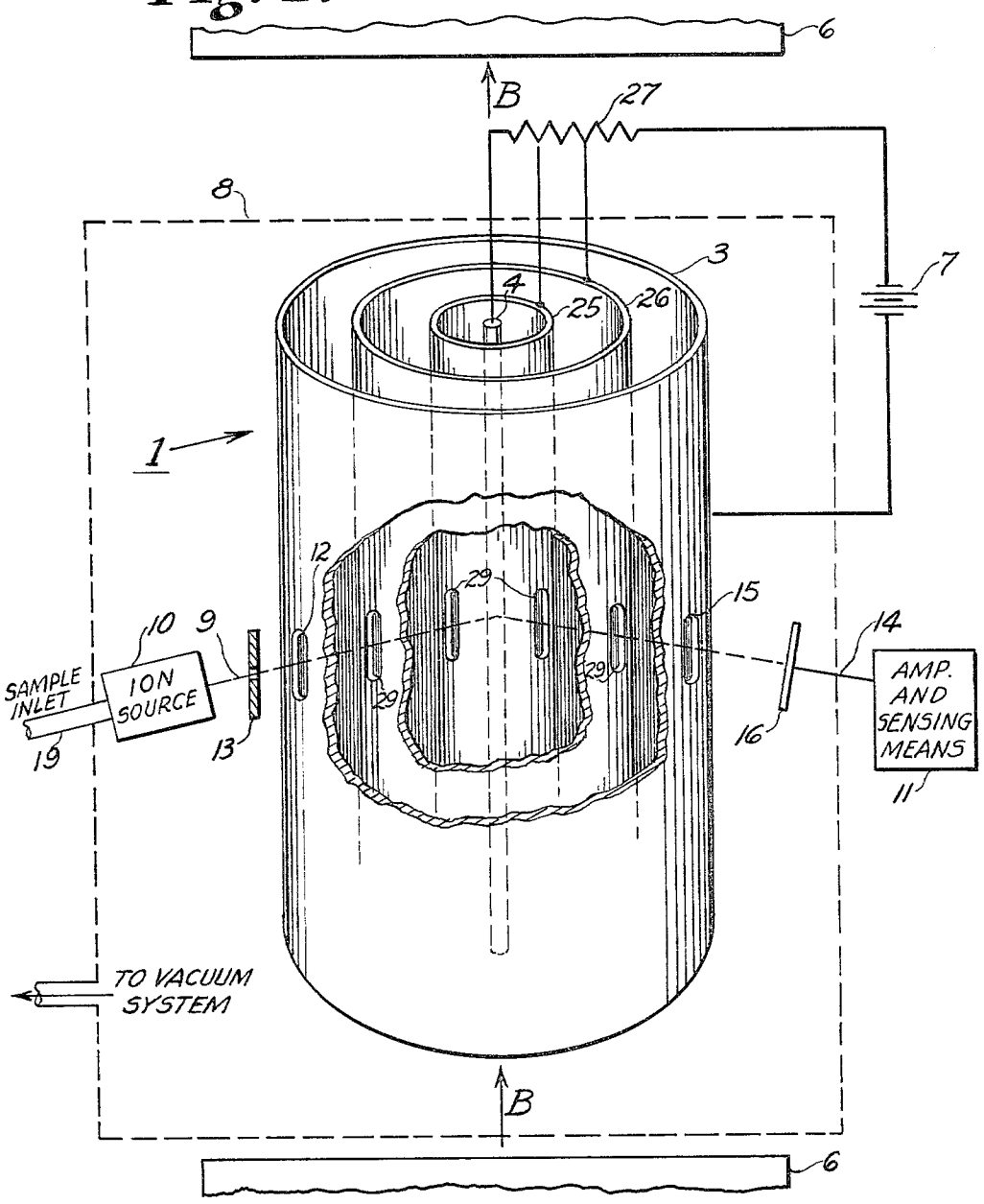
March 8, 1966 HANS GEORG NÖLLER 3,239,662

MASS SPECTROMETER HAVING A CONCENTRIC CYLINDRICAL ELECTRODE STRUCTURE

Filed Sept. 30, 1963 2 Sheets-Sheet 1

Fig. 1.



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Filed Sept. 30, 1963 2 Sheets-Sheet 2

Fig. 2.

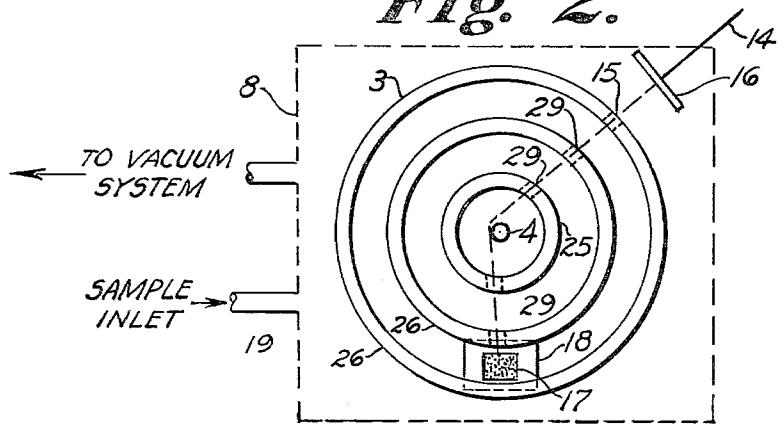
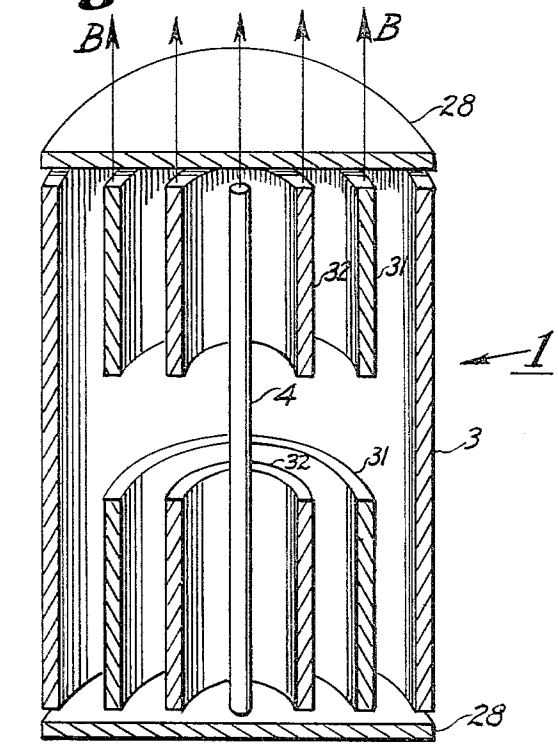


Fig. 3.



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United States Patent Office 3,239,662 Patented Mar. 8, 1966

3,239,662

MASS SPECTROMETER HAVING A CONCENTRIC CYLINDRICAL ELECTRODE STRUCTURE

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Filed Sept. 30, 1963, Ser. No. 313,723
Claims priority, application Germany, Oct. 9, 1962, L 43,148
10 Claims. (Cl. 250—41.9)

This invention relates to a mass spectrometer and is particularly suited for use as a vacuum leak detector.

Mass spectrometers are known in which ions are created by electron collision and in which these ions are subjected to electric and magnetic fields. By these means there occurs a spatial separation of the ions according to their masses so that ions of a certain mass are collected on a collector electrode and thereby measured. For example, magnetic sector field mass spectrometers are known in which the ions are directed through focusing electric and magnetic fields in succession before collection by a collecting electrode. Also known are cycloidal mass spectrometers in which the ions are simultaneously subjected to a homogenous electric and to a homogenous magnetic field before collection. These known devices have in general suffered from one or more of the following disadvantages: low sensitivity, excessive size, high cost, etc.

The objective of this invention is to provide a mass spectrometer which is simpler, smaller, less expensive, and exhibits a high sensitivity so that components with very small partial pressure can be determined in a gas mixture.

One feature of this invention is the provision of a crossed field mass spectrometer wherein a cylindrical condenser provides a cylindrically symmetrical electrical field whose axis of symmetry is parallel to an applied magnetic force.

Another feature of this invention is the provision of a mass spectrometer of the above-featured type which includes an electron source for producing ionization within the outer electrode of the cylindrical condenser.

Another feature of this invention is the provision of a mass spectrometer of the first featured type which includes an ion source for directing a beam of ions into the electric field produced by the cylindrical condenser.

Another feature of this invention is the provision of a mass spectrometer of the above-featured type wherein the outer electrode of the cylindrical condenser is provided with an aperture for the injection of an ion beam and an aperture for the withdrawal of an ion signal.

Another feature of this invention is the provision of a mass spectrometer of the above-featured types including an apertured cylindrical electrode baffle which is concentrically positioned between the electrodes of the cylindrical condenser and is selectively apertured to allow passage of ions having a desired mass.

Another feature of this invention is the provision of a cylindrical condenser mass spectrometer including cylindrical focusing electrodes which are concentrically positioned between the electrodes of the cylindrical condenser and are symmetric about the center thereof.

These and other objects and features of the present invention will become more apparent upon a perusal of the following specifications taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic drawing of a preferred embodiment of the present invention and includes a partially cut-away isometric view of the cylindrical condenser portion thereof;

FIG. 2 is a schematic drawing of another embodiment

showing a top view of the cylindrical condenser assembly shown in FIG. 1 and a modified ion source; and

FIG. 3 is a schematic drawing of another preferred embodiment of the present invention illustrating a modification of the cylindrical condenser assembly shown in FIGS. 1 and 2.

Referring now to FIG. 1, there is shown with the evacuable envelope 8 a cylindrical condenser 1 having an inner cylindrical electrode 4 coaxial and coextensive with the hollow outer cylindrical electrode 3. A voltage source 7 is connected between the outer electrode 3 and the inner electrode 4, and a magnetic field B is provided parallel to the central axis of cylindrical condenser 1 by the magnetic pieces 6.

Ions created or directed within the outer electrode 3 (in a manner described below) will move towards the inner electrode 4 under the influence of the cylindrically symmetrical electric field existing between the electrodes 3 and 4. They are, however, deviated from their path by the applied magnetic field so that with suitably selected field magnitudes the ions will move past the inner electrode 4 and again reach a point in the neighborhood of the outer electrode, whereby their velocity is again reduced towards zero. This process can be repeated as often as desired.

Since the deflection angle which is described by an ion when traversing such an orbit depends upon the specific mass of the ion in addition to the properties of the fields, the described arrangement can be used for separating ions according to mass. Furthermore, it is characteristic for this arrangement that the angle of the deflection is larger for ions of smaller mass. If, therefore, field strengths are selected to provide an orbit for a given mass which passes immediately adjacent to the center electrode, all ions of larger mass will hit the center electrode and be thereby eliminated. For this reason the present invention is particularly well suited for use in detecting ions of small mass and, therefore, for use in vacuum applications as a helium leak detector.

In the embodiment shown in FIG. 1 ionization of a sample gas occurs in the ion source 10 and the resultant ion beam 9 is directed into the cylindrical condenser 1 through an aperture 12 in the outer electrode 3. A focusing electrode 13 is used to direct the ion beam 9 through the aperture 12. The ions of the selected mass are deflected in a given path around the center electrode 4 and to a point near an aperture 15, which is situated at a predetermined position in the cylindrical surface of the outer electrode 3. The ions of selected mass are attracted through the outlet aperture 15 and collected by the collector electrode 16, which is located within the envelope 8. The conventional amplifier and ion current sensing device 11 is connected to the collector electrode 16 by the electrical lead 14. Ions having other than the selected mass will be collected by the inner electrode 4. This arrangement can also be used for the simultaneous measurement of several differing mass ions by having a plurality of outlet apertures and collector electrodes (not shown) positioned at suitable places along the outer electrode 3. Also, the mass spectrometer can be so operated that the ions of selected mass make only one oscillation within the outer electrode 3 before reaching the collector electrode 16, or they can run through several cycles before reaching a suitably positioned collector electrode and outlet aperture.

Ions can also be produced within the cylindrical condenser 1 as shown in FIG. 2 wherein the conventional electron source 18 is positioned within the envelope 8 and directs a beam of electrons 17 adjacent the inner surface of the outer electrode 3 and parallel to the applied magnetic field. The electron beam will cause ionization of the sample gas molecules which have entered the en-

velope 8 through the sample inlet 19 and the outer cylindrical electrode 3 through the open ends thereof. The resulting ions will respond to the crossed electric and magnetic fields in the manner described above.

For certain applications it is desirable to provide the cylindrical condenser 1 with the cylindrical baffle electrodes 17 and 18, 25 and 26, which are positioned between the inner and outer electrodes and are concentric therewith. The adjustable potentiometer 27 energizes the baffle cylinders 25 and 26 with a potential which corresponds to the electric field potential at their radial position. The apertures 29 are strategically located in the anticipated flight path of the ions having the selected mass. Thus, the ions of selected mass will be transmitted by the apertures 29 and permitted to exit through the outlet aperture 15 for collection by the collector electrode 16. Ions having other than the selected mass will be influenced into different flight paths so as to be intercepted by the solid portions of the baffle electrodes 25 and 26.

The embodiment shown in FIG. 3 is identical to that of FIG. 1 except that the baffle cylinders 25 and 26 are replaced by a pair of separated focusing electrode cylinders 31, 32 which are positioned symmetrically about the center point of the cylindrical condenser 1. In this embodiment each pair of focusing cylinders 31, 32 are given slightly more positive potentials than that of the electric field at their radial position. This enables the focusing electrodes to help focus ions toward the longitudinal center of the cylindrical condenser 1 in addition to collecting secondary electrons formed by the impingement of ions on the inner electrode 4. Additional longitudinal focusing of the ion beam 9 can be obtained with the spaced end electrodes 28, which are at a slightly more positive potential than the outer electrode 3.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is, therefore, to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A mass spectrometer apparatus comprising a solid outer cylindrical electrode, an inner cylindrical electrode positioned within and concentric with said solid outer cylindrical electrode, means for applying a potential between said solid outer cylindrical electrode and said inner cylindrical electrode so as to produce a cylindrically symmetrical electric field therebetween, means for directing a magnetic field in the area between said solid outer cylindrical electrode and said inner cylindrical electrode in a direction parallel to the center axis of the cylindrically electric field, means to provide a supply of ions within said solid outer cylindrical electrode, the cylinder surface of said solid outer cylindrical electrode having an outlet aperture to allow ions of a given mass to pass out of said solid outer cylindrical electrode, and ion collector means positioned outside said solid outer cylindrical electrode for detecting said ions of a given mass.

2. The apparatus according to claim 1 including a cylindrical electrode baffle positioned between said outer cylindrical electrode and said inner cylindrical electrode, means for applying a potential to said cylindrical electrode baffle, and wherein said cylindrical electrode baffle is provided with apertures positioned to allow passage of ions having the given mass.

3. The apparatus according to claim 2 wherein said means for applying a potential between said outer cylindrical electrode and said inner cylindrical electrode to provide a more positive potential on said outer cylindrical electrode than on said inner cylindrical electrode, and wherein said means for applying a potential to said cylindrical electrode baffle applies a potential thereto which is intermediate to the potentials applied to said outer and inner cylindrical electrodes.

4. The apparatus according to claim 1 including a pair of longitudinally aligned cylindrical focusing electrodes concentrically positioned between said outer cylindrical electrode and said inner cylinder electrode, means for applying a potential to said cylindrical focusing electrodes, and wherein said pair of cylindrical focusing electrodes are separated by a transverse gap therebetween.

5. The apparatus according to claim 4 wherein said means for applying a potential between said outer cylindrical electrode and said inner cylindrical electrode applies a more positive potential on said outer cylindrical electrode than on said inner cylindrical electrode, and wherein said means for applying a potential to said cylindrical focusing electrodes applies a potential thereto which is intermediate to the potentials applied to said outer and inner cylindrical electrodes.

6. The apparatus according to claim 1 wherein said outer cylindrical electrode contains an inlet aperture and said mass spectrometer apparatus includes an ion source adapted to pass a supply of ions through said inlet aperture into said outer cylindrical electrode to thereby provide the supply of ions within said outer cylindrical electrode.

7. The apparatus according to claim 6 including a cylindrical electrode baffle positioned between said outer cylindrical electrode and said inner cylindrical electrode, means for applying a potential to said cylindrical electrode baffle, and wherein said cylindrical electrode baffle is provided with apertures positioned to allow passage of ions having the given mass.

8. The apparatus according to claim 7 wherein said means for applying a potential between said outer cylindrical electrode and said inner cylindrical electrode applies a more positive potential on said outer cylindrical electrode than on said inner cylindrical electrode and said means for applying a potential to said cylindrical electrode baffle applies a potential thereto which is intermediate to the potentials applied to said outer and inner cylindrical electrodes.

9. The apparatus according to claim 1 wherein the apparatus comprises means to provide the supply of ions by inducing gas ionization within said outer cylindrical electrode.

10. The apparatus according to claim 9 wherein said outer cylindrical electrode contains a gas inlet opening to admit a supply of ionizable gas into said outer cylindrical electrode.

References Cited by the Examiner

UNITED STATES PATENTS

2,535,032	12/1950	Bennett	250—41.9
2,735,942	2/1956	Brubaker	250—41.9
3,004,158	10/1961	Steimel	250—41.9

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