxial sampling pathways of the analyte ion beam prior to entering the entrance of a mass spectrometer for decreasing chemical background, and can be done in such a way as to permit multiple sprayers, increasing sample throughput and sensitivity for LC/MS (liquid chromatography/MS). The interface includes an ion source having an exit from which a beam of analyte ions are emitted, a curtain plate and an aperture in the curtain plate member, an orifice plate having an orifice therein. The orifice plate is being spaced from the curtain plate member defining a flow passageway therebetween, and the aperture in the orifice plate is aligned with a sample entrance to a first vacuum stage of a mass spectrometer maintained substantially lower than atmospheric pressure. The aperture in the curtain plate member is non coaxially aligned with the orifice in the orifice plate and the interface includes a gas flow mechanism for directing a counter flow gas into the flow passageway.

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HIGH SENSITIVITY MASS SPECTROMETER INTERFACE FOR MULTIPLE ION SOURCES

CROSS REFERENCE TO RELATED U.S PATENT APPLICATION

This patent application relates to U.S. utility patent application Serial No. 60/758,202 filed on January 12, 2006 entitled HIGH SENSITIVITY MASS SPECTROMETER INTERFACE FOR MULTIPLE ION SOURCES, filed in English, which is incorporated herein in its entirety by reference.

FIELD OF THE INVENTION

The present invention relates to a method and apparatus for increasing throughput while minimizing intersource interference, increasing sensitivity and reducing chemical noise at the input to a mass spectrometer.

BACKGROUND OF THE INVENTION

Mass spectrometry (MS) is a well-known technique for obtaining a molecular weight and structural information on chemical compounds. According to mass spectrometry, molecules may be "weighed" by ionizing the molecules and measuring the response of their trajectories in a vacuum to electric and magnetic fields. Ions are “weighed” according to their mass-to-charge (m/z) values.

Atmospheric pressure ion sources (API) have become increasingly important as a means for generating ions used in mass spectrometers. Some common atmospheric pressure ion sources include Electrospray or nebulization assisted Electrospray (ES), Atmospheric Pressure Chemical Ionization (APCI), and Matrix Assisted Laser Desorption Ionization (MALDI). These ion sources produce charged particles, such as protonated molecular ions or adduct, from analyte species in solution or solid form, in a region which is approximately at atmospheric pressure.

Conventionally a single type source is used one at a time. However, it is sometimes preferable to use multiple ion sources simultaneously, for example to increase the number of samples analyzed per unit time, also know as throughput. Also, some analyte samples respond well to one approach, such as ESI, and others to another approach such as APCI, and it is desirable

to provide a simultaneous approach that is optimal for the formation of charged species.

Mass spectrometers generally operate in a vacuum maintained between 10^{-4} to 10^{-10} torr depending on the mass analyzer type. Thus once created, the charged particles must be transported into vacuum for mass analysis. A portion of the ions created in the API sources are entrained in the bath gas within the API source chamber and are swept into vacuum along with a carrier gas through an orifice into vacuum. One challenging aspect for high sensitivity lies in efficient transportation of the desired charged ions from atmosphere to the vacuum.

The API sources are advantageous because they provide a gentle means for charging molecules without inducing fragmentation. They also provide ease of use because the sample can be introduced at atmosphere.

API sources have a disadvantage of producing high chemical background and relatively low sensitivity. This is believed to be caused by sampling of impurites attached to the analyte ion (for example, cluster molecules, atoms or ions, or other undesired adduct ions), caused by incomplete desolvation during the API process. In this way, along with desolvated ions, many such droplets of varying diameters can enter into the mass spectrometer and consequently produce a large level of chemical noise across the entire mass range. Additionally incompletely vaporized droplets linger near the sampling orifice.

These problems can be most severe for high liquid sample flow rates, that typically range from 0.2 to 2.0 mL/min. Efficient Electrospray Ionization (ESI) at high flow rate requires sufficient heat for desolvation and a method to deter large clusters from entering the vacuum chamber while enhancing the ion capture. High flow rate analyses are important to industries that have large throughput requirements (such as drug development today, and in the future, protein analysis) because such flow rates are presently necessary for the High pressure Liquid Chromotography (HPLC) techniques performed prior to mass spectrometric analyisis. For most modern applications of ESI and APCI, liquid samples are passed through the source at high flow rates.

To reduce the problem of incomplete desolvation, heated gases are commonly employed to vaporize with a flow direction opposite, or counter, to

sprayed droplets in order to desolvate ions at atmospheric pressure. Since the heated gases remove much of the solvent vapor from the stream of gas before being drawn into the vacuum chamber, this technique increases the concentration of ions of interest in the vacuum chamber.

For example, United States Patent No. 4,023,398 teaches a technique whereby ions pass through an orifice into a vacuum chamber, while a gas curtain upstream from the orifice reduces transmission of solvent vapor into the vacuum chamber. The gas is heated to hasten evaporation of the solvent from the droplets, thereby producing desolvated ions at substantially atmospheric pressure. United States Patent No. 4,531,056 teaches a similar technique, whereby an inert gas is introduced into the electrospray chamber in a direction opposite to a flow from the capillary. The electrospray chamber remains at or slightly greater than atmospheric pressure. Ions of interest are produced within the electrospray chamber, and the inert gas flow substantially reduces the concentration of solvent vapor that enters the analyzer. United States Patent Nos. 4,842,701 and 4,885,076 disclose a system that combines capillary zone electrophoresis with electrospray for gas analysis of an analyte mixture. Again, the electrospray occurs at atmospheric pressure, and a heated countercurrent gas flow technique is used to desolvate the spray droplets.

While the counter flowing gas concept described above results in reasonable sensitivity, it is typically incorporated using a largely coaxial geometry between the sprayer and the mass spectrometer. This substantially decreases the ruggedness of the interface between the electrospray and the mass spectrometer, since a portion of the spray can still enter the mass spectrometer. It also reduces the sensitivity since the desolvation time spent in the flow is small.

Now, importantly, it is often useful and desirable to operate with multiple ion sources substantially simultaneously, for example using two or more ESI sources, or an APCI and ESI source, while also reducing the chemical noise and maintaining the simplicity of the atmospheric pressure source. This permits higher throughput or sensitivity (improved signal-to-noise) of sample than is possible with a single ion source, as well as other

useful functions such as providing the possibility of on-the-fly calibration. Thus signal-to-noise (sensitivity) and functionality are enhanced,

Prior art interfaces exist that contain multiple sprayers. However they are complex devices, requiring moving parts such as rotating cylinders and blocking apertures to select the appropriate sprayer, or utilizing multiple apertures to a vacuum system, thereby increasing vacuum load, increasing cost or reducing sensitivity. For example, United States Patent No. 6,784,422 teaches approaches for multiple sprayers using multiple sampling apertures directed into the low pressure of the mass spectrometer. It also teaches various approaches to blocking these apertures, and switching the ion beams near these apertures. This approach disadvantageously increases vacuum load, increasing cost or reducing sensitivity.

It is therefore desirable to provide an improved mass spectrometer interface for atmospheric pressure ionization sources suitable for multiple sources having improved sensitivity, enhanced stability and ruggedness and more functionality than prior interfaces, with substantially reduced complexity and cost, and reduced or eliminated source-to-source interference, .

SUMMARY OF THE INVENTION

In the broadest aspect of the invention there is provided an interface for a mass spectrometer uses non coaxial sampling pathways of the analyte ion beam prior to entering the entrance of a mass spectrometer for decreasing chemical background, and can be done in such a way as to permit multiple sprayers, increasing sample throughput and sensitivity for LC/MS (liquid chromatography/MS).

In one aspect of the invention there is provided a mass spectrometer interface, comprising:

a) at least a first ion source having an exit from which a beam of analyte ions are emitted;

b) a curtain plate member and a first aperture in the curtain plate member;

c) an orifice plate member having an orifice therein, said orifice plate member being spaced from said curtain plate member defining a flow passageway therebetween, the aperture in the orifice plate being aligned with

a sample entrance to a first vacuum stage of a mass spectrometer maintained substantially lower than atmospheric pressure, the first aperture in the curtain plate member being non coaxially aligned with the orifice in the orifice plate;

d) gas flow mechanism for directing a counter flow gas into said flow passageway;

e) power supply for applying suitable voltages to the ion source, curtain plate member and the orifice plate member for electrostatic lensing of the analyte ions emitted from an ion source toward the sample entrance through the aperture in the curtain plate member and the orifice in the orifice plate member.

In operation, when analyte ions from the at least a first ion source are directed in an initial flow direction towards the first aperture located in the curtain plate member some of these analyte ions are drawn through the first aperture by an electric field between the orifice plate and the curtain plate, and wherein the analyte ions entering through the first aperture in the curtain plate towards the orifice in the orifice plate encounter a counter flow gas in the flow passageway away from the orifice in the orifice plate, and wherein a low pressure maintained in a vicinity of the sample entrance of the first vacuum stage of the mass spectrometer draws analyte ions through the orifice in the orifice plate towards the sample entrance of the mass spectrometer.

The present invention also provides a method of injecting at least one analyte ion beam, produced in at least one ion source, into a mass spectrometer, comprising the steps of:

directing at least one beam of analyte ions towards an inlet structure of a mass spectrometer interface having at least two apertures which are non coaxially aligned with the at least one beam of analyte ions having an ion beam path which has at least two changes of direction prior to entering a sample entrance of a mass spectrometer, a first change of direction being at an angle (α) in a range from about 30 to 120 degrees and a second change of direction being at an angle (β) in a range from about 30 to120 degrees, such that the at least one beam of analyte ions is traveling in a third direction toward the entrance to the mass spectrometer so that impurities attached to analyte ions in said at least one beam of analyte ions are separated from said

analyte ions for reducing chemical background in said at least one analyte ion beam entering said inlet of a mass spectrometer.

The present invention also provides a mass spectrometer interface, comprising:

a) a plurality of ion sources each producing a beam of analyte ions;

b) an inlet structure for passing at least one beam of ions from at least one of said plurality of ion sources into a sample entrance of a mass spectrometer;

c) selection mechanism for selecting a pre-selected number of the ion beams for passage through the inlet structure into the sample entrance of the mass spectrometer while blocking any remaining ion beams, said selection mechanism including a plurality of steering gas sources with each of said plurality of steering gas sources being associated with a respective ion source so that gas emitted from a selected steering gas source intersects with the beam of analyte ions emitted by respective ion source associated therewith and directs said beam of analyte ions into said inlet structure, and including a pulse controller for independently pulsing each of said plurality of steering gas sources on and off, depending on which ion beam or ion beams are to be selected.

A further understanding of the functional and advantageous aspects of the invention can be realized by reference to the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The method and apparatus for increasing throughput and sensitivity and reducing chemical background in mass spectrometry, in accordance with the present invention will now be described, by way of example only, reference being made to the accompanying drawings, in which:

Figure 1 shows a side view of a Prior Art ion sampling interface for directing an analyte ion beam into a mass spectrometer;

Figure 2 shows side view of a sample interface for directing an analyte ion beam into a mass spectrometer to enhance sensitivity and ruggedness and reduce chemical noise constructed in accordance with the present invention;

Figure 2a is similar to Figure 2 but showing the normals to the apertures in the inlet structure;

Figure 3 shows side view of an alternative embodiment of a sample interface;

Figure 3a is similar to Figure 3 but showing the trajectory of a beam of analyte ions through the inlet structure;

Figure 4 shows a side view of another alternative embodiment of a sample interface;

Figure 4B shows a side view of an alternative embodiment of a sample interface;

Figure 4c shows a top view of an alternative embodiment of a sample interface;

Figure 5 shows a side view of another alternative embodiment of a sample interface;

Figure 6 shows an end view of another alternative embodiment of a sample interface;

Figure 7 shows an end view of another alternative embodiment of a sample interface;

Figure 8 shows a side view of another alternative embodiment of a sample interface;

Figure 9 shows a side view of another alternative embodiment of a sample interface;

Figure 10 shows a side view of another alternative embodiment of a sample interface;

Figure 11 shows an end view of another alternative embodiment of a sample interface;

Figure 12 shows an embodiment of a heated sample interface; and

Figure 13 shows another embodiment an ion sampling interface.

DETAILED DESCRIPTION OF THE INVENTION

The systems described herein are directed, in general, to embodiments of interfaces for ion sources for mass spectrometers and particularly interfaces for multiple ion sources. Although embodiments of the present invention are disclosed herein, the disclosed embodiments are merely

exemplary and it should be understood that the invention relates to many alternative forms. Including different shapes and sizes Furthermore, the Figures are not drawn to scale and some features may be exaggerated or minimized to show details of particular features while related elements may have been eliminated to prevent obscuring novel aspects. Therefore, specific structural and functional details disclosed herein are not to be interpreted as limiting but merely as a basis for the claims and as a representative basis for enabling someone skilled in the art to employ the present invention in a variety of manner. For purposes of instruction and not limitation, the illustrated embodiments are all directed to embodiments of interfaces for ion sources for mass spectrometers.

As used herein, the term "about", when used in conjunction with ranges of dimensions of particles or other physical properties or characteristics, is meant to cover slight variations that may exist in the upper and lower limits of the ranges of dimensions so as to not exclude embodiments where on average most of the dimensions are satisfied but where statistically dimensions may exist outside this region. It is not the intention to exclude embodiments such as these from the present invention.

Figure 1 shows a prior art design of a typical ion sampling arrangement into a mass spectrometer. Ions generated from an atmospheric ion source **50** are sent in the direction **56** towards a mass spectrometer inlet structure which includes the counter plate aperture **60** located in the counter plate **51**. These ions are drawn through the aperture **60** located in counter plate **51** through the counter flow gas **52** towards the aperture **61** located in sampling plate **53** which leads into the first stage of the mass spectrometer. Both apertures **60** and **61** are aligned along a common axis **54** so that both apertures **60** and **61** are "coaxially aligned" as the term is used herein Typical voltages for an electrospray positive ion source **50**, the counter plate **51**, and the sampling plate **53** are 5000V, 1000V, and 100V, respectively. These voltages ensure the positive ions are directed from the ion source **50** to the sampling plate aperture **61** whereupon the atmosphere gas flow pushes them into the low pressure region of the first stage of a mass spectrometer. For negative ion detection the polarity of these typical voltages are -5,000V, -1000V, and -100V, respectively. This low pressure region of the first stage of

the mass spectrometer is usually less than 10 torr. The spacing between the counter plate aperture **60** and the sampling plate aperture **61** is sufficiently small that desolvation is incomplete and chemical noise is high, which reduces the ion flux through the sampling aperture **61**. Large droplets from ion source **50** are sampled in a substantially coaxial geometry to the mass spectrometer, and therefore contaminating particles enter the mass spectrometer, decreasing stability, ruggedness and ease of use. The flow direction pattern herein involves one 90 degree bend from the exit of ion source **50** and along axis **54** into the spectrometer.

Figure 2 shows a sample interface for directing an analyte ion beam into a mass spectrometer shown generally at **8** constructed in accordance with the present invention that enhances desolvation reduces chemical noise and contamination, and permits cost-effective use of multiple sprayers. Ions from atmospheric ion source **10** are directed towards an inlet structure which includes a curtain plate aperture **12** located in a curtain plate member **14** shown in the form of a counter flow cap comprising a first elongate tube. These ions are sampled at roughly 90 degrees to this initial flow direction through aperture **12** located in curtain plate member **14**. The counter flow gas **19** is typically clean and dry, and flows in the direction of the region of volume **80** in counter flow cap **14** as shown.

The aperture **12** in the curtain plate member is non coaxial with the orifice or entrance **18** of the orifice plate member **15.** Typical sizes of aperture **12** may be in the range of about 1 to about 5 mm. The second elongate tube inserted into the first elongate tube is positioned such that the first opposed end of the second elongate tube is substantially adjacent to the aperture. Typical spacing of aperture **12** and the aperture **18** may be about 3-10 mm

Ions from the aperture **12** are directed towards the orifice **18** located in the orifice plate member **15** shown in the form of a second elongate tube. A vacuum pump is located on the first stage of the mass spectrometer and results in a low pressure, typically less than about 10 torr in the elongate tube **15** resulting in the ions being drawn through the orifice **18** in elongate tube **15**. The orifice plate **15** when in the form of the tube as shown does not need to have a constant diameter, but can be cone-shaped as shown. Typical diameters of orifice **18** are about 200-1000 micron and the pump speed of the

vacuum pump is in the range of about 25-80 l/min. The counter gas flow in direction **19** is maintained to ensure a mild velocity (typically about 0.1-2 m/s) of counter flow gas through counter cap aperture **12** from volume **80**. Typical voltages required to produce a positive ion flow from atmospheric ion source **10**, counter flow cap **14** and elongate tube **15** may be about 5,000V, 500-2000V, and 0-100V, respectively. The ions from the ion source **10** are drawn into the region **80** within flow cap **14** against the flow **19** of the counter gas through aperture **12** by the potential difference between the inner tube **15** and the counter flow cap **14**.

In general, in the embodiment of the sample interface shown at **8** in **Figure 2** the distance of the counter cap aperture **12** to sampling tube aperture **18** may be more than twice the distance of the counter plate aperture **60** to sampling plate aperture **61** in **Figure 1**. For example, aperture **12** may be displaced from aperture **18** by about 5mm-10 mm. In addition, in **Figure 2**, the ion flow direction changes through two 90 degree bends before being admitted into the low pressure region of the mass spectrometer. Referring to Figure 2a, in the non coaxial arrangement of aperture 12 and orifice 18, the angle between the normal N1 to the first aperture in tube 14 and the normal N2 to the orifice in tube 15 is 90 degrees. With the positioning of the aperture 12 being adjacent to orifice 18 the path followed by the analyte ion beam has two 90 degree bends. The first 90 degree bend prevents a portion of the spray from entering volume **80**, but is not sufficient to prevent contamination and all droplets from entering the mass spectrometer. A second bend between aperture **12** and aperture **18** provides further protection from contamination as well as a longer transit path in the counterflow gas. More bends in the ion flow from the ion source **50** would assist in removing large droplets that are incapable of sharp flow direction changes. Although a 90 degree line of site is shown between aperture **12** and aperture **18**, other substantially non-coaxial angles such as about 30 degrees, 45 degrees, 120 degrees, or 135 degrees would be suitable, preventing line of site from any portion of the spray (and therefore contamination) from entering the mass spectrometer, while providing a longer transit time and more collisions for effective desolvation. Thus this longer desolvation time very advantageously increases the sensitivity of the mass spectrometer. Both of these bends assist in increasing

sensitivity, reducing chemical noise and system contamination. Counter flow gas 19 may be heated to further assist desolvation.

Figure 3 shows an alternative embodiment of a portion of a sample interface **9** into the mass spectrometer which is a modification of the sample interface **8** shown in **Figure 2**. To further increase the time for ion desolvation, in the embodiment shown at **9** in **Figure 3**, the flow cap aperture **12** located in flow cap **14** has been displaced relative to the front open end **18** of the sampling tube **15** by about 3-10mm. An opening **35**, in the front of the counter flow cap **14** is connected to an outlet for the counter flow gas **19**. Counter flow gas may now have a larger velocity component within elongate tube of the flow cap **14**, for example in the range of about 1 to about 20 m/s, to prevent diffusion losses within the volume, and to direct the analyte ion flow toward the orifice in open end **18** of tube **15**. Thus counter flow gas velocity is maintained through the counter cap aperture **12**, while analyte ion current drawn through cap aperture **12**, and approximately following path **40** (the broken line in **Figure 3**) the analyte current is pushed towards the front of the sampling tube **15**, and then towards it's opening **18** by the counter flow gas, to be then pushed down the sampling tube **15** by the flow of gas from the predominantly atmospheric pressure cap region downstream to the lower pressure region of the sampling tube **15**. In this way, analyte ion current that is comprised of a mixture of completely desolvated ions, partially desolvated ions, and actual charged droplets, is provided more time in which to desolvate, as droplet desolvation at lower pressures is very inefficient, i.e., in the lower pressure regions of the mass spectrometer. Admitting droplets into the mass spectrometer eventually leads to changes in mass spectrometric sensitivity due to surface charge accumulation, and the possibility of chemical noise contamination.

Referring to Figure 3a, in the non coaxial arrangement of aperture 12 and orifice 18, the angle between the normal N1 to the first aperture in tube 14 and the normal N2 to the orifice in tube 15 is still 90 degrees. With the positioning of the aperture 12 being adjacent to orifice 18 the path followed by the analyte ion beam has two 90 degree bends.

While the angle between the normals N1 and N2 in Figures 2 and 3 is 90 degrees, it will be appreciated that the present invention is not limited to 90

degrees between the aperture normals but may be any angle as long as they are not coaxially aligned. Figure 3a shows the trajectory of the analyte ion beam undergoes two changes, the first defined by an angle α and the second defined by an angle β. The angle α may vary in a range from typically about 30 to 120 degrees and the second angle β may vary in a range typically from about 30 to120 degrees.

Typically, this desolvation process is aided by increasing the temperature of the cap region **80**, by directly heating the cap **14**, and/or heating the counter flow gas **19**. The flow of gas **19** may be assisted by a pump or by a pressurized source.

In order to be able to analyze the output from liquid chromatographs more efficiently using mass spectrometry, it has become important to couple more than one liquid chromatograph to a given mass spectrometer.

Figure 4 shows another embodiment of a sample interface **81**. Sample interface **81** is similar to sample interface **8** in **Figure 2** but includes an additional atmospheric ion source **11** and an additional corresponding counter flow cap aperture **13** located with respect to the end of ion source **11** similar to the location of counter flow cap aperture **12** with respect to the end of atmospheric ion source **10**. In this way, the ion outputs of the two separate ion sources **10** and **11** can be combined simultaneously at the sampling tube aperture **18**, just before entry into the sampling tube **15**, thereby minimizing interaction between the two ion streams from ion sources **10** and **11**.

In an alternative embodiment of a sample interface into a mass spectrometer shown at **130A** in **Figure 4B**, the atmospheric ion sources **10** and **11** are displaced relative to the counter flow cap **14**, and steering gas sources **300** and **302** are positioned to intersect with the ion sources respectively. Without flow of gas from gas sources **300** and **302**, the displacement of atmospheric sources **10** and **11** causes minimal ion flow through apertures **12** and **13**, respectively. Although lateral displacement relative to the counter flow cap is shown, angular displacement is also possible. For example, gas source **300** emits gas in the direction shown to steer the ion flow from ion source **10** towards the vicinity of counter flow aperture **12**. In a typical application, the steering gas flows **300** and **302** may be pulsed successively to alternately sample ions from ion sources **10** and **11**,

respectively. An output signal may simultaneously be sent to a recording device to indicate and record which flow **300** or **302** is pulsed on or off. This in turn indicates which ion source is sampled or not sampled. It is preferred to have a gas controlling element (not shown), such as a solenoid valve, positioned reasonably close to the opening so that the gas flow can be controlled quickly. For example, reasonably inexpensive digital solenoid valves from Parker Hannifin Corporation have cycle response times less than 30msec and life cycle ratings greater than 200 million. Digital gas flow controllers can also be used to provide adjustable flow rates so that ion detection may be optimized. In this embodiment, gas flow from the steering gas sources **300** and **302** are used to observe ions from the ion sources **10**, and **11**.

In another embodiment of a sample interface into a mass spectrometer, a top view of **Figure 4b** is shown at **130C** in **Figure 4C**, and steering gas source **300** is repositioned relative to ion source **10**. Ion source **11** is not shown for clarity purposes. In this configuration, gas from steering gas source **300** pushes ions from source **10** away from curtain cap aperture **12** resulting in minimal detection of ions from ion source **10**. In this way, ion detection optimization from ion source **10**, e.g., the position of ion source relative to aperture **12** and the inherent nebulizing gas flow within ion source **10**, can be performed with the gas flow from gas source **300** turned off. In this respect of ease of optimization, embodiment **130C** of **Figure 4C** is preferred to embodiment **130A** of **Figure 4B**. Typically the gas flow from gas source **300** will be pulsed off or on as ions from source **10** are to be detected or not, respectively. Similarly, steering gas source **302** (not shown) can be positioned to push ions from ion source **11** away from curtain cap aperture **13** (not shown). As above, an output signal may simultaneously be sent to a recording device to indicate and record which flow **300** or **302** is activated to in turn indicate which ion source (or analyte ion beam) is sampled. In either embodiment 130A or 130C, steering gas flows **300** and **302** may also be heated.

The steering gas sources provide a selection mechanism for selecting a pre-selected number of the ion beams for passage through the inlet structure formed by the curtain cap **14** and the tube **15** into the sample

entrance of the mass spectrometer while blocking any remaining ion beams. The selection mechanism may including a plurality of steering gas sources with each of the plurality of steering gas sources being associated with a respective ion source so that gas emitted from a selected steering gas source intersects with the beam of analyte ions emitted by respective ion source associated therewith and directs the beam of analyte ions into said inlet structure. A pulse controller may be used for independently pulsing each of the plurality of steering gas sources on and off, depending on which ion beam or ion beams are to be selected.

While the selection mechanism is shown with the non-coaxially aligned apertures in the inlet structure of Figure 2 and the various other embodiments described above, it will be appreciated that this selection mechanism may be used or retrofitted into existing inlet structures such as shown in Figure 1 which use coaxially aligned apertures. Thus, it will be appreciated that the use of a steering gas to steer an ion beam is suitable for any form of ion source or mass spectrometer interface, whether the apertures in the counterflow and sampling regions are coaxial or non coaxial, and as well in the absence of a counterflow gas all together, and therefore as such is not limited to the embodiments in this description Additionally, the pulsing of the steering gas is suitable for any number of embodiments using any number or types of ion sources, not limited to the embodiments within this description.

In order to increase ion desolvation time in the sample interface **81** into the mass spectrometer in **Figure 4**, the counter flow apertures **12** and **13** may be displaced downstream from the exits of the ion sources **10** and **11** in flow cap **24** as shown in the sample interface **90** in **Figure 5**, similar to the displacement in **Figure 3**. By displacing apertures **12** and **13** in flow cap **14** downstream relative to the sampling tube aperture **18** also effectively displaces them upstream with respect to the counter gas flow **19**. As in sample interface **9** shown in **Figure 3,** an opening **35** is located in the front of the counter flow cap **14** and is connected to an outlet for the counter flow gas **19**.

Alternatively the position of aperture **18** of sampling tube **15** may be displaced relative to the apertures **12** and **13** by a similar amount as in **9** or **90**

but with a reverse direction of the curtain gas flow. Further lens may be added to aid in the ion extraction.

Figure 6 shows another embodiment of a sample interface into a mass spectrometer configured to allow one to sample reactions between opposite polarity ions which is suitable for any embodiment of this invention. In sample interface **100** the counter flow cap **14** is shown as having a square cross-section, for example, and has been separated electrically into two halves, **14A** and **14B**, with insulators **30**. For example, ion source **10** could be an electrospray source producing positive ions and be at 5,000V, with counter flow cap **14A** at about 1500V, and the sampling tube **15** at about 0V. At the same time, ion source **11** could be an atmospheric pressure chemical ionization source which includes a corona needle at -6,000V, counter flow cap **14B** at -1,500V. In this way, opposite polarity ions react for a short time at atmospheric pressure before being extracted down the sampling tube into a mass spectrometer, or any other detection device.

The approaches for the interfaces in the embodiments need not be limited to one or two ion sources, as **Figure 7** shows an end view of another embodiment of a sample interface **110** into a mass spectrometer, wherein two additional ion sources **25** and **26**, and their corresponding counter flow cap apertures, **70** and **71** are included.

In the different embodiments of sample interfaces into mass spectrometers described above, the ions from the single or multiple ion sources **10**, **11**, **25** and **26** are introduced simultaneously into the mass spectrometer through the aperture **18** and flow down the sample tube **15**.

In sample interface **110** shown in **Figure 7**, ions from one or more ion sources can be admitted into to the sampling tube aperture **18**, by effectively turning off the ion current from all other ion sources except the ion source, or sources, of interest. Typically, this would involve turning the ion source voltage to that approximately applied to the counter flow cap **14**. For example, to admit only positive ions from ion source **25**, ion source **25** may be set to approximately 5,000V, ion sources **10**, **26**, and **11** would set to the counter flow voltage of about 1,000V, and the sampling tube **15** would be set at 0V. An output signal may simultaneously be sent to a recording device to record whether one or more ion source **10**,**11**, **25** or **26** is sampled.

Another useful feature of multiple sprayers is the ability to provide to one or more sprayers calibration samples or external samples, for example in order to calibrate on the fly or to use an external standard, as may be useful to compensate for instrument drift and improve the accuracy and precision of sample analysis.

Another embodiment of a sample interface into a mass spectrometer shown at **120** in **Figure 8**, configured to optionally allow any combination of beams from the different ion sources by addition of lens elements **16** and **17** located just inside flow cap **14** adjacent to apertures **12** and **13** respectively. In this configuration it is possible to switch from one liquid chromatograph output to another by changing the voltages on added lens elements. An output signal may simultaneously be sent to a recording device to record the voltage on lense **16** or **17** to indicate which ion source is sampled. In sample interface **120** the two atmospheric pressure ion sources **10** and **11** may be any one of an electrospray, atmospheric pressure chemical ionization, or atmospheric pressure photoionization ion sources to give a few non-limiting examples. These sources operate at or around atmospheric pressure. Liquid analyte from two liquid chromatographs (not shown) flows into ion sources **10** and **11**. Ions emitted from sources **10** and **11** are shown by arrows on sources **10** and **11** as flowing in the direction of apertures **12** and **13** respectively, on the counter flow cap **14**. Ions from sprayer **10** and **11** are admitted into the interior **80** of counter flow cap **14** by voltage on the sampling tube **15**. Ions are drawn through the front of the sampling tube **15**, by the voltage difference applied between the sampling tube **15** and the lenses **16** and **17**, and counter flow cap **14**, as well as by the flow of gas from the counter flow cap interior **80** down the sampling tube **15**.

Typically there is a counter flow of dry clean counter flow gas **19** with a flow sufficient to match the gas flow into the sampling tube **15**, and still provide a small outward flow though the apertures **12** and **13** located in flow cap **14**.

In another embodiment of a sample interface into a mass spectrometer shown at **130a** in **Figure 9a**, the electrostatic lenses **16a** and **17a** are placed outside the counter flow cap **14** adjacent to their associated apertures **12** and **13** respectively. By appropriate choice of voltages applied to lenses **16a** and

17a, the flow of ions may be controlled through apertures **12** and **13** from ion sources **10** and **11**.

In order to further increase the ion desolvation time, sample interface **120** shown in **Figure 8** may be reconfigured to give sample interface **140** shown in **Figure 10**. In sample interface **140** the cap apertures **12** and **13** and associated lenses **16** and **17** respectively have been displaced relative to the front aperture **18** of the sampling tube **15**. Counter flow gas opening **35** is connected to an outlet for the counter flow gas **19** similar to sample interface **90** in **Figure 5**. Analyte current is admitted through cap apertures **12** and **13** by lenses **16** and **17** respectively, approximately along the dotted lines, **40** and **41**, respectively, towards the aperture of the sampling tube **18**, by the counter flow gas **19**, to be then pushed down the sampling tube **15** by the flow of gas from the predominantly atmospheric pressure cap region down to the lower pressure region of the sampling tube. Voltages on lenses 16 and 17 may be switched to select one or more ion sources, with a signal output to record which ion source is sampled.

Figure 11 shows an end view of another embodiment of a sample interface **140** configured to double the number of ion sources from the two displayed in **Figure 10**. Sample interface **150** includes additional ion sources **25** and **26** spaced downstream from apertures **70** and **71** respectively located in flow cap **14**. Lenses **27** and **28** are located inside flow cap adjacent to apertures **70** and **71**, respectively. Typical operation involves admitting only one ion source output into the mass spectrometer at a time, with a signal output to record which ion source is sampled. Multiple sprayers may also be admitted simultaneously, with output means to determine which sprayers are sampled.

Figure 12 is an example of another embodiment sampling interface **210F** constructed in accordance with the present invention. Two sources **200** and **202** generate ion flows **204** and **206**, orthogonally positioned to apertures **208** and **211** in counter flow cap **212**. A counter current gas flow (not shown) is passed through **212** to aid in desolvation. The two counterflow cap apertures **208** and **211** are positioned orthogonal to the sampling aperture (not shown). The interface channels **218** and curtain cap **208** may be further heated by means of one or more heaters **220**. Ions are entrained in a flow of

gas through channel **218**, and the channel **218** is pumped by a vacuum pump near **297F**. Ions are sampled through aperture **246F** into the mass spectrometer. Ion sampling may be aided by deflector devices **280F** and **282F**, electrically insulated from the housing by insulator supports **288F** and **298F**.

As a further example, **Figure 13** shows an alternative embodiment of a mass spectrometer interface shown generally at **400** for minimizing or reducing multiple sprayer interaction in which the curtain plate member **101** is a plate having two apertures **110a** and **110b**. The orifice plate member **103** is also a planar plate having an orifice **111** which is aligned with the sample input to the mass spectrometer. Interface **400** uses the same principle of apertures **110a** and **110b** non-coaxially aligned with orifice **111** as shown in interface **81** shown in **Figure 4** for example. Steering gases **300** and **302** emit gas in the direction shown to steer the ion flow from ion source **118** and **100** towards the vicinity of counter flow apertures **110a** and **110b**. In a typical application, the steering gas flows **300** and **302** will be pulsed successively to alternately sample ions from ion sources **10** and **11**, respectively. Alternatively gas sources **300** and **302** can be configured to selectively steer ions away from apertures **110a and 110b**. An output signal indicates which ion source is sampled.

While the counter flow cap **14** shown in the Figures is cylindrical it will be understood that it is not restricted to cylindrical tubes and thus the term "tube" is not to be restricted to cylindrically shaped tubes but tubes of any shape including square, polygonal etc. are to be understood as being covered by the present invention for both the first and second tubes. It is noted that sampling tube **15** is tapered in the Figures but it will be understood that the sampling tube **15** does not need to be tapered and may be straight.

It will be appreciated that all interfaces described above could be configured with steering gas as described in interfaces **130A** and **130C** of **Figures 4B** and **4C**.

It will also be appreciated that in all the embodiments described herein that the operating pressures in the region adjacent to the entrance **18** of sampling tube **15** within the interior of the counter flow cap **14** may be

substantially above or below atmosphere, but typically in a range from about 100 Torr to about 2 atmospheres.

It will also be appreciated that in all the embodiments described herein that voltages applied to the ion sources or to electrodes outside of the counterflow region, or to electrodes within the counterflow gas region, may be both DC and time varying, and additional auxiliary gas flows internal and external are within the scope of the invention.

It will also be appreciated that within the embodiments, the multiple ion sources include but are not limited to conventional atmospheric pressure sources such as electrospray ionization, photoionization, and chemical ionization. All interfaces may include an output signal may simultaneously be sent to a recording device to indicate which ion source is sampled. Also, it is sometimes advantageous to have one, two, three or four or more ion sources operating simultaneously, and therefore the descriptions are not limited to operating one ion source at a time.

It will also be appreciated that in all the embodiments described herein that heaters may be placed within or near the counter flow cap **14** or near the ion sources.

As used herein, the terms, “comprises” and “comprising” are to be construed as being inclusive and open ended, and not exclusive. Specifically, when used in this specification including claims, the terms, “comprises” and “comprising” and variations thereof mean the specified features, steps or components are included. These terms are not to be interpreted to exclude the presence of other features, steps or components.

The foregoing description of the preferred embodiments of the invention has been presented to illustrate the principles of the invention and not to limit the invention to the particular embodiment illustrated. It is intended that the scope of the invention be defined by all of the embodiments encompassed within the following claims and their equivalents.

THEREFORE WHAT IS CLAIMED IS:

1. A mass spectrometer interface, comprising:

a) at least a first ion source having an exit from which a beam of analyte ions are emitted;

b) a curtain plate member and a first aperture in the curtain plate member;

c) an orifice plate member having an orifice therein, said orifice plate member being spaced from said curtain plate member defining a flow passageway therebetween, the aperture in the orifice plate being aligned with a sample entrance to a first vacuum stage of a mass spectrometer maintained substantially lower than atmospheric pressure, the first aperture in the curtain plate member being non coaxially aligned with the orifice in the orifice plate;

d) gas flow mechanism for directing a counter flow gas into said flow passageway;

e) power supply for applying suitable voltages to the ion source, curtain plate member and the orifice plate member for electrostatic lensing of the analyte ions emitted from an ion source toward the sample entrance through the aperture in the curtain plate member and the orifice in the orifice plate member; and

f) wherein when analyte ions from the at least a first ion source are directed in an initial flow direction towards the first aperture located in the curtain plate member some of these analyte ions are drawn through the first aperture by an electric field between the orifice plate and the curtain plate, and wherein the analyte ions entering through the first aperture in the curtain plate towards the orifice in the orifice plate encounter a counter flow gas in the flow passageway away from the orifice in the orifice plate, and wherein a low pressure maintained in a vicinity of the sample entrance of the first vacuum stage of the mass spectrometer draws analyte ions through the orifice in the orifice plate towards the sample entrance of the mass spectrometer.

2. The interface according to claim 1 including a pressure controller for maintaining a pressure in a volume defined between said curtain plate member and said orifice plate member of at least about 100 Torr.

3. The interface according to claim 1 including at least one steering gas source positioned so that gas emitted from said at least one steering gas source intersects with the analyte ions emitted by the at least one steering gas source to steer analyte ions with respect to said aperture in the curtain plate member.

4. The interface according to claim 3 including a heater for heating the steering gas.

5. The interface according to claim 1, 2, 3 or 4 including a heater for heating the curtain plate member and the orifice plate member to further enhance desolvation.

6. The interface according to claim 1, 2, 3 or 4 wherein an angle between the aperture in the curtain plate member and the orifice in the orifice member is between about 30 degrees and about 135 degrees.

7. The interface according to claim 1, 2, 3 or 4 wherein an angle between the aperture in the curtain plate member and the orifice in the orifice member is between about 45 degrees and about 135 degrees.

8. The interface according to claim 1, 2, 3 or 4 wherein an angle between the aperture in the curtain plate member and the orifice in the orifice member is between about 90 degrees and about 135 degrees.

9. The interface according to claim 1, 2, 3 or 4 wherein an angle between the aperture in the curtain plate member and the orifice in the orifice member is between about 100 degrees and about 135 degrees.

10. The interface according to any one of claims 1 to 9 wherein said curtain plate member is a first planar metal plate, and wherein said orifice plate member is a second planar metal plate spaced from said first planar metal plate, and wherein the at least a first ion source is positioned with respect to

said curtain plate member so that said first aperture is located downstream of said exit.

11. The interface according to any one of claims 1 to 10 including a first electrostatic lens electrode located adjacent to said first aperture and wherein said power supply is configured to apply pre-selected voltages to said first electrostatic lens electrode.

12. The interface according to any one of claims 1 to 11 wherein said curtain plate member includes a second aperture spaced from said first aperture and in non coaxial relationship with respect to said orifice, including a second ion source having an exit for producing an analyte ion beam and wherein the second ion source is positioned with respect to said curtain plate member so that said second aperture is located downstream of said exit, and wherein said power supply is configured for switching at least voltages on the first and second ion sources on and off, depending on which beam of analyte ions is to be selected.

13. The interface according to claim 12 including two steering gas sources, a first steering gas source being associated with the first ion source and the second being associated with the second ion source, the first steering gas source being positioned so that gas emitted from said first steering gas source intersects with the analyte ions emitted by the first ion source and the second steering gas source being positioned so that gas emitted from said second steering gas source intersects with the analyte ions emitted by the second ion source to steer analyte ions from the two ion sources with respect to said aperture in the curtain plate member, and including a pulse controller for pulsing the first and second steering gas sources on and off, depending on which ion beam is to be selected.

14. The interface according to claim 12 wherein said power supply includes indicator means for indicating which of the first and second ion sources is switched on or off.

15. The interface according to claim 1 including a first electrostatic lens electrode located adjacent to said first aperture, and including a second electrostatic lens electrode located adjacent to said second aperture, and wherein said power supply is configured to independently apply pre-selected voltages to said first and second electrostatic lens electrodes.

16. The interface according to claim 1 wherein said curtain plate member comprises a counter flow cap including a first elongate tube having a tube wall with the first aperture located in the tube wall and least a first open end and wherein said orifice plate comprises a second elongate tube having opposed first and second ends with the first end being open and forming the orifice and the second end terminating at the sample entrance to a first vacuum stage of a mass spectrometer,

wherein a portion of the second elongate tube with the first open end is located within the at least a first open end of the first elongate tube, the counter flow cap and the second elongate tube being positioned with respect to a sample entrance of a mass spectrometer so that the second open end of the second elongate tube opens toward the sample entrance, the portion of the second elongate tube inserted into the at least a first open end of the counter flow cap having a smaller diameter than a diameter of the first elongate tube and wherein an annular space between the counter flow cap and the inserted portion of the second elongate tube forms said flow passageway, and

and wherein said gas flow mechanism directs the counter flow gas into said flow passageway from the at least a first open end of the first elongate tube.

17. The interface according to claim 16 including a heater for heating the counter flow cap and the second elongate tube to further enhance desolvation.

18. The interface according to claim 16 wherein said at least a first ion source is orientated 90 with respect to said first aperture, and wherein said first aperture is oriented 90 degrees to said orifice in said elongate tube.

19. The interface according to claim 16 wherein the portion of the second elongate tube located in the first elongate tube is positioned such that the first opposed end of the second elongate tube is substantially adjacent to the aperture with the orifice at an angle of about 90 degrees with respect to the first aperture, and wherein the first elongate tube has a second closed end spaced from the first open end of the second elongate tube.

20. The interface according to claim 16 wherein said first open end of said second elongate tube is located upstream of said first aperture, and wherein said first elongate tube has a second open end spaced from orifice in the second elongate tube.

21. The interface according to claim 19 wherein said first elongate tube has at least a second aperture in the tube wall spaced a same distance from said second closed end of the first elongate tube as the first aperture, and including at least a second ion source, and wherein the portion of the second elongate tube inserted into the first elongate tube is positioned such that the first opposed end of the second elongate tube is substantially adjacent to the at least a second aperture.

22. The interface according to claim 21 wherein said first ion source is an ion source for producing positive ions, and said second ion source is an ion source for producing negative ions, wherein at least some of the opposite polarity ions from the first and second ion sources react before being extracted down the second elongate tube into the entrance of the mass spectrometer.

23. The interface according to claim 21 wherein said first elongate tube has at least a second aperture in the tube wall spaced a same distance from said second closed end of the first elongate tube as the first aperture, and including at least a second ion source, and wherein the portion of the second elongate tube inserted into the first elongate tube is positioned such that the first opposed end of the second elongate tube is located upstream of said at least a second aperture, and wherein said power supply is configured for

switching voltages on at least the first and second ion sources, depending on which beam of analyte ions is to be selected.

24. The interface according to claim 23 wherein said first elongate tube has a rectangular cross section made of first and second tube sections separated by an electrical insulator, wherein said first aperture is located in the first tube section and the at least a second aperture is located in the second tube section, and wherein said power supply is configured to independently apply pre-selected voltages to the first and second rectangular sections.

25. The interface according to claim 23 wherein said first ion source is an electrospray source with a positive potential bias applied thereto for producing positive ions, and said second ion source is an atmospheric pressure chemical ionization source with a negative potential bias applied thereto for producing negative ions, wherein opposite polarity ions from the first and second ion sources react for a short time at atmospheric pressure before being extracted down the second elongate tube into the entrance of the mass spectrometer.

26. The interface according to claim 24 including a first electrostatic lens electrode located adjacent to said first aperture inside said first elongate tube, and including a second electrostatic lens electrode located adjacent to said at least a second aperture inside said first elongate tube, and wherein said power supply is configured to independently apply pre-selected voltages to said first and second electrostatic lens electrodes.

27. The interface according to claim 24 including a first electrostatic lens electrode located adjacent to said first aperture outside said first elongate tube, and including a second electrostatic lens electrode located adjacent to said at least a second aperture located outside said first elongate tube, and wherein said power supply is configured to independently apply pre-selected voltages to said first and second electrostatic lens electrodes.

28. The interface according to claim 23 including a first electrostatic lens electrode located adjacent to said first aperture inside said first elongate tube, and including a second electrostatic lens electrode located adjacent to said at least a second aperture inside said first elongate tube, and wherein said power supply is configured to independently apply pre-selected voltages to said first and second electrostatic lens electrodes.

29. The interface according to claim 13 wherein said pulse controller includes a signal means for indicating which of said first and second steering gas sources are switched on or off for recording which steering gas source is switched on or off.

30. The interface according to claim 15 wherein said power supply is configured for switching voltages on the first and second lens electrodes on and off, depending on which beam of analyte ions is to be selected.

31. The interface according to claim 23 wherein said power supply includes indicator means for indicating which of the first and second ion sources is switched on or off.

32. The interface according to claim 30 wherein said power supply includes indicator means for indicating which of the first and second ion sources is switched on or off.

33. The interface according to claim 26 wherein said power supply is configured for switching voltages on the first and second lens electrodes on and off, depending on which beam of analyte ions is to be selected, and wherein the power supply indicator means for indicating which of the first and second ion sources is switched on or off.

34. The interface according to claim 27 wherein said power supply is configured for switching voltages on the first and second lens electrodes on and off, depending on which beam of analyte ions is to be selected, and

wherein the power supply indicator means for indicating which of the first and second ion sources is switched on or off.

35. The interface according to claim 28 wherein said power supply is configured for switching voltages on the first and second lens electrodes on and off, depending on which beam of analyte ions is to be selected, and wherein the power supply indicator means for indicating which of the first and second ion sources is switched on or off.

36. The interface according to claim 1 wherein said at least a first ion source is orientated with respect to said first aperture, and said first aperture is non coaxially oriented with respect to said orifice in said second elongate tube such that a path of the at least one beam of analyte ions from said first ion source to the sample entrance of the mass spectrometer has at least two changes of direction, a first change of direction being at an angle (α) in a range from about 30 to 120 degrees and a second change of direction being at an angle (β) in a range from about 30 to120 degrees.

37. The interface according to claim 16 wherein said at least a first ion source is orientated with respect to said first aperture, and said first aperture is oriented with respect to said orifice in said second elongate tube such that a path of the at least one beam of analyte ions from said first ion source to the sample entrance of the mass spectrometer has at least two changes of direction, a first change of direction being at an angle (α) in a range from about 30 to 120 degrees and a second change of direction being at an angle (β) in a range from about 30 to120 degrees.

38. A mass spectrometer interface, comprising:

a) a plurality of ion sources each producing a beam of analyte ions;

b) an inlet structure for passing at least one beam of ions from at least one of said plurality of ion sources into a sample entrance of a mass spectrometer;

c) selection mechanism for selecting a pre-selected number of the ion beams for passage through the inlet structure into the sample entrance of the

mass spectrometer while blocking any remaining ion beams, said selection mechanism including a plurality of steering gas sources with each of said plurality of steering gas sources being associated with a respective ion source so that gas emitted from a selected steering gas source intersects with the beam of analyte ions emitted by respective ion source associated therewith and directs said beam of analyte ions into said inlet structure, and including a pulse controller for independently pulsing each of said plurality of steering gas sources on and off, depending on which ion beam or ion beams are to be selected.

39. The interface according to claim 38 wherein said pulse controller includes a signal means for indicating which of said plurality of gas sources are switched on or off for recording which steering gas source is switched on or off.

40. The interface according to claim 38 or 39 wherein the inlet structure includes at least two coaxially aligned apertures through which a selected number of beams of analyte ions pass into the sample entrance of the mass spectrometer.

41. The interface according to claim 38 or 39 wherein the inlet structure includes at least two non-coaxially aligned apertures through which a selected number of beams of analyte ions pass into the sample entrance of the mass spectrometer.

42. The interface according to claim 38, 39, 40 or 41 including a power supply for applying suitable voltages to the plurality of ion source and selected positions on the inlet structure for electrostatic lensing of the analyte ions emitted from a pre-selected number of said plurality of ion sources toward the sample entrance through the inlet structure.

43. A method of injecting at least one analyte ion beam, produced in at least one ion source, into a mass spectrometer, comprising the steps of:

directing at least one beam of analyte ions towards an inlet structure of a mass spectrometer interface having at least two apertures which are non coaxially aligned with the at least one beam of analyte ions having an ion beam path which has at least two changes of direction prior to entering a sample entrance of a mass spectrometer, a first change of direction being at an angle (α) in a range from about 30 to 120 degrees and a second change of direction being at an angle (β) in a range from about 30 to120 degrees, such that the at least one beam of analyte ions is traveling in a third direction toward the entrance to the mass spectrometer so that impurities attached to analyte ions in said at least one beam of analyte ions are separated from said analyte ions for reducing chemical background in said at least one analyte ion beam entering said inlet of a mass spectrometer.

44. The method according to claim 43 including directing at least one beam of steering gas towards the at least one beam of analyte so that gas emitted from said at least one gas source intersects with the at least one beam of analyte ions, and including a pulse controller for pulsing the at least one steering gas source on and off, depending on which ion beam is to be selected

45. The method according to claim 43 or 44 wherein said at least one analyte ion beam includes at least a second analyte ion beam originating from a second ion source, including directing said at least a second analyte ion beam towards an inlet of a mass spectrometer along a path having at least two changes of direction including a first change of direction being at an angle (α) in a range from about 30 to 120 degrees and a second change of direction being at an angle (β) in a range from about 30 to120 degrees, such that the at least a second analyte ion beam is traveling in the third direction toward the entrance to the mass spectrometer so that impurities attached to analyte ions in said at least a second analyte ion beam are separated from said analyte ions for reducing chemical background in said at least a second analyte ion beam entering said inlet of a mass spectrometer.

46. The method according to claim 45 wherein said at least two apertures are oriented at an angle of about 90 degrees with respect to each other.

47. The method according to claim 43, 44, 45 or 46 including electrostatically focusing and directing said at least one analyte ion beam using at least one electrostatic lens positioned along said ion beam path.

48 The method according to claim 45 wherein one of the analyte ion beams is a calibrant.

49 The method according to claim 45 wherein one of the analyte ion beams is an external standard.

50. The method according to claim 45 wherein said first ion source is an ion source for producing positive ions, and said second ion source is an ion source for producing negative ions, including maintaining a pres-selected pressure in the inlet structure where the positive ions and negative ions mix to allow at least some opposite polarity ions from the first and second ion sources to react for a short time prior to being extracted down the second elongate tube into the entrance of the mass spectrometer.

51. The method according to claim 50 wherein said pre-selected pressure is atmospheric pressure.

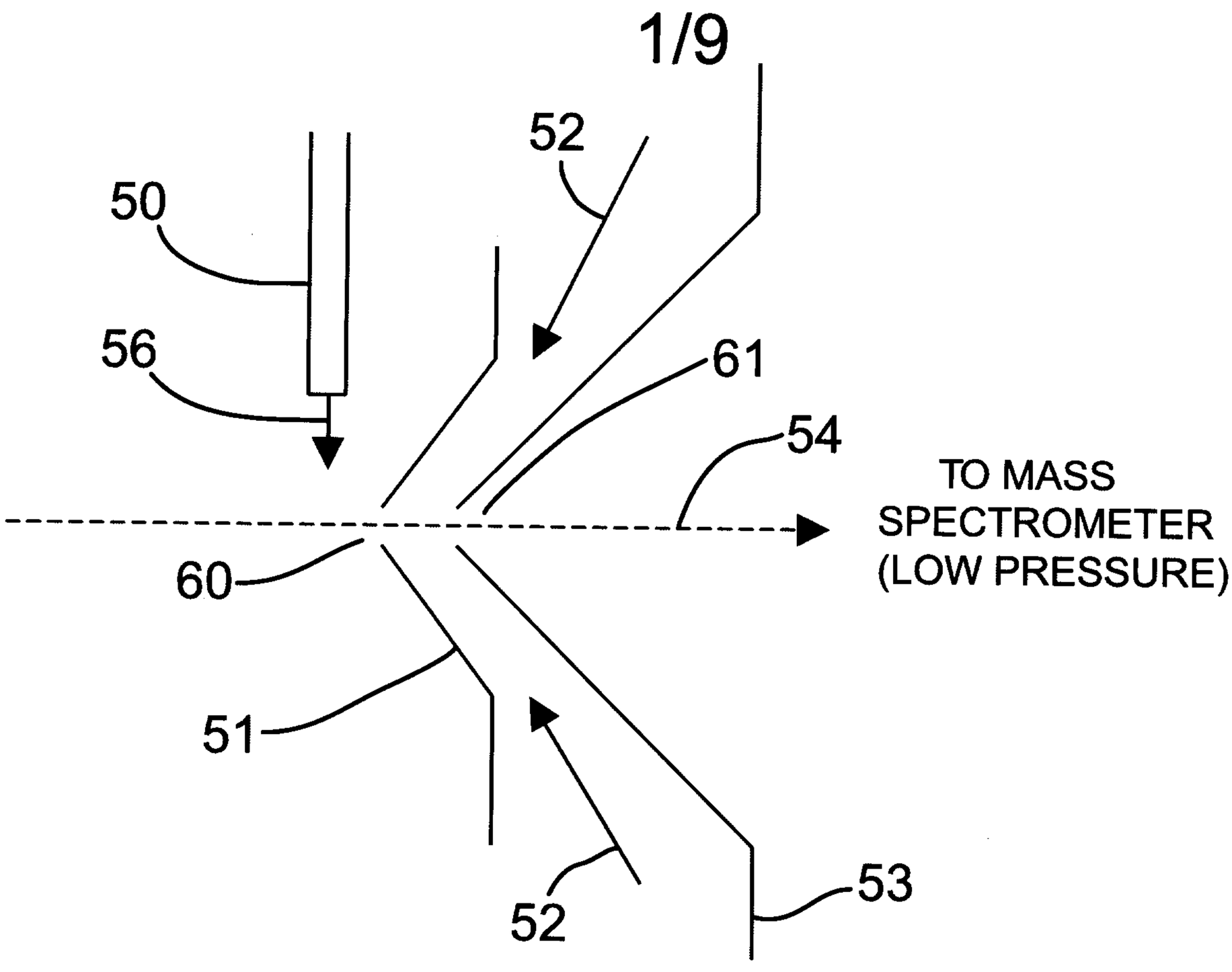


FIGURE 1
PRIOR ART

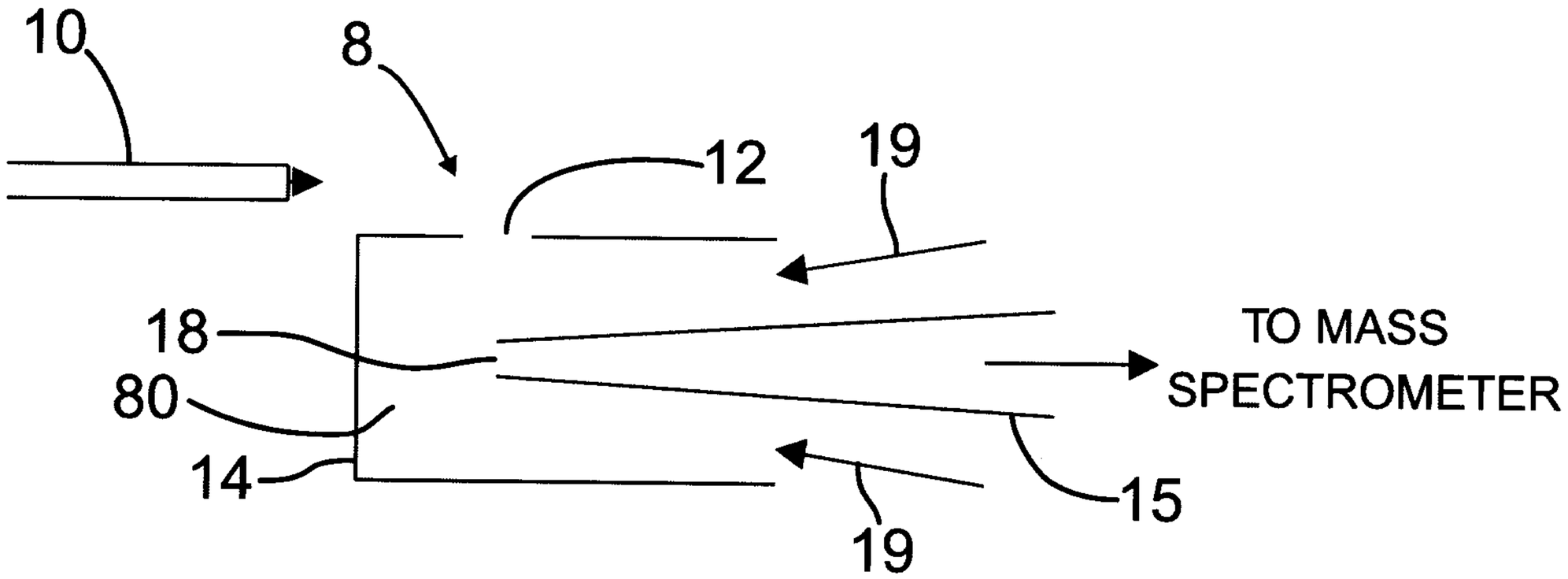


FIGURE 2

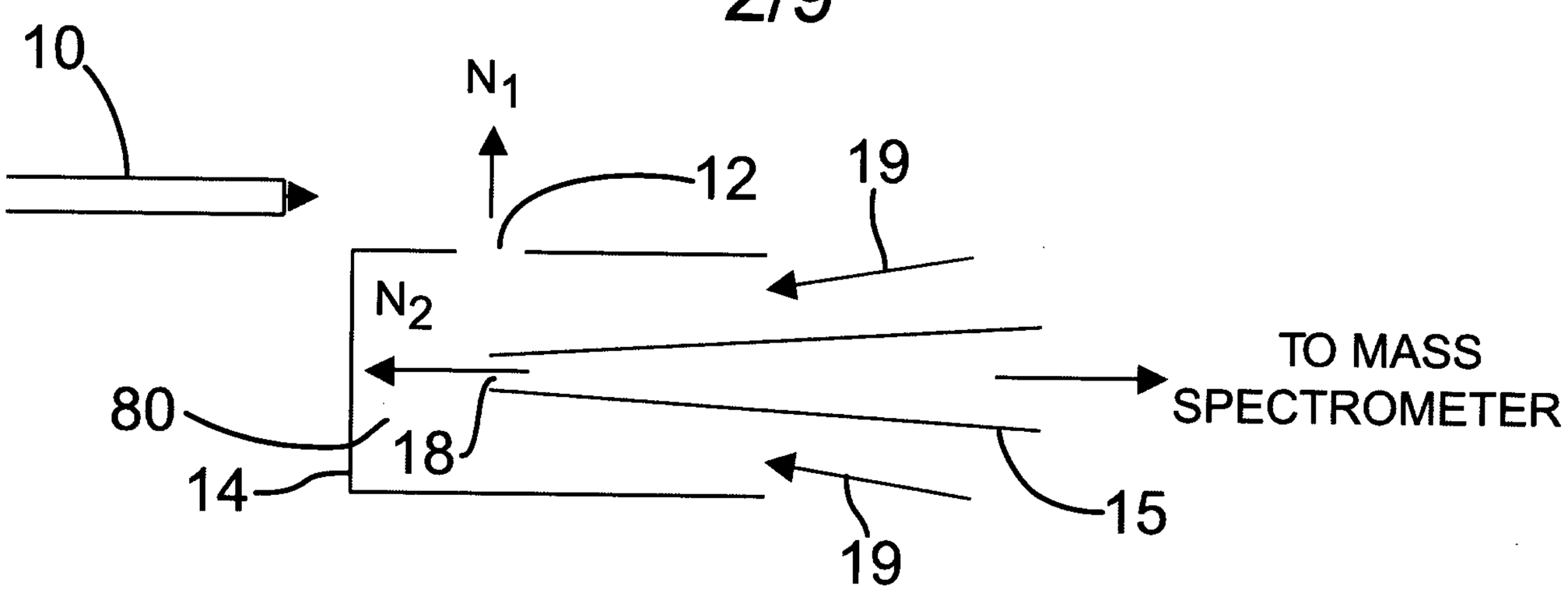


FIGURE 2a

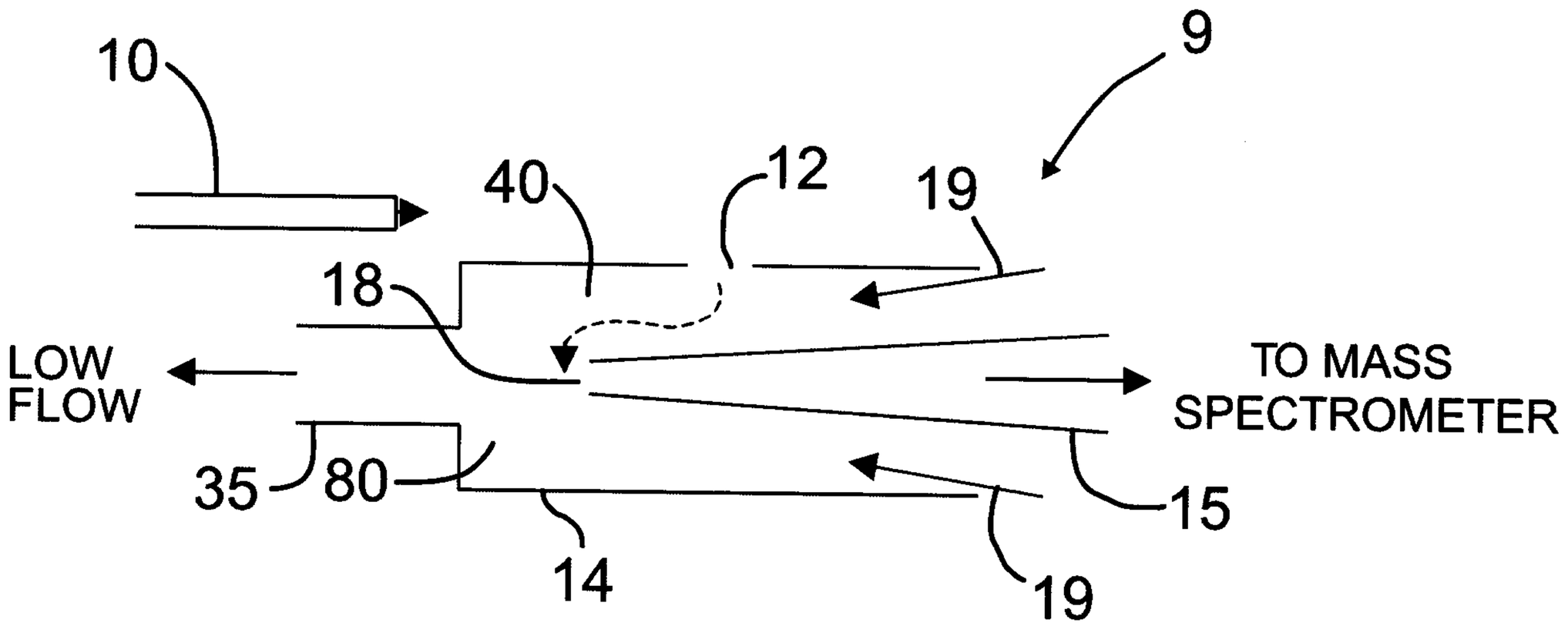


FIGURE 3

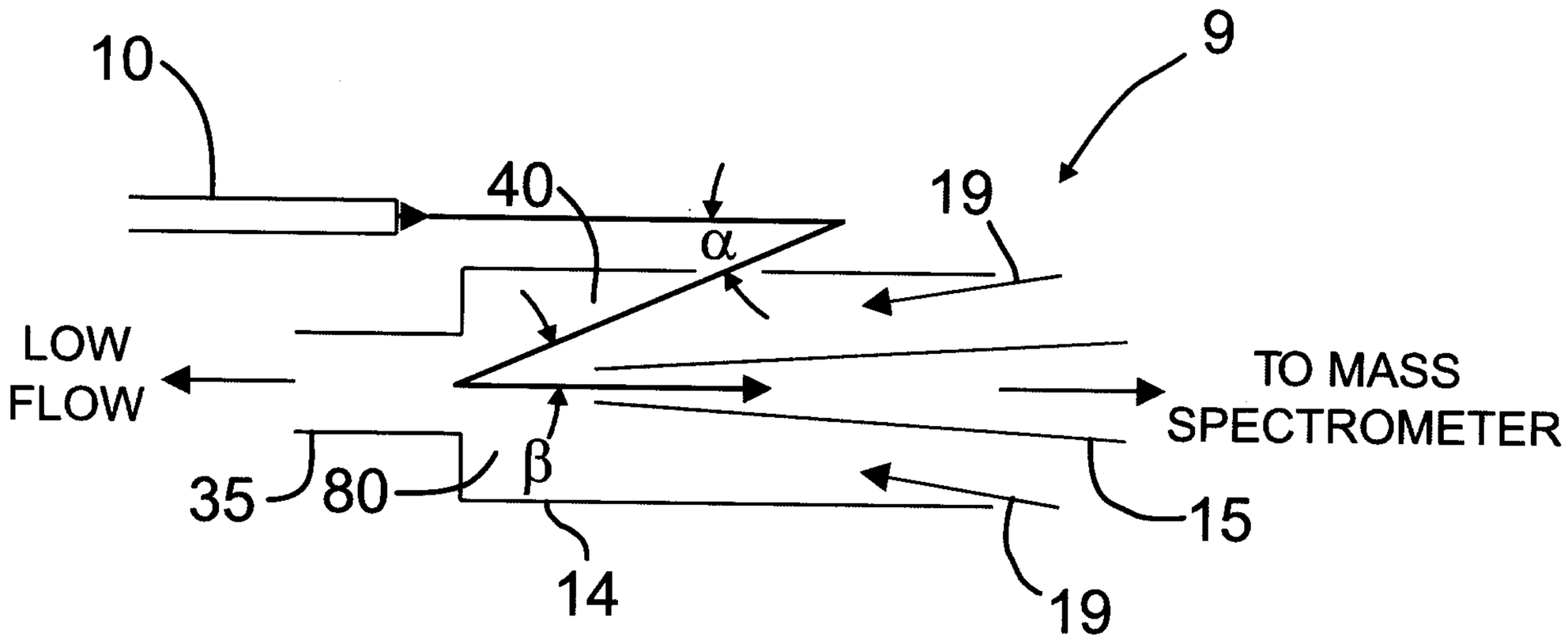


FIGURE 3a

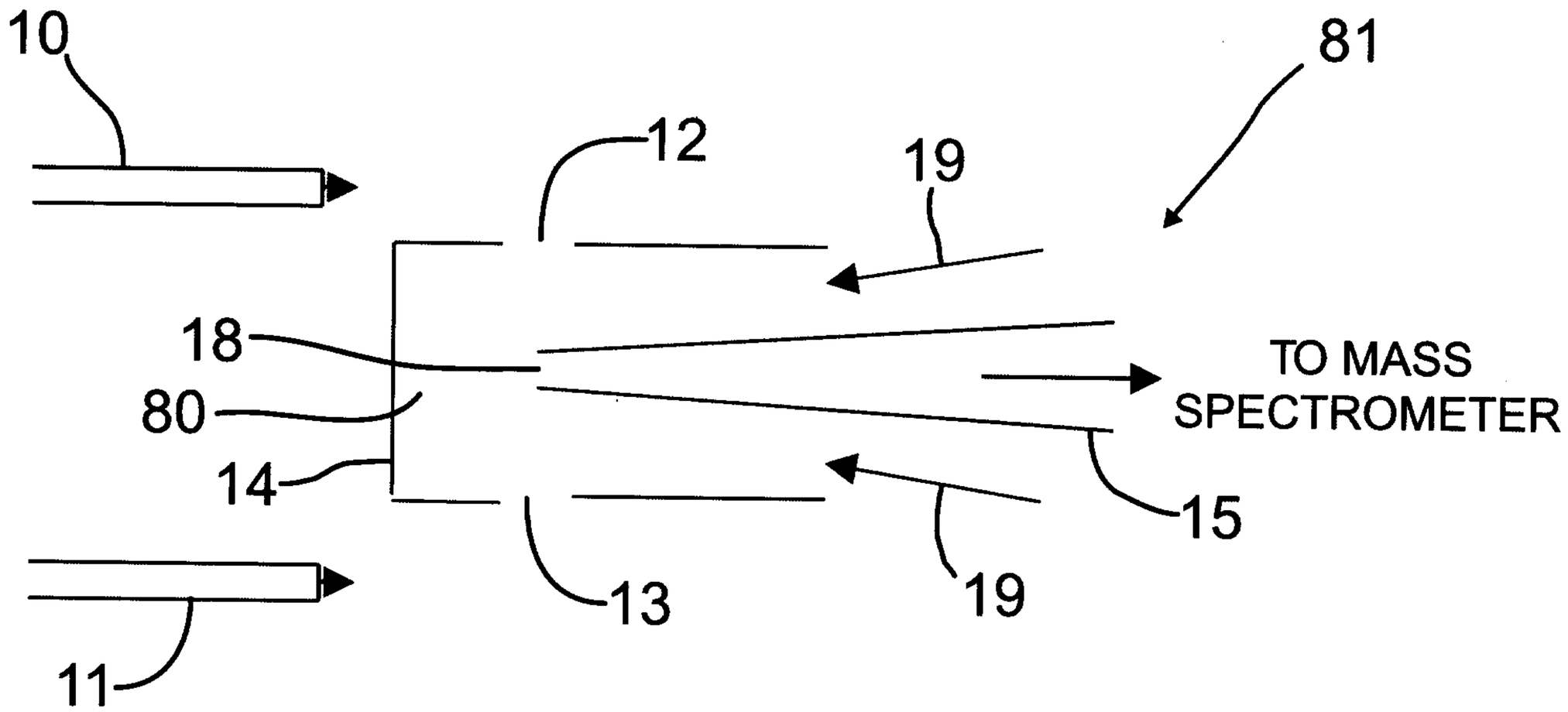


FIGURE 4

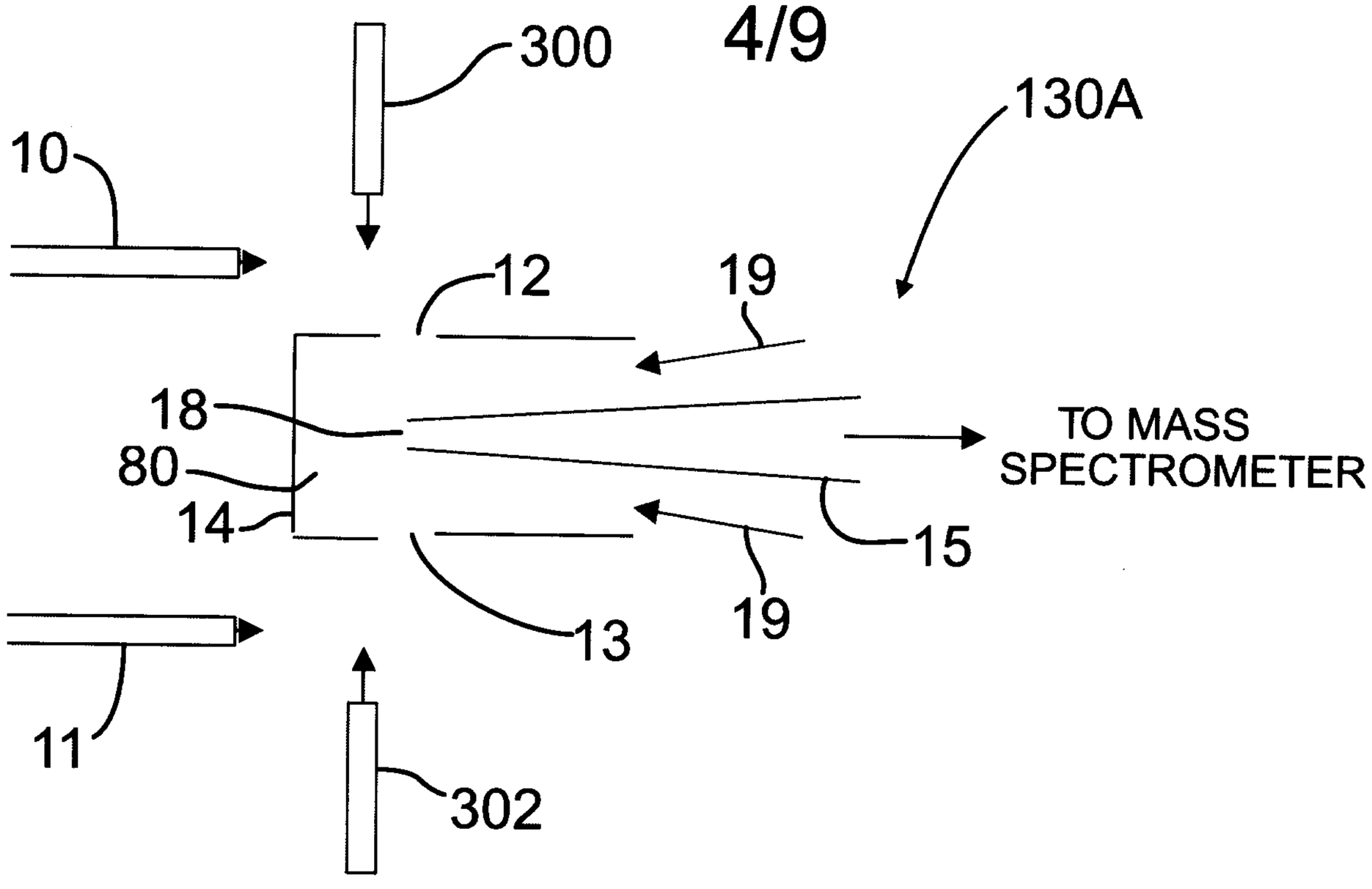


FIGURE 4B

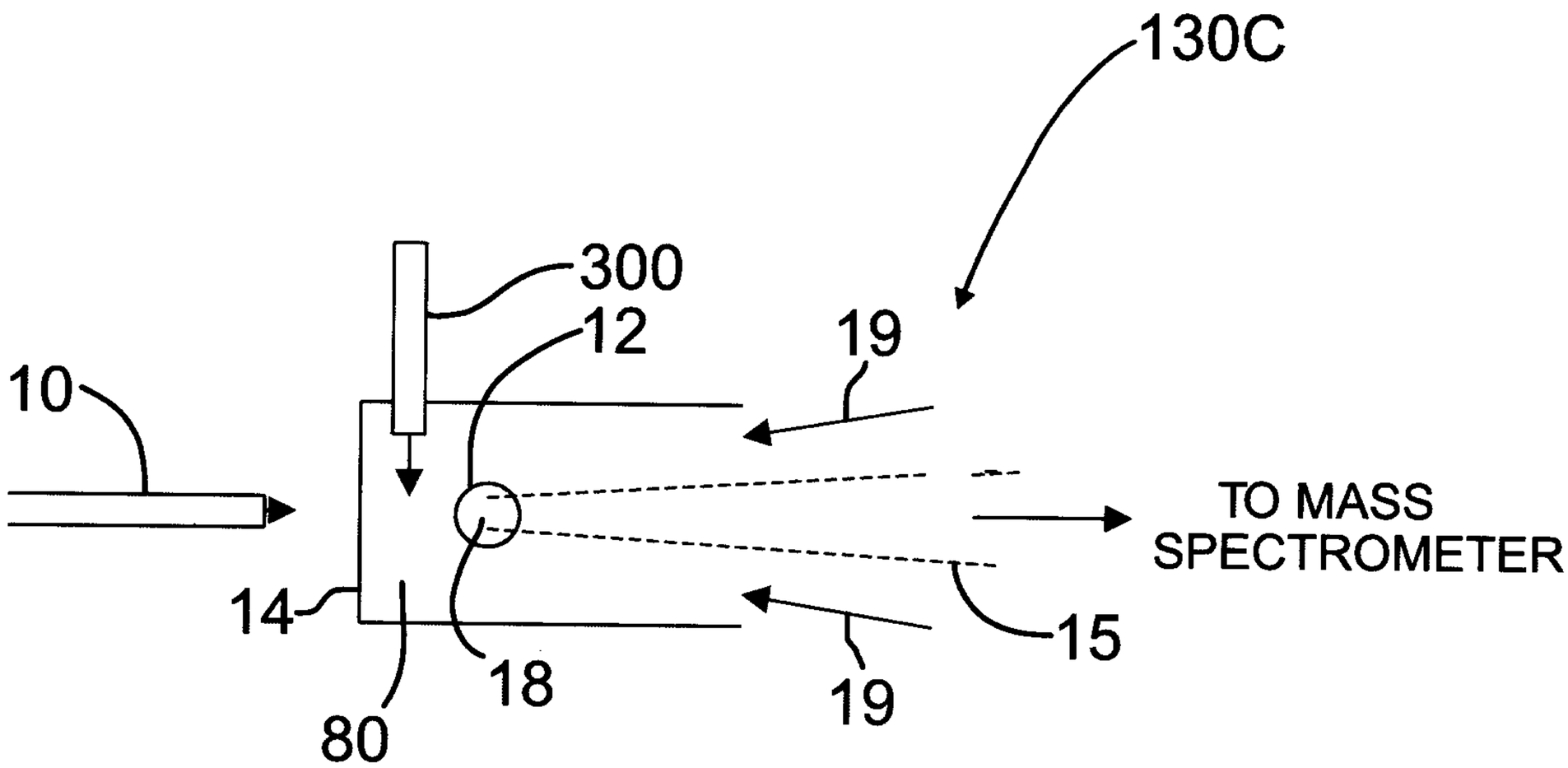


FIGURE 4C

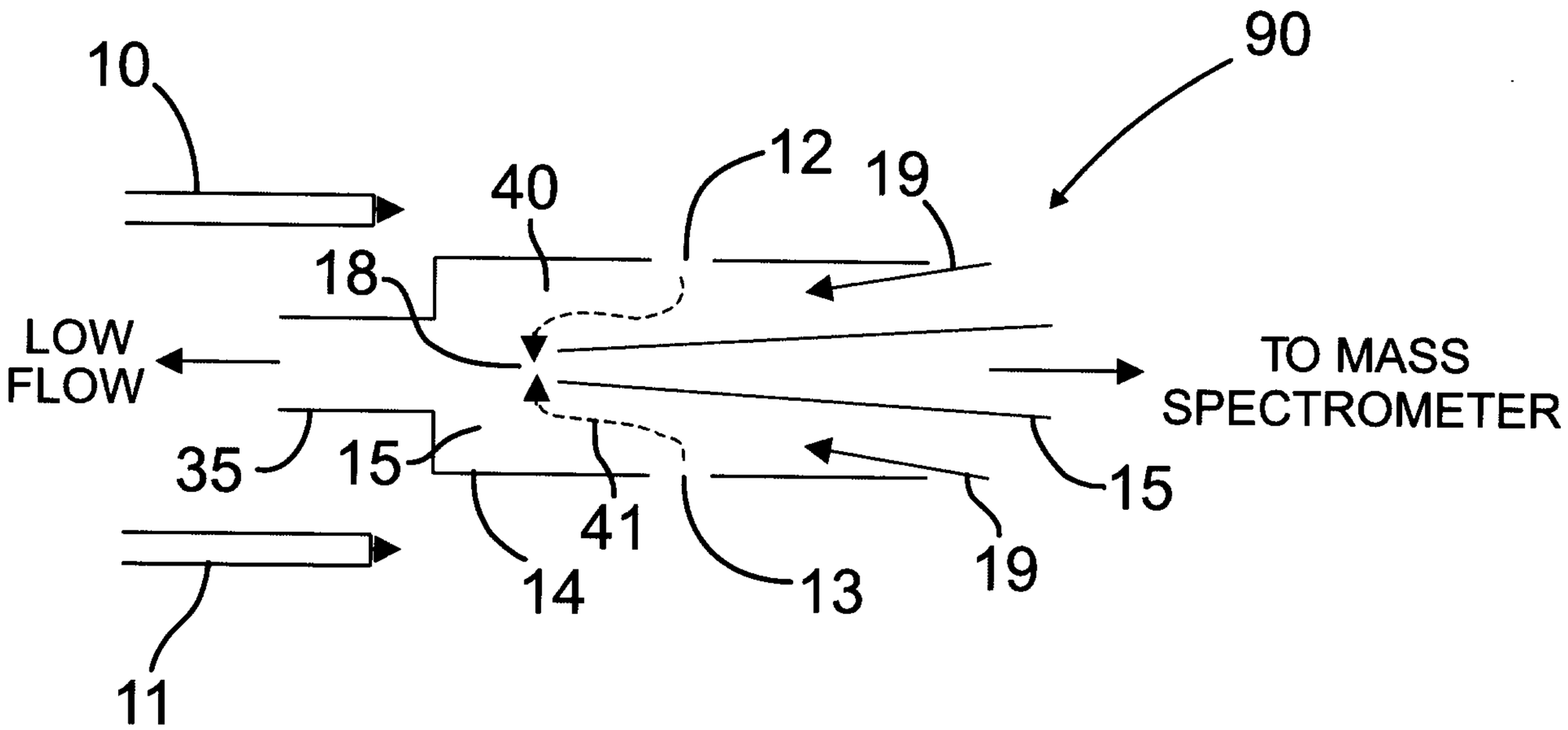


FIGURE 5

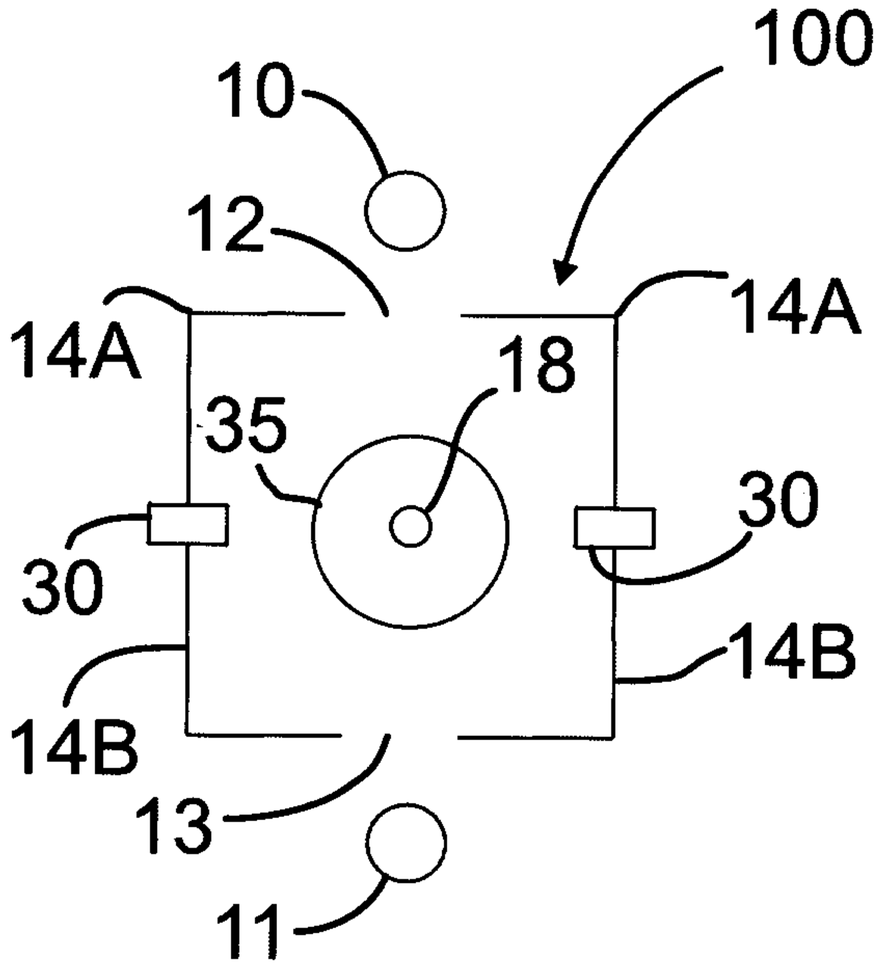


FIGURE 6

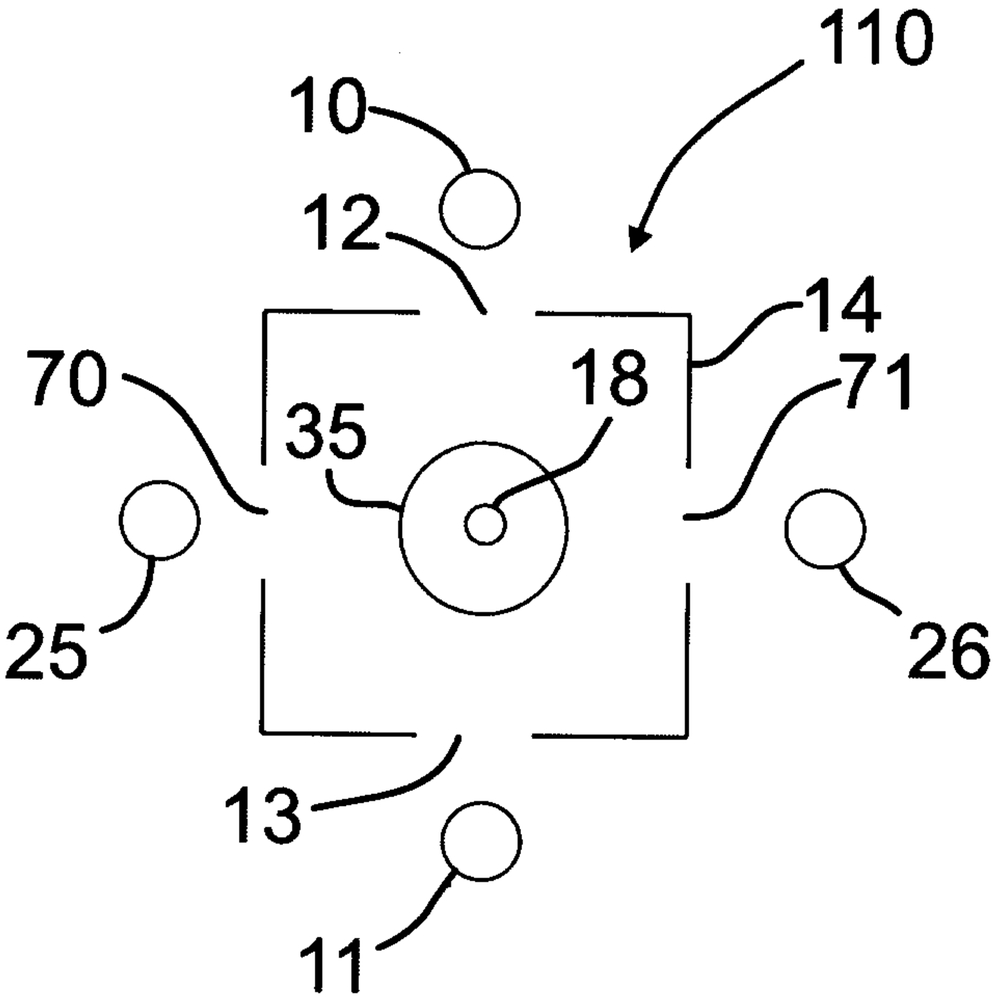


FIGURE 7

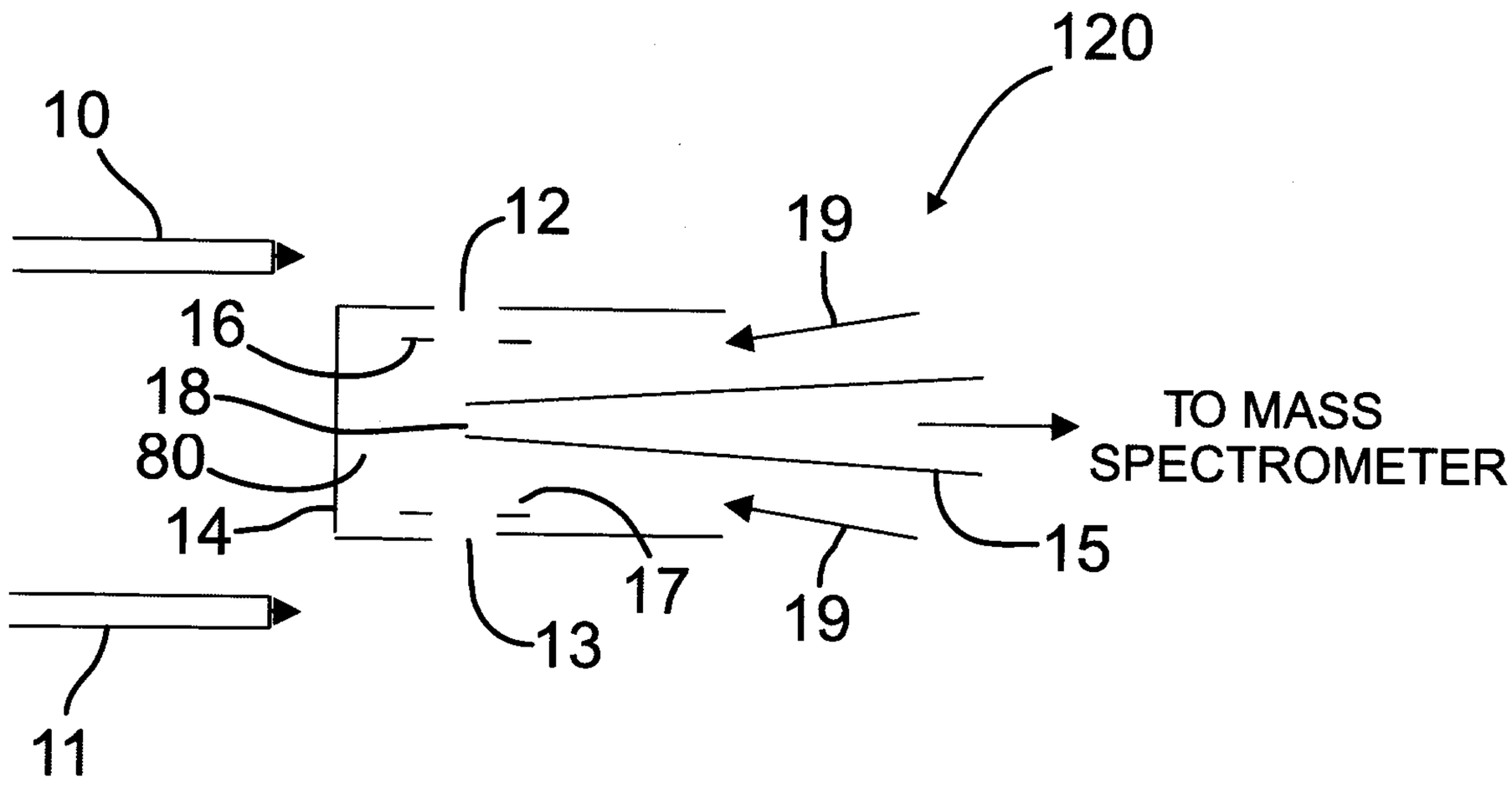


FIGURE 8

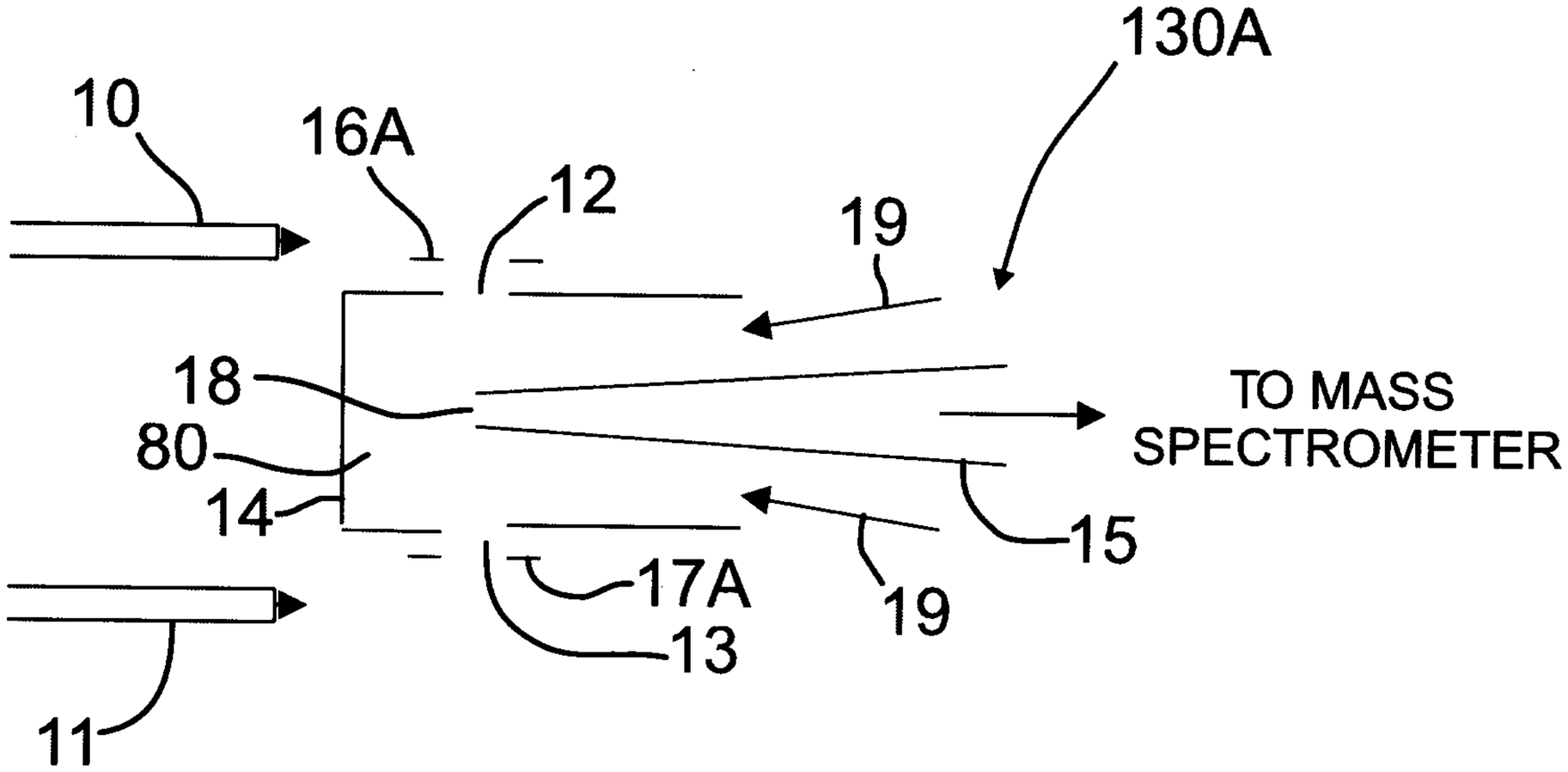


FIGURE 9

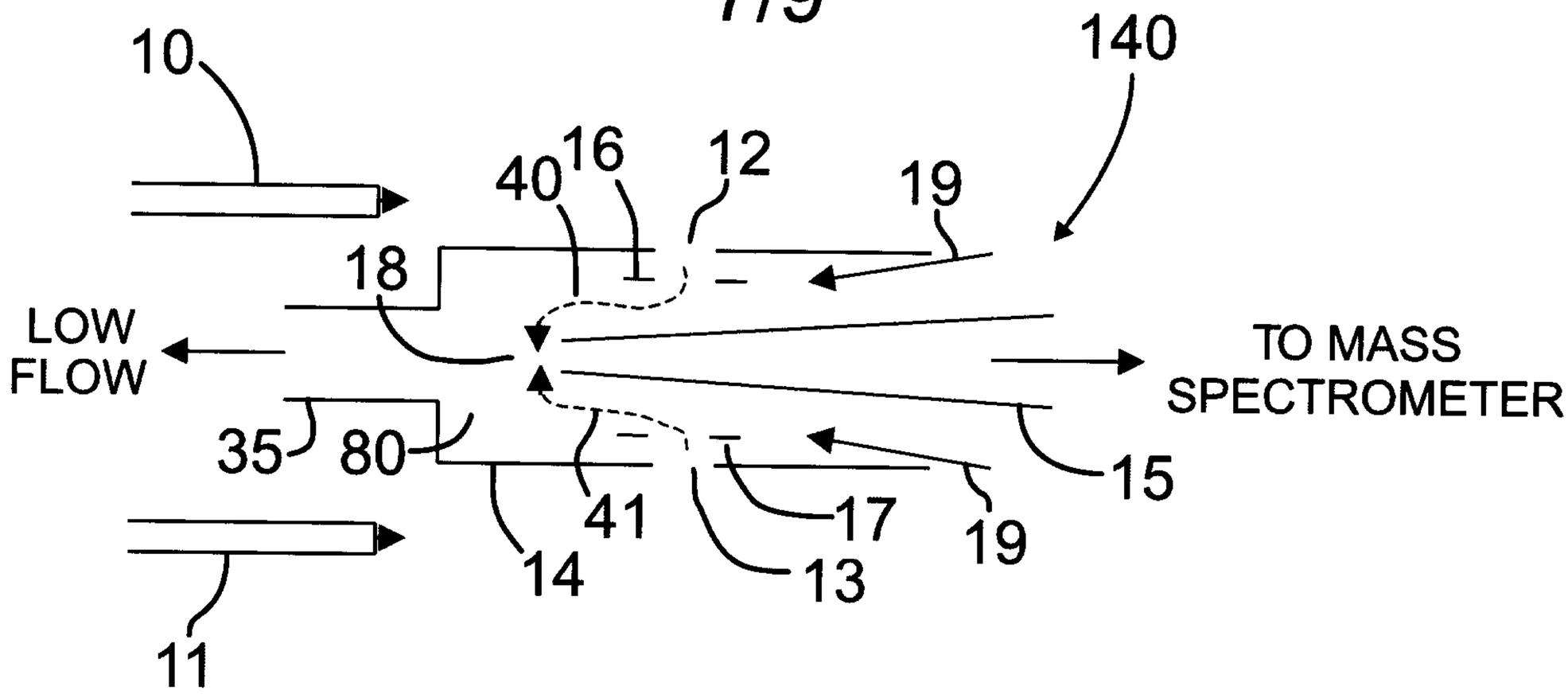


FIGURE 10

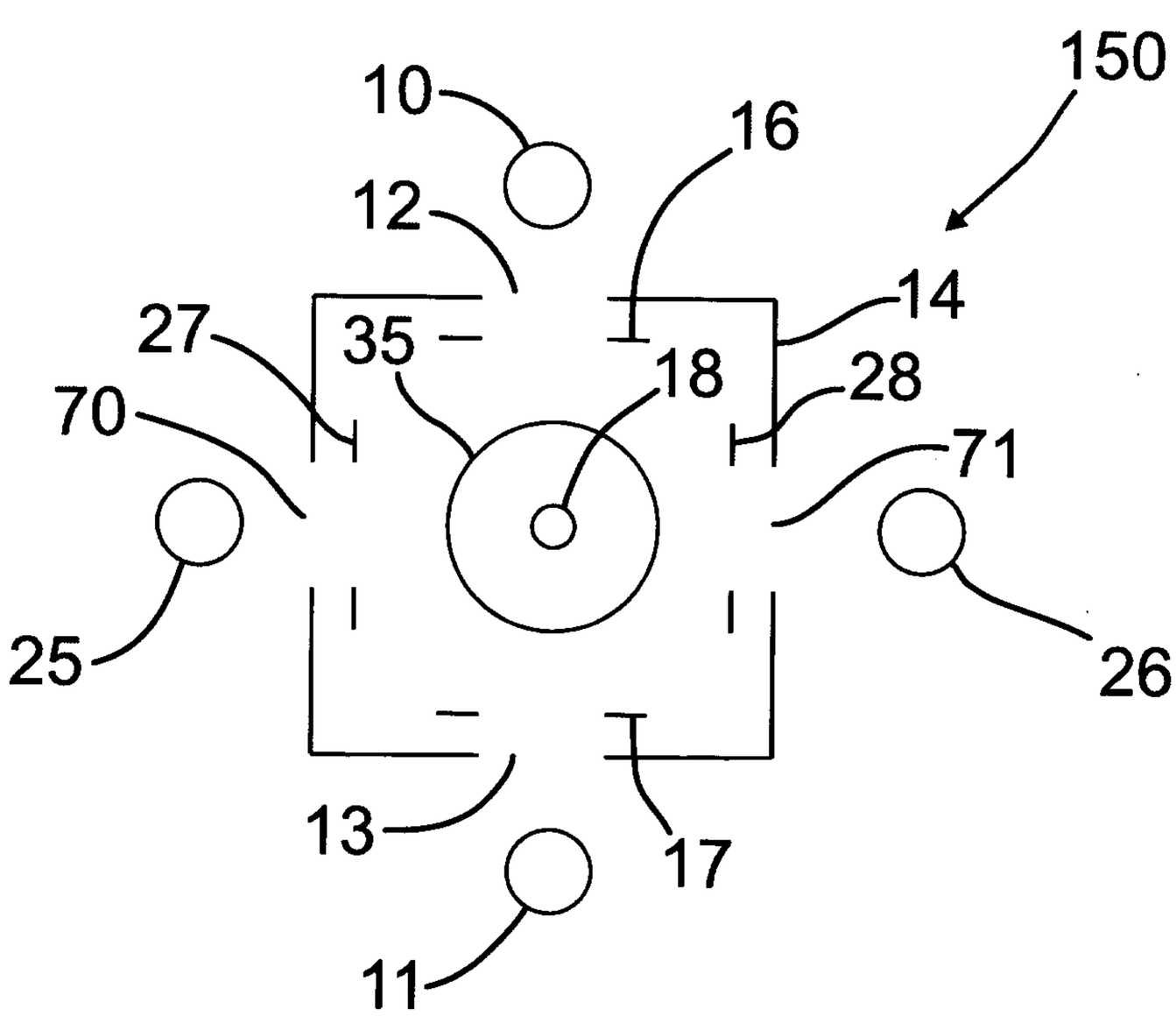
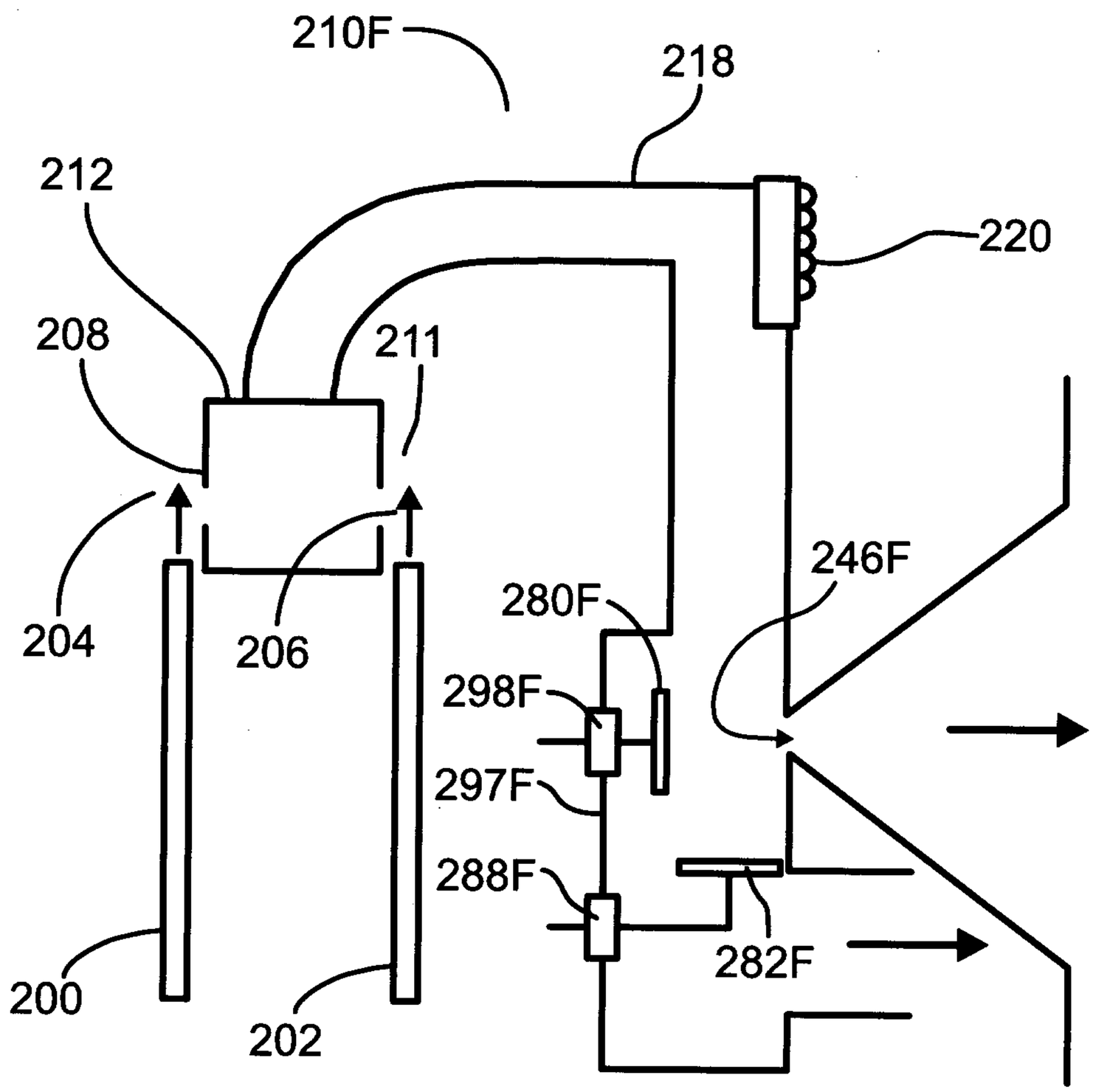


FIGURE 11


210F
218
212
220
208
211
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206
246F
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298F
297F
288F
282F
200
202

FIGURE 12

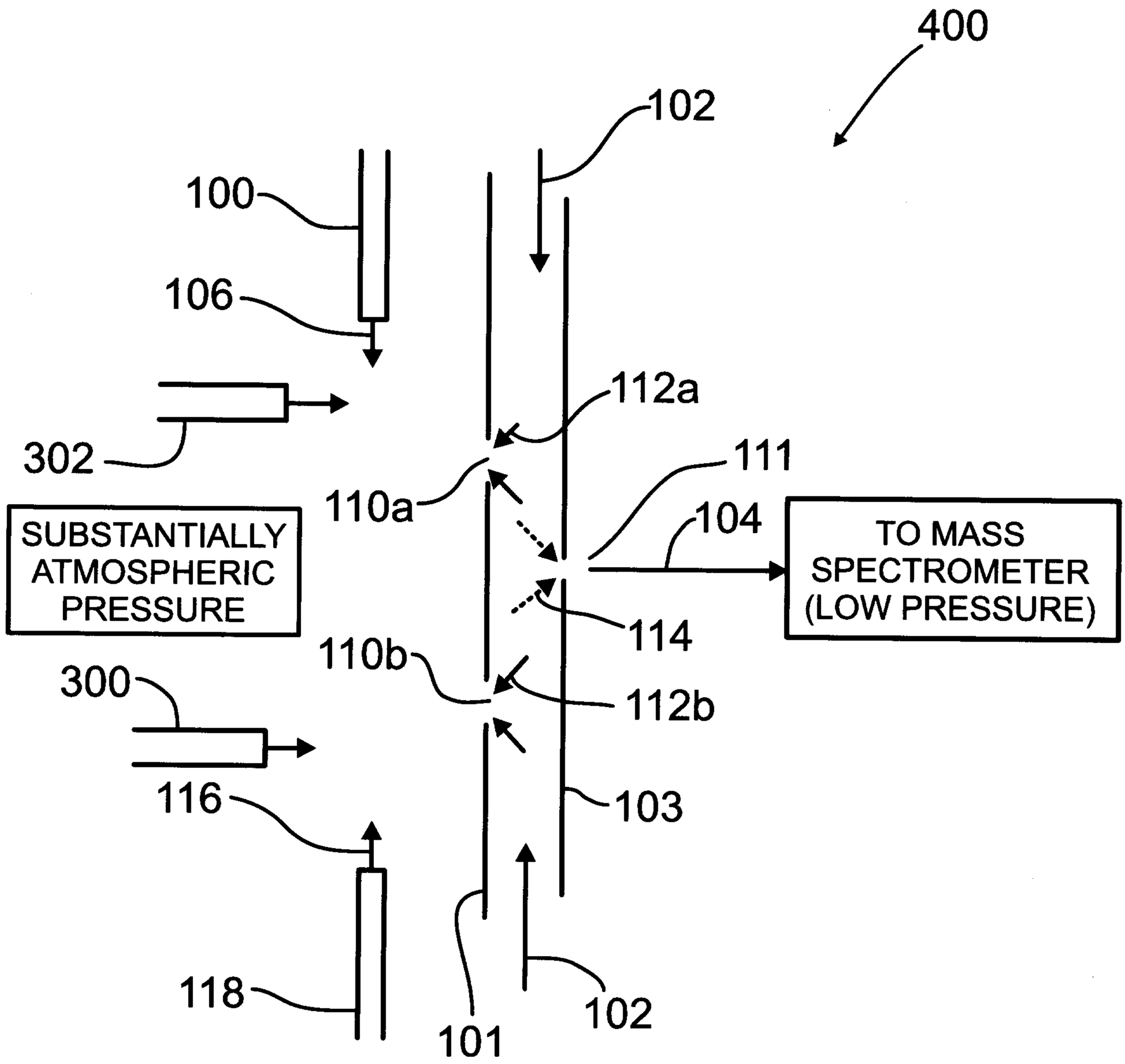
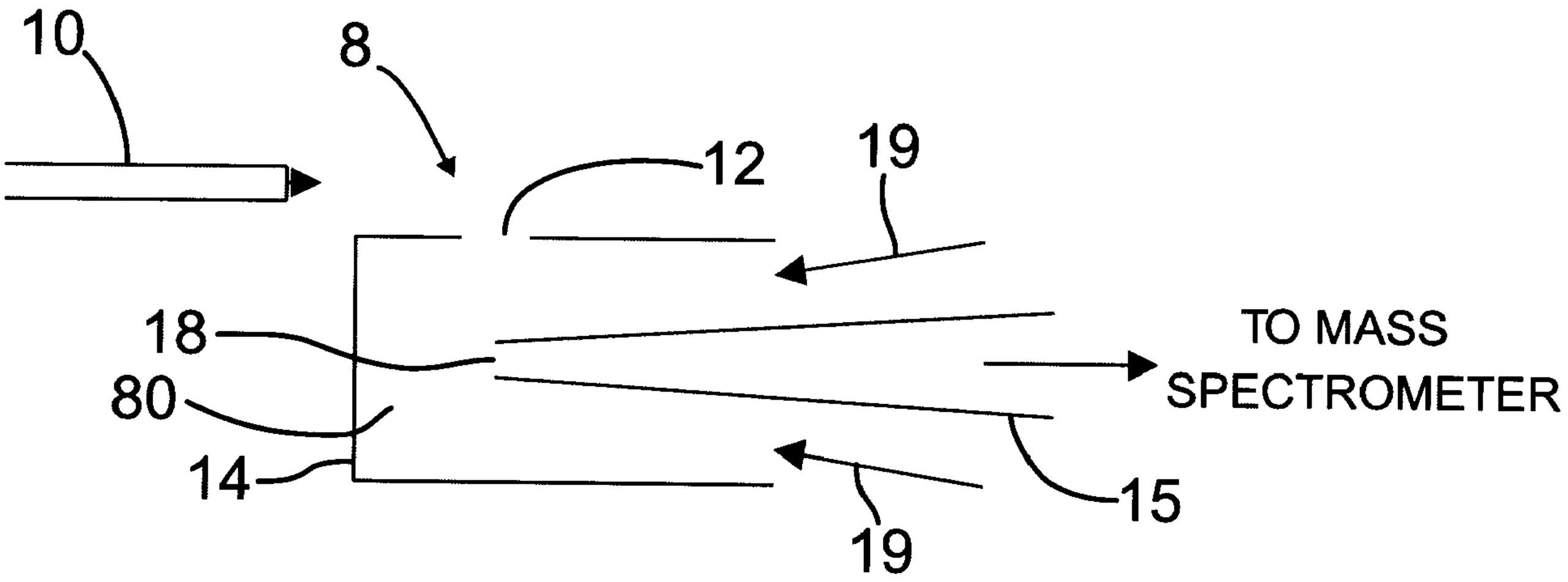

400
102
100
106
302
112a
111
110a
104
SUBSTANTIALLY ATMOSPHERIC PRESSURE
TO MASS SPECTROMETER (LOW PRESSURE)
114
110b
300
112b
116
103
118
101
102

FIGURE 13


10
8
12
19
18
80
14
TO MASS
SPECTROMETER
15
19