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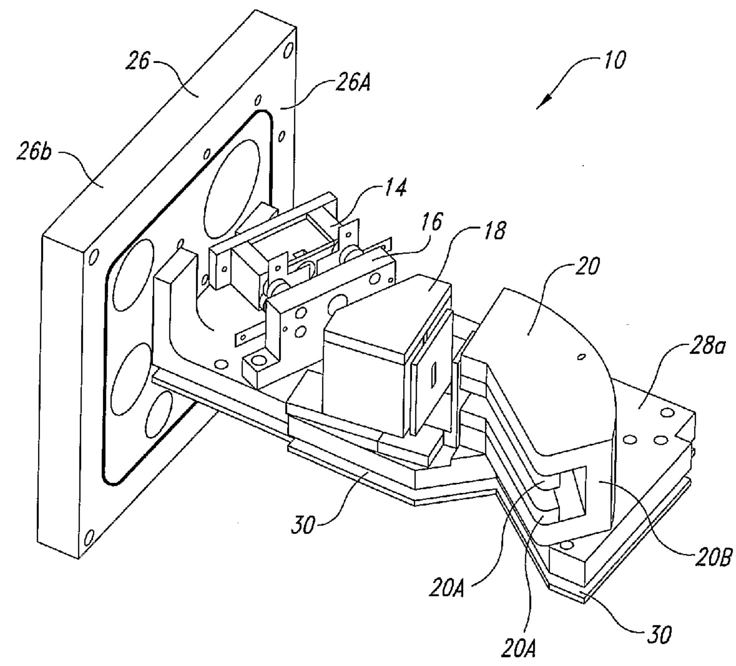
(54) Title: GAS CHROMATOGRAPH AND MASS SPECTROMETER



(57) Abstract: An integral gas chromatograph / mass spectrometer system is assembled by attaching a gas chromatograph assembly on one side and a mass spectrometer assembly on the other side of a master flange. The gas chromatograph assembly is accurately positioned on a holder board integrally connected to the master flange. The mass spectrometry assembly is accurately positioned on a base plate that is integrally connected to the master flange.

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GAS CHROMATOGRAPH AND MASS SPECTROMETER

CROSS-REFERENCES TO RELATED APPLICATION(S)

This application claims the benefit of U.S. Provisional Patent Application No. 60/557,920 filed on March 31, 2004; U.S. Provisional Patent Application No.60/557,969 filed on March 31, 2004; U.S. Provisional Patent Application No.60/550,663 filed on March 5, 2004; and U.S. Provisional Patent Application No. 60/550,664 filed on March 5, 2004 where these four provisional applications are incorporated herein by reference in their entireties.

BACKGROUND OF THE INVENTION

Field of the Invention

This disclosure generally relates to analytic instruments, and more particularly relates to gas chromatographs, and mass spectrometers and/or mass spectrographs.

Description of the Related Art

Mass spectrometry is widely used in many applications ranging from process monitoring to life sciences. Over the course of the last 60 years, a wide variety of instruments have been developed. The focus of new developments has been two fold: (1) a push for ever higher mass range with high mass resolution, and (2) on developing small, desktop mass spectrometry instruments.

Mass spectrometers are often coupled with gas chromatographs for analysis of complex mixtures. This is particularly useful for analysis of volatile organic compounds (VOCs) and semi-volatile organic compounds (semi-VOCs). A combined gas chromatograph and mass spectrometer or spectrograph (GC/MS) instrument typically includes a gas inlet system, which may include the gas chromatograph portion of the GC/MS instrument. The GC/MS instrument typically also includes an electron impact (EI) based ionizer with ion extractor, ion optic components to focus the ion beam, ion separation components, and ion detection components. Ionization can also be carried out via chemical ionization.

Ion separation can be performed in the time or spatial domain. An example for mass separation in the time domain is a time of flight mass spectrometer. Spatial separation is seen in commonly used quadrupole mass spectrometers. Here a “quadrupole filter” allows only one mass/charge ratio to be transmitted from the ionizer to the detector. A full mass spectrum is recorded by scanning the mass range through a “mass filter.” Other spatial separation approaches are based on magnetic fields, where either ion energy or magnetic field strength is varied, the mass filter allowing only one mass/charge ratio to be transmitted. A spectrum can be recorded by scanning through the mass range.

One type of mass spectrometer is a mass spectrograph. In a mass spectrograph the ions are spatially separated in a magnetic field and detected with a position sensitive detector. The concept of a double focusing mass spectrograph was first introduced by Mattauch and Herzog (MH) in 1940 (J. Mattauch, Ergebnisse der exakten Naturwissenschaften, vol. 19, pages 170-236, 1940).

Double focusing refers to the ability of an instrument to refocus both the energy spread as well as the spatial beam spread. Modern developments in magnet and micro-machining technologies allow dramatic reductions in the size of these instruments. The length of the focal plane in a mass spectrograph capable of VOC and semi-VOC analysis is reduced to a few centimeters.

Some typical specifications of a small confocal plane layout Mattauch-Herzog instrument are summarized below:

Electron impact ionization, Rhenium filament
DC-voltages and permanent magnet
Ion Energy: 0.5-2.5 kV DC
Mass Range: 2-200 D
Faraday cup detector array or strip charge detector
Integrating operational amplifier with up to 10^{11} gain
Duty Cycle: > 99%
Read-Out time: 0.03 sec to 10 sec

Sensitivity: approximately 10ppm with strip charge detector.

In addition, the ion optic elements are mounted in the vacuum chamber floor or on chamber walls. The ion optic elements can also be an integral part of the vacuum housing. In small instruments, the ion optic elements can be built on a base plate which acts as an "optical bench" to support the ion optic elements. The base plate is mounted against a vacuum or master flange to provide a vacuum seal needed to operate the mass spectrometer under vacuum. The base plate can also function as the vacuum or master flange itself.

A Mattauch-Herzog ion detector is a position sensitive detector. Numerous concepts have been developed over the last decades. Recent developments focus on solid state based direct ion detection as an alternative to previously used electro optical ion detection (EOID).

EOID employs a multi-channel-plate (MCP) to convert ions into electrons, amplify the electrons, and illuminate a phosphorus film by bombarding the phosphorus film with the electrons emitted from the MCP. The image formed on phosphorus film is recorded using a photo diode array, for example, via a fiber optic coupler. This type of EOID is described in detail in U.S. Patent 5,801,380.

The EOID is intended for the simultaneous measurement of ions spatially separated along the focal plane of the mass spectrometer. The EOID operates by converting ions to electrons and then to photons. The photons form images of the ion-induced signals. The ions generate electrons by impinging on a micro-channel electron multiplier array. The electrons are accelerated to a phosphor-coated fiber-optic plate that generates photon images. These images are detected using a photo detector array such as the photo diode array. The EOID, although highly advantageous in many ways, is relatively complicated since it requires multiple conversions. In addition, there may be complications from the use of phosphors, which may limit the dynamic range of the detector. The micro-channel device may also be complicated, since it may require a high-voltage, for example 1 KV, to be applied. In addition, the micro-channel device may be placed in a vacuum environment with a pressure of about 106 Torr. The micro-channel device may experience ion feedback and electric discharge when operating at such high pressures. Additionally, fringe magnetic fields may affect the electron trajectory. Isotropic phosphorescence emission may also affect the resolution. The resolution of the mass analyzer may therefore be compromised due to these and other effects.

According to a different configuration, a direct charge measurement can be based on a micro-machined Faraday cup detector array (FCDA). Here, an array of individually addressable Faraday cups monitors the ion beam. The charge collected in individual elements of the array is provided to an amplifier via a multiplexer unit. This layout reduces the number of amplifiers and feedthroughs needed. This concept is described in detail in recent publications, such as "A. A. Scheidemann, R. B. Darling, F. J. Schumacher, and A. Isakarov, Tech. Digest of the 14th Int. Forum on Process Analytical Chem. (IFPAC-2000), Lake Las Vegas, Nevada, Jan. 23-26, 2000, abstract 1-067"; "R. B. Darling, A. A. Scheidemann, K. N. Bhat, and T.-C. Chen., Proc. of the 14th IEEE Int. Conf. on Micro Electro Mechanical Systems (MEMS-2001), Interlaken, Switzerland, Jan. 21-25, 2001, pp. 90-93"; and Non-Provisional Patent Application 09/744,360 titled "Charged Particle Beam Detection System."

Other references discussing mass spectrometers include "Nier, D. J. Schlutter Rev. Sci. Instrum. 56(2), page 214-219, 1985; and T. W. Burgoyne et. al. J. Am. Soc. Mass Spectrum 8, pages 307-318, 1997.

Alternatively, a flat metallic strip referred to as a strip charge detector (SCD) positioned on a grounded and insulated background can be used to monitor the ion beam. This is particularly suitable for low energy ions. Again the charge is provided to an amplifier via a multiplexer.

Another embodiment of an ion detector array is disclosed in U.S. Patent 6,576,899 and is referred to as a shift register based direct ion detector.

The shift register based direct ion detector defines a charge sensing system that can be used in a GC/MS instrument, with a modification to allow direct measurement of ions in the mass spectrometer device without conversion to electrons and photons (*e.g.*, EOID prior to measurement). The ion detector may use charge coupled device (CCD) technology employing metal oxide semiconductors. The GC/MS instrument may use direct detection and collection of the charged particles using the ion detector. The detected charged particles form the equivalent of an image charge that directly accumulates in a shift register associated with a part of the CCD. This signal charge can be clocked through the CCD in a conventional way, to a single output amplifier. Since the CCD uses only one charge-to-voltage conversion amplifier for the entire detector, signal gains and offset variation of individual elements in the detector array are minimized.

In a Mattauch-Herzog detector array which can be composed of a FCDA, a SCD, or another type of the aforementioned detectors, is placed at the exit end of the magnet, which is commonly referred to as the "focal plane."

The FCDA can be made by deep reactive ion etching (DRIE). The SCD can be made by vapor deposition. A dice with an active element (FCDA or SCD) is usually cut out of a wafer with conventional techniques such as laser cutting or sawing.

The FCDA or SCD dice is placed in front of the magnet and electrically connected to the multiplexer and amplifier unit, which is referred to as a "FARADAY CUP DETECTOR ARRAY" - "INPUT/OUTPUT" - "PRINTED CIRCUIT BOARD" (FCDA-I/O-PCB), to read out the charge collected with the detector elements.

Patents discussing mass spectrometers and gas chromatographs include U.S. Patent 5,317,151, U.S. Patent 5,801,380, U.S. Patent 6,182,831, U.S. Patent 6,191,419, U.S. Patent 6,403,956, and U.S. Patent 6,576,899.

Figure 1 shows a double focusing Mattauch-Herzog mass spectrometer assembly 10 with a gas chromatograph assembly 12. The gas chromatograph assembly 12 comprises a sample injector valve V, which has an entry port S for introduction of the sample, an exit port W for the waste after the sample has been vaporized and/or decomposed, typically by heat. The sample to be analyzed (referred to as analyte) is carried by a carrier gas to a column M (capillary tube, usually coated with polymeric materials). The carrier gas may be inert (*e.g.*, helium), or may not be inert. The constituents of the analyte are separated by different absorption rates on the wall of the column M, which has a rather small inside diameter, for example on the order of about 50 -- 500 μm. The carrier gas flows typically at 2-5 atm. cm^3/sec. The constituents of the analyte are received by the ionizer 14 of the mass spectrometer 10 for further spectrometric analysis.

A larger bore of the capillary tube corresponds to a larger bore of the vacuum pump in the mass spectrometer core. A smaller bore of the capillary tube causes narrower peaks of the effluent to be even more narrow, which is indicative of a large loss of signal. A compromise for this problem is addressed by U.S. Patent 6,046,451.

The double focusing mass spectrometry assembly 10 comprises an ionizer 14, a shunt and aperture 16, an electrostatic energy analyzer 18, a magnetic section 20, and a focal plane section 22.

In traditional Mattauch-Herzog instruments the ion optics are placed on the vacuum chamber wall, and the position sensitive ion detector is mounted on the exit flange of the ion flight path. This arrangement is required as a result of having the magnet outside of the vacuum. The multiplexer and amplifier unit is also positioned outside of the vacuum chamber in the case of traditional Mattauch-Herzog instruments.

There are many problems associated with traditional combined GC/MS instruments, due mainly to the fact that the gas chromatograph and the mass spectrometer are separate units. The separate units have separate power supplies, separate, input/output devices, as well as other components, making them heavier and cumbersome. In addition, the analyte has to be transferred from the gas chromatograph to the mass spectrometer, necessitating special handling of the capillary tube, which is very sensitive, and therefore difficult to connect between the two separate instruments.

BRIEF SUMMARY OF THE INVENTION

This disclosure relates to a GC/MS system that includes a master flange comprising a vacuum feed-through, the master flange having a first side and a second side; a holder board integrally connected to the second side of the master flange; a base plate integrally connected to the first side of the master flange; a chromatograph supported on the holder board; and an mass spectrometry assembly of an ionizer, shunt and aperture group, electrostatic energy analyzer, magnetic section, and a focal plane section comprising an ion detector, all supported on the base plate.

In one aspect, a gas chromatograph and a mass spectrometer are assembled into one unit where all parts of the gas chromatograph are placed on a holder board and all the parts of the mass spectrometer are placed on a base plate. Both the holder board and the base plate are integral parts of a vacuum or master flange.

In another aspect, an analytic instrument includes a master flange comprising a first side, a second side, and a vacuum feed-through passage extending between the first side and the second side; a holder board coupled to the second side of the master flange; a base plate coupled to the first side of the master flange; a gas chromatograph coupled to the holder board; and a mass spectrometer assembly supported by the base plate, the mass spectrometer assembly having an ionizer, a shunt and aperture group, an electrostatic energy analyzer, a magnetic section, and a focal plane section, which includes an ion detector, wherein the ionizer receives an analyte via the vacuum feed-through passage of the master flange.

In yet another aspect, an analytic system includes a gas chromatograph assembly; a vacuum housing; a mass spectrometer assembly at least partially received within the vacuum housing; a flange having a first side, a second side opposed to the first side, and a passage extending from the first side to the second side to permit the transfer of an analyte from the gas chromatograph assembly to the mass spectrometer assembly; a first extension securely connected to the first side of the flange and supportingly engaging the gas chromatograph assembly; and a second extension securely connected to a second side of the flange and supportingly engaging the mass spectrometer assembly.

In still yet another aspect, a method of assembling a gas chromatograph assembly and mass spectrometer assembly includes securely coupling a first extension to a first side of a flange, the flange having the first side, a second side, and a passage extending from the first side to the second side to permit the transfer of an analyte from the gas chromatograph assembly to the mass spectrometer assembly; supporting the gas chromatograph assembly on the first extension; securely coupling the second extension to the second side of the flange; supporting the mass spectrometer assembly on the second extension; and affixing a vacuum housing to the flange, the vacuum housing configured to encompass the mass spectrometer assembly and the second extension.

In addition, the master flange can include electrical connectors for electrical transfer between the first side and the second side of the master flange.

In one embodiment, a vacuum housing is supported on the first side of the master flange so that a vacuum can be applied to the mass spectrometry assembly. One or more pumps, in series or in parallel, may be connected to the vacuum housing.

In another embodiment, the GC/MS assembly includes a GC controller disposed under the holder board and may further include a MCP/CCD controller.

In yet another embodiment, the GC/MS assembly includes a valve block (sample injector valve) and a transfer line, which is aligned with the vacuum feed-through.

BRIEF DESCRIPTION OF THE SEVERAL VIEWS OF THE DRAWINGS

In the drawings, identical reference numbers identify similar elements or acts. The sizes and relative positions of elements in the drawings are not necessarily drawn to scale. For example, the shapes of various elements and angles are not drawn to scale, and some of these elements are arbitrarily enlarged and positioned to improve drawing legibility. Further, the particular shapes of the elements as drawn, are not intended to convey any information regarding the actual shape of the particular elements, and have been solely selected for ease of recognition in the drawings.

Figure 1 is a schematic view of a Mattauch Herzog spectrometer connected to a gas chromatograph according to the prior art, wherein the two instruments are separate units.

Figure 2 is a perspective view of a GC/MS instrument according to one illustrated embodiment, where a gas chromatograph and a vacuum housing are integrally connected to a master flange.

Figure 3 is an isometric view of a portion of the mass spectrometer within the vacuum housing including a base plate, an ionizer, an electrostatic energy analyzer, and a magnetic section.

DETAILED DESCRIPTION OF THE INVENTION

As aforementioned, the illustrated embodiments are related to integral assemblies of GS/MC instruments.

In the following description, certain specific details are set forth in order to provide a thorough understanding of various embodiments of the invention. However, one skilled in the art will understand that the invention may be practiced without these details. In other instances, well-known structures associated with gas chromatograph and mass spectrometer assemblies, such as those described above and/or referenced herein, have not necessarily been illustrated or described in detail to avoid unnecessarily obscuring descriptions of the embodiments of the invention.

Unless the context requires otherwise, throughout the specification and claims which follow, the word “comprise” and variations thereof, such as, “comprises” and “comprising” are to be construed in an open, inclusive sense, that is as “including, but not limited to.”

The terms “integral,” “integral connection,” “connect,” and/or variations thereof as used herein refers to a means for achieving a secure connection, which may be accomplished by bolts, screws, or other mechanical means, such that the relative position of the connected components remains substantially fixed during operation of the GS/MS instrument.

The headings provided herein are for convenience only and do not interpret the scope or meaning of the claimed invention.

Figures 2 and 3 show an analytical instrument in the form of a GC/MS instrument 1 according to the illustrated embodiment. The GC/MS instrument 1 comprises a master flange 26 with a first side 26A, a second side 26B, and a vacuum feed-through 4 extending from the first side 26A to the second side 26B.

A holder board 28B having a support side extension 28C is integrally connected to the second side 26B of the master flange 26. A base plate 28A is integrally connected to the first side 26A of the master flange 26.

A gas chromatograph assembly 12 (Figure 2) is supported on the holder board 28B, and a mass spectrometry assembly 10 (Figure 3) is supported on the base plate 28A, in very well defined and predetermined positions.

A sample injector valve V with a lid 13 is attached to the exterior of the gas chromatograph assembly 12.

Inside the gas chromatograph assembly 12, a microbore column or capillary tube (not shown) originates at the sample injector valve V and ends into a transfer line 2. The transfer line 2 is aligned with the vacuum feed-through 4, and is coupled to the vacuum feed-through 4, at least during operation. The vacuum feed-through 4 is connected to an inlet of the ionizer 14 of the mass spectrometry assembly 10 on the other side of the master flange 26.

The gas chromatograph assembly 12 can also include a means for stabilizing the temperature of the microbore column (not shown) within a desired range.

The master flange can include electrical connectors 5 for electrical power transfer between the first side 26A and the second side 26B of the master flange 26.

A vacuum housing 27 may be supported on the first side 26A of the master flange, so that a vacuum can be applied to the components of the mass spectrometry assembly 10.

The GC/MS instrument 1 may further include a gas chromatograph controller 6 disposed under the holder board 28B and/or an MCP/CCD controller 7, as previously described.

One or more pumps (not shown for purposes of clarity), connected in series or in parallel, may be connected to a bottom region of the vacuum housing 27 on the side of the MCP/CCD controller 7.

Referring to Figure 3, the major components or the Mattauch-Herzog Sector of a miniaturized mass spectrometer assembly 10 are shown to be located on the first side 26A of the master flange 26 according to the illustrated embodiment. The base plate 28A is supported on the first side 26A of the master flange 26. The vacuum housing 17 covers the vacuum space within which the major components of the mass spectrometer assembly 10 are residing. Using the base plate 28A to support the components of the mass spectrometry assembly 10 results in a sturdy and accurate configuration.

The ionizer 14 is secured on the base plate 28A, close to the vacuum flange 26, with a shunt and aperture combination 16 in front of the ionizer 14. Further from the flange 26 is an electrostatic energy analyzer 18, which is also secured on the base plate 28.

A magnetic sector or magnetic section 20 is also secured on the base plate 28. The magnetic sector 20 comprises a yoke 20B and magnets 20A attached to the yoke 20B. In one embodiment, the yoke has magnetic flux saturation value in the range of about 15,000 G to 20,000 G. The yokes 20B can be made from a hyperco-51A VNiFe alloy.

The volume and mass of a magnet is typically inversely proportional to the energy product value of the magnetic material. A typical magnetic material is AlNiCo V (Aluminum Nickel Cobalt), which has an energy product of about 5-6 MGOe. Other materials include, but are not limited to Sm-Co (Samarium Cobalt) alloys and Nd-B-Fe (Neodymium Boron Iron) alloys. Some of these materials, in particular Nd-B-Fe, may be sensitive to temperature variations. Thus, methods for temperature compensation may be necessary to avoid frequent instrument calibrations and other temperature related problems. One way to compensate for temperature variations is described in U.S. Patent 6,403,956.

During operation of the GC/MS instrument 1, a sample of a substance to be analyzed is introduced to the sample injector valve V and at least part of it is decomposed or vaporized. The resulting analyte is carried by a gas, which may be inert such as helium for example, or not inert, to the capillary tube inside the gas chromatograph assembly 12, where its constituents are separated by different absorption rates on the wall of the capillary tube. The analyte then passes through the transfer line 2 and the vacuum feed-through 4 to the ionizer 14 where it is bombarded by electrons to produce ions. The ions are focused in the shunt and aperture section 16 to form an ion beam 24. The ions are then separated according to their charge/mass ratio as the ion beam travels through the electrostatic energy analyzer 18 and the magnetic section 20. The ions with a desired charge/mass ratio are then detected by the focal plane section 22. The focal plane section 22 is described in U.S. Patent 5,801,380. The operation takes place under vacuum of the order of about 10^{-5} Torr with a use of a vacuum pump (not shown).

The GC/MS instrument 1 is a single integral unit with the mass spectrometer assembly 10 under vacuum and the gas chromatograph assembly 12 under atmospheric pressure. The close proximity of all the components produces a robust system and substantially reduces a considerable amount of electronic and electromagnetic noise that two separate units present.

Further, the GC/MS instrument 1 described herein may include other advantages, such as:

(1) The system may be more compact than two combined systems;

(2) The system may be lighter in weight;

(3) If the mass spectrometry assembly is taken out of the vacuum housing, the gas chromatograph assembly does not need to be separated from the mass spectrometry assembly;

(4) It may be possible to check the location of the column after the entire GC/MS instrument 1 is put together;

(5) The GC/MS instrument 1 is easy to assemble and disassemble;

(6) Low cost;

(7) The electronics to drive the gas chromatograph function are located directly under the gas chromatograph assembly. Thus, the cables are short, and noise pick-up (*e.g.*, from the sensitive thermo-sensors) will be limited;

(8) Tests of the gas chromatograph functionality (such as heat on/off, gas chromatograph lid open/close, valve(s) open/close, can be tested while the has chromatograph assembly is outside the GC/MS instrument 1. The only cable connector needed may be an extension cable for supply of the inputs to the gas chromatograph driver, and main power (*e.g.*, 24 V);

(9) In case of failure, the entire gas chromatograph assembly 12 can readily be exchanged:

    a) Open vacuum feed-through 10; and

    b) Separate the gas chromatograph-holder board (6) from the master flange (two screws).

    c) Such an exchange maintains the gas chromatograph and gas chromatograph electronics together during removal and replacement, which permits easy service and reduces assembly cost.

In addition to the embodiments described herein, the following devices and/or assemblies may be combined with the disclosed embodiments in a variety of ways.

Although the embodiments presented above refer to specific types of ion detectors such as Strip Charge Detector Arrays, Faraday Cup Detector Arrays, and Shift Register Based Direct Ion Detection Chips, it is understood and appreciated that any type of ion detector arrays may be used.

The various embodiments described above can be combined to provide further embodiments. All of the above U.S. patents, U.S. patent application publications, U.S. patent applications, foreign patents, foreign patent applications and non-patent publications referred to in this specification and/or listed in the Application Data Sheet including but not limited to U.S. Provisional Patent Application No. 60/557,920 ; U.S. Provisional Patent Application No.60/557,969 ; U.S. Provisional Patent Application No.60/550,663 ; and U.S. Provisional Patent Application No. 60/550,664 ; U.S. Patent No. 5,801,380; U.S. Non-Provisional Patent Application No. 09/744,360; U.S. Patent No. 6,576,899; U.S. Patent No. 5,317,151, U.S. Patent No. 5,801,380, U.S. Patent No. 6,182,831, U.S. Patent No. 6,191,419, U.S. Patent No. 6,403,956; and U.S. Patent No. 6,046,451, are incorporated herein by reference, in their entirety.

In addition, the published materials by J. Mattauch, Ergebnisse der exakten Naturwissenschaften, vol. 19, pages 170-236, 1940; A. A. Scheidemann, R. B. Darling, F. J. Schumacher, and A. Isakarov, Tech. Digest of the 14th Int. Forum on Process Analytical Chem. (IFPAC-2000), Lake Las Vegas, Nevada, Jan. 23-26, 2000, abstract 1-067"; "R. B. Darling, A. A. Scheidemann, K. N. Bhat, and T.-C. Chen., Proc. of the 14th IEEE Int. Conf. on Micro Electro Mechanical Systems (MEMS-2001), Interlaken, Switzerland, Jan. 21-25, 2001, pp. 90-93; Nier, D. J. Schlutter Rev. Sci. Instrum. 56(2), page 214-219, 1985; and T. W. Burgoyne et. al., J. Am. Soc. Mass Spectrum 8, pages 307-318, 1997, are incorporated by reference in their entirety.

Aspects of the invention can be modified, if necessary, to employ devices, features, and concepts of the various patents, applications and publications to provide yet further embodiments of the invention. These and other changes can be made to the invention in light of the above detailed description. In general, in the following claims, the terms used should not be construed to limit the invention to the specific embodiments disclosed in the specification and the claims, but should be construed to include all GS/MS instruments that operate in accordance with the claims. Accordingly, the invention is not limited by the disclosure, but instead its scope is to be determined entirely by the following claims.

CLAIMS

1. An analytic instrument, comprising:

a master flange comprising a first side, a second side, and a vacuum feed-through passage extending between the first side and the second side;

a holder board coupled to the second side of the master flange;

a base plate coupled to the first side of the master flange;

a gas chromatograph coupled to the holder board; and

a mass spectrometer assembly supported by the base plate, the mass spectrometer assembly having an ionizer, a shunt and aperture group, an electrostatic energy analyzer, a magnetic section, and a focal plane section, which includes an ion detector, wherein the ionizer receives an analyte via the vacuum feed-through passage of the master flange.

2. The analytic instrument of claim 1, further comprising:

a vacuum housing supported on the first side of the master flange.

3. The analytic instrument of claim 2, further comprising:

a pump connected to the vacuum housing.

4. The analytic instrument of claim 1, further comprising:

at least one electrical connector to transfer electrical signals across the master flange.

5. The analytic instrument of claim 1, further comprising:

a controller disposed under the holder board.

6. The analytic instrument of claim 1, further comprising:

an inlet to receive a sample to be analyzed by the system.

7. The analytic instrument of claim 6, further comprising:

a transfer line aligned with the vacuum feed-through passage of the master flange, the transfer line in fluid communication with the inlet.

8. An analytic system comprising:

a gas chromatograph assembly;

a vacuum housing;

a mass spectrometer assembly at least partially received within the vacuum housing;

a flange having a first side, a second side opposed to the first side, and a passage extending from the first side to the second side to permit the transfer of an analyte from the gas chromatograph assembly to the mass spectrometer assembly;

a first extension securely connected to the first side of the flange and supportingly engaging the gas chromatograph assembly; and

a second extension securely connected to a second side of the flange and supportingly engaging the mass spectrometer assembly.

9. The analytic system of claim 8 wherein the mass spectrometer assembly includes an ionizer.

10. The analytic system of claim 9, further comprising:

a transfer line aligned with at least a portion of the passage in the flange, the transfer line communicates with the ionizer through the passage in the flange.

11. The analytic system of claim 10, further comprising:

a sample injector valve to receive an analytical sample, the sample injector valve connected to the transfer line.

12. The analytic system of claim 11 wherein the gas chromatograph assembly includes a column in communication with the sample injector valve.

13. The analytic system of claim 12 wherein the column is positioned in the system such that its location is visually verifiable.

14. The analytic system of claim 8, further comprising:

means for stabilizing a temperature within the gas chromatograph assembly.

15. The analytic system of claim 8, further comprising:

an electrical connector extending from the first extension to the second extension to transfer power across the flange.

16. The analytic system of claim 8, further comprising:

means for transferring power across the master flange.

17. The analytic system of claim 8 wherein the mass spectrometer assembly is a double focusing mass spectrometer.

18. The analytic system of claim 8 wherein the gas chromatograph assembly is selectively removable from the mass spectrometer assembly by disconnecting the first extension from the first side of the flange.

19. A method of assembling a gas chromatograph assembly and mass spectrometer assembly comprising:

securely coupling a first extension to a first side of a flange, the flange having the first side, a second side, and a passage extending from the first side to the second side to permit the transfer of an analyte from the gas chromatograph assembly to the mass spectrometer assembly;

supporting the gas chromatograph assembly on the first extension;

securely coupling the second extension to the second side of the flange;

supporting the mass spectrometer assembly on the second extension; and affixing a vacuum housing to the flange, the vacuum housing configured to encompass the mass spectrometer assembly and the second extension.

20. The method of claim 19 wherein supporting the mass spectrometer assembly on the second extension includes placing an ionizer in a close relationship with the flange.

21. The method of claim 19, further comprising:

placing a gas chromatograph controller under the second extension.

22. The method of claim 19, further comprising:

arranging electrical connectors from the first side to the second side of the flange.

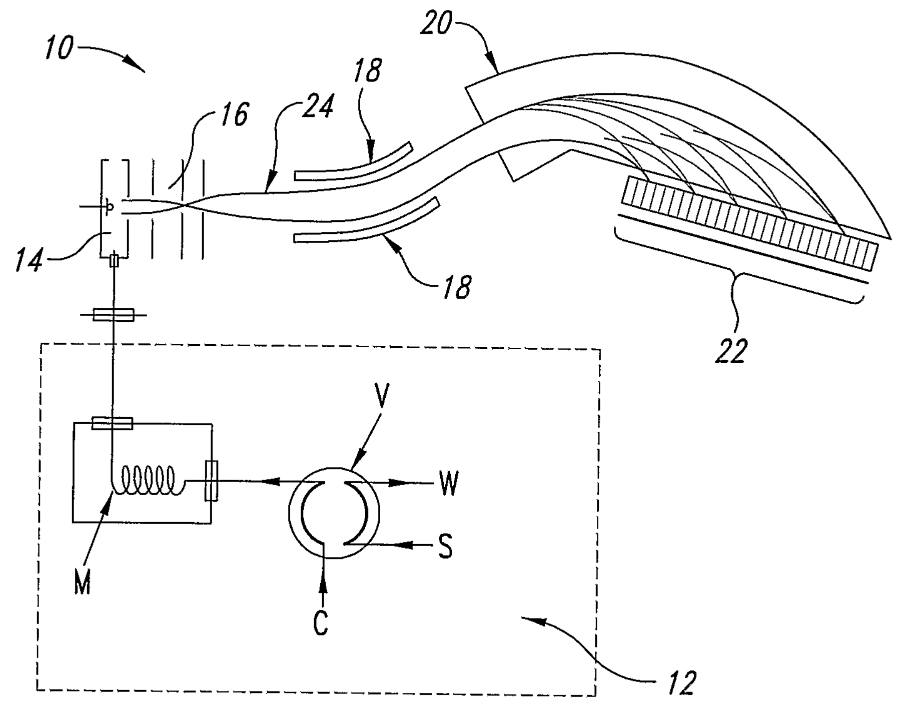

FIG. 1
(Prior Art)

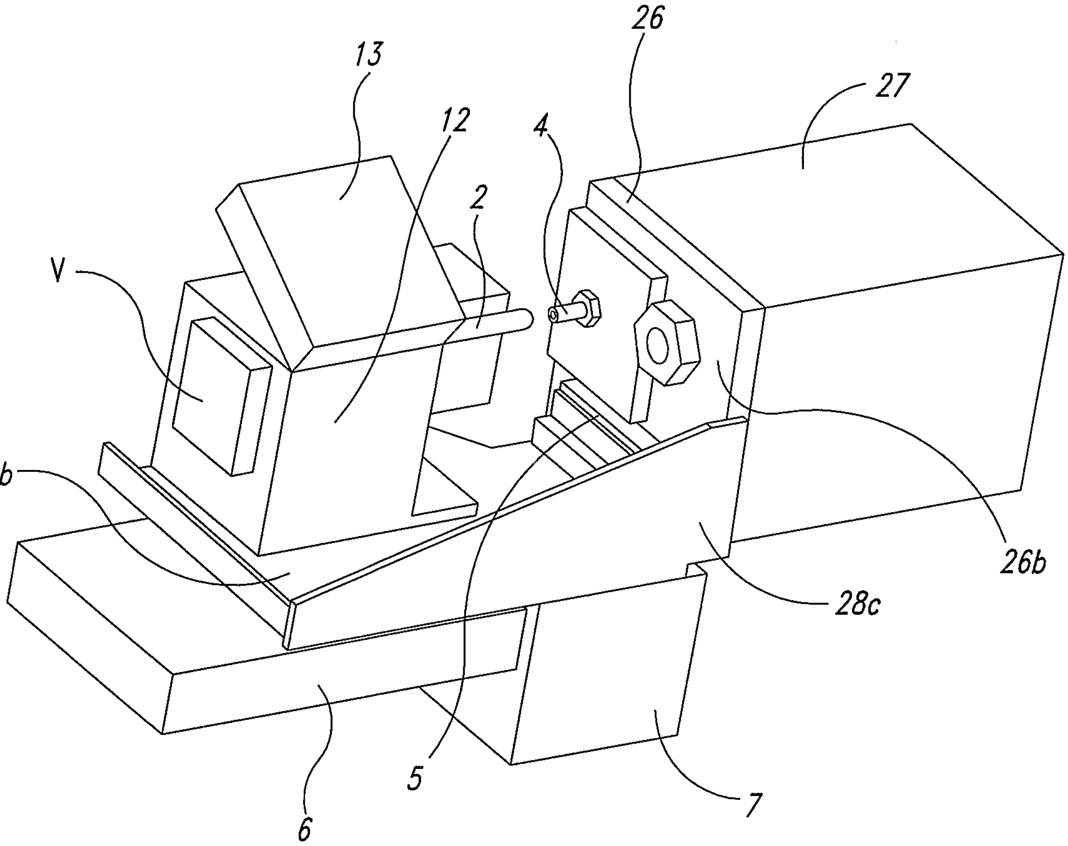

FIG. 2

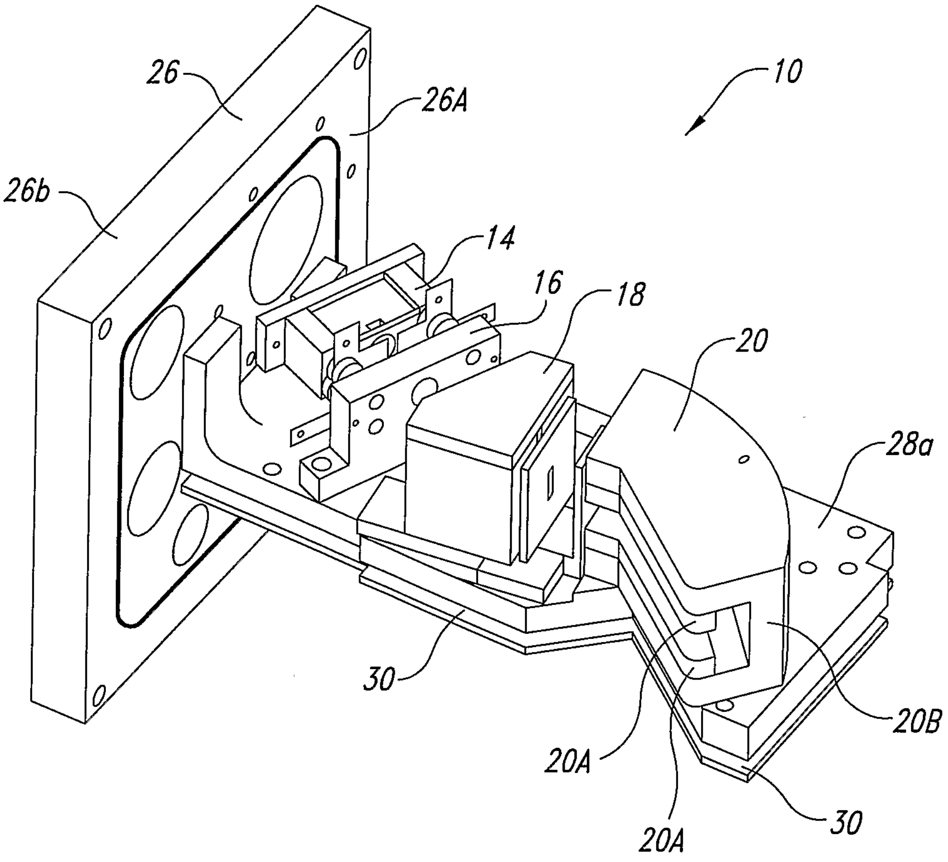

FIG. 3