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MASS SPECTROMETERS

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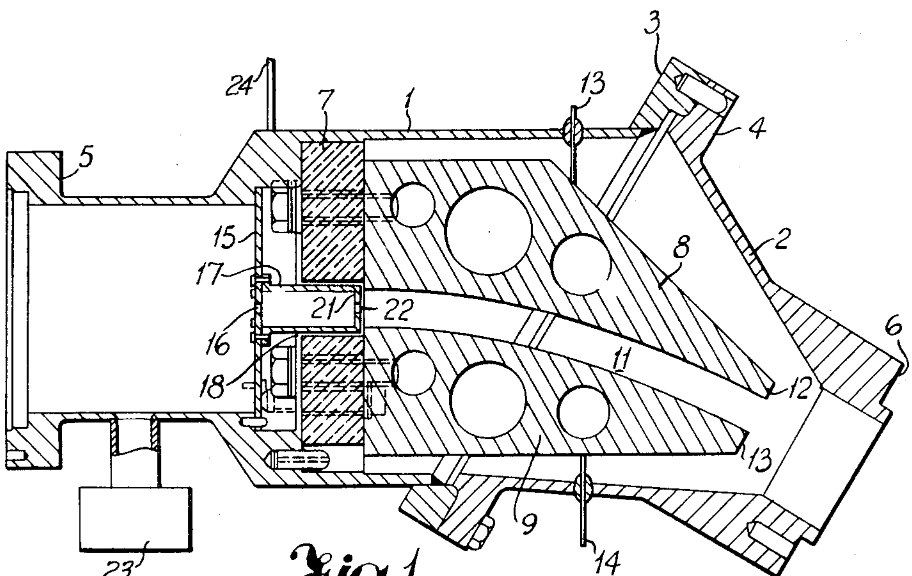

Fig. 1

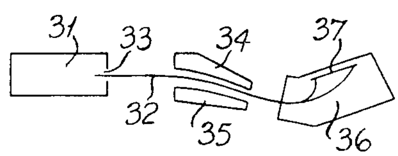

Fig. 2

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MASS SPECTROMETERS

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The present invention relates to mass spectrometers and more particularly to electrostatic analysers for use in mass spectrometers.

A mass spectrometer is an apparatus which can be adapted for analysing the constituent elements of a material. The material is ionized, and this may, for example, be performed by causing an intermittent arc to form between two rod electrodes formed from the material and situated in vacuo. The resultant ions formed from the different constituent elements of the material will have different masses dependent on the position of the elements in the periodic table. Those ions with a positive charge are formed into a narrow beam by accelerating and focussing electrodes and a narrow section of this beam is selected by an aperture known as the source slit. This narrow section of the beam is subsequently passed into a magnetic field where the ions are deflected laterally in accordance with their mass, their kinetic energy and the strength of the magnetic field.

When an ion beam comprising ions of different mass passes through the magnetic field, it will therefore be dispersed and a spectrum will be formed. By collecting the dispersed beam on a suitable detector, which may be a photographic plate, an indication may be obtained of the constituent elements of the material and the quantity of each element present in the material.

However, if the ions are produced by forming an intermittent arc between two rod electrodes of the specimen material the electrical potential at the point of formation will vary with both position and time. Therefore, the ions in the beam from the source slit will have different kinetic energies and on passing through the magnetic field will not be deflected so as to form a spectrum in accordance with their masses only, and a true indication of the constituent elements of the material will not be obtained. Also high resolution between the ions of almost identical mass will not be obtainable.

In order to avoid this disadvantage, the ion beam is passed through an electrostatic analyser before it is passed into the magnetic analyser. The electrostatic analyser is formed from two deflecting plates connected to suitable potentials and between which the ion beam is passed. The individual ions will be deflected in accordance with their kinetic energy and the ion beam will be dispersed slightly since the ions will have different energies. The ion beam, on leaving the electrostatic analyser, will therefore enter the magnetic analyser in a slightly dispersed state. The ions will still have different kinetic energies.

The deflection of each ion in the magnetic field of the magnetic analyser will be in accordance with the mass of the ion, the kinetic energy of the ion and the strength of the magnetic field. The different deflections due to the different kinetic energies of the ions will be compensated for by the initial deflection in the electrostatic analyser, since the deflection in the electrostatic analyser is arranged to be in the opposite direction to that in the magnetic analyser.

By a suitable choice of the potentials on the electrostatic deflecting plates and by suitable design of the apparatus, the resultant total deflection of each ion can be arranged to be in accordance with its mass and the strength of the magnetic field only, and hence a true mass

spectrum will be formed and a true and accurate indication of the constituent elements of the material can be obtained from the mass spectrometer.

The electrostatic deflecting plates are conveniently mounted on an insulating holder which is attached to the body of the electrostatic analyser. Stray ions may strike the insulating surfaces and may build up a charge on these surfaces. This charge will tend to deflect the beam and result in further dispersion of the beam which cannot be accounted for. This additional dispersion will cause further inaccuracies in the results obtained from the mass spectrometer.

The object of the present invention is to provide an improved type of electrostatic analyser for use in a mass spectrometer.

According to the present invention, an electrostatic analyser for a mass spectrometer comprises a chamber adapted to form a path for a beam of ions, means for evacuating said chamber, an annular insulating plate extending across said chamber, two electrodes mounted on the first face of said insulating plate and extending along the direction of movement of said ions and separated laterally by a gap through which said ion beam is adapted to pass, means for connecting said electrodes respectively to suitable sources of electric potential, an annular electrically conducting shield extending across and co-axially with the second face of said insulating plate, and means for connecting said conducting shield to a suitable source of electric potential, the arrangement being such that the beam of ions passes through the aperture in said annular conducting shield and is prevented from coming into contact with the surface of said insulating plate.

The insulating plate may be formed from a sheet of optically flat heat resisting glass.

The conducting shield may be formed with a cylindrical portion which extends within the aperture within said insulating plate and is attached to a flat plate extending across the second surface of said insulating plate.

In order that the invention may be more readily understood reference will now be made to the accompanying drawings in which:

FIG. 1 is a side view, sectioned on a plane through the axis of an electrostatic analyser, and

FIG. 2 is a diagram of the layout of a mass spectrometer which includes an electrostatic analyser.

With reference to FIG. 1, the chamber of the analyser is formed from a cylindrical member 1 and a conical member 2 joined together by means of two flanges 3 and 4. The two members 1 and 2 are conveniently formed from stainless steel and may each be formed from a solid block of stainless steel. The free end of the cylindrical member 1 is formed with a flange 5 whereby the analyser may be attached to an ion source. This may be of the type described in co-pending patent application Serial No. 3,426 of January 19, 1960, of Craig. The free end 6 of the conical member 2 is adapted to be connected to a magnetic analyser which may be of the type described in co-pending patent application Serial No. 3,428 of January 19, 1960, of Craig. The chamber of the electrostatic analyser is conveniently evacuated by a pump which is connected to the magnetic analyser and hence the electrostatic analyser is evacuated through the aperture at the free end 6. Alternatively the chamber of the analyser may be directly connected to a separate evacuating pump 23.

A plate 7 of insulating material, which may be a block of optically flat heat resisting glass, such as that known under the name "Pyrex," a registered trademark, extends across the inside of the cylindrical member 1 and is suitably fixed therein. The plate 7 is conveniently of the same shape as the inside of the cylindrical member 1. The face of the plate 7 which is remote from the connection to the ion source is accurately ground and two electrodes 8 and 9 are attached to this face by a suitable means. These electrodes extend longitudinally within the chamber and are separated laterally by a longitudinally extending gap 11. The electrodes 8 and 9 are accurately machined, so that the gap 11 is of the required width and has the required curvature. The ends 12, 13 of the electrodes are not supported but the electrodes are arranged to be so rigid that they are kept in position by being attached to the plate 7. The electrodes extend laterally across the chamber and the surfaces facing the gap may be cylindrical or toroidal.

The electrodes are connected by means of leads 13, 14 to suitable sources of electric potential so that an electric field of the required intensity is formed in the gap 11. A shield 15 of electrically conducting material, such as stainless steel, extends across the evacuated chamber on the side of the plate 7 which is nearest to the ion source. This conducting shield 15 is formed with a central aperture 16 which may be circular or in the form of a slit. A cylindrical conducting member 17, which may also be made of stainless steel, extends from the plate 15 into the aperture 18 in the centre of the insulating plate 7 and the cylindrical member 17 is closed at its other end by a plate 21 having a central aperture 22. The shield 15 and the cylindrical member 17 are electrically connected to the body of the analyser and this is conveniently earthed through a lead 24. Neither the shield 15 nor the member 17 are in contact with the insulating plate 7, and the cylindrical member 17 extends within the aperture 18 right up to, but not in contact with, the edges of the electrodes 8 and 9.

When the electrostatic analyser is connected to an ion source, the ion beam entering from the ion source into the free end of the cylindrical member 1 will pass successively through apertures 16 and 22 into the gap 11. The ions of the ion beam will be deflected in the gap 11, if the potentials of electrodes 8 and 9 are suitably chosen.

As described above, the beam will be dispersed as ions having different kinetic energy will be deflected by different amounts. The action of the shield 15 and the cylindrical member 17 prevents any stray ions from striking the surface of the insulating plate 7 and hence prevents the build up of a charge on the surfaces of the insulating plate. As described above, this undesirable charge would further deflect the ion beam.

It is not convenient or necessary to support the free ends of electrodes 8 and 9. Therefore, there is no need to provide a second shield at the other extreme end of the gap 11 to prevent contamination of the surfaces of insulating supporting members. By accurately machining the faces of the insulating plate 7 the electrodes can be positioned accurately and rigidly within the chamber of the analyser.

FIG. 2 illustrates diagrammatically a mass spectrometer, which includes an electrostatic analyser. The mass spectrometer comprises an ion source 31 from which an ion beam 32 is projected through the source slit 33. The ion beam passes through the electrostatic analyser formed from two electrodes 34, 35 and is slightly dispersed therein. The slightly dispersed beam then passes into the magnetic field 36 of the magnetic analyser and

is further dispersed. The spectrum so formed is collected by a detector 37 which is conveniently a photographic plate. The developed image obtained gives an indication of the quantities of each element which is present in the material being analysed.

What I claim is:

1. An electrostatic analyser for a mass spectrometer comprising a chamber adapted to form a path for a beam of ions, means for evacuating said chamber, an annular electrically insulating plate extending across said chamber, two electrodes mounted on the first face of said insulating plate and extending along the direction of movement of said ions, longitudinal edges to said electrodes defining a gap through which said ion beam is adapted to pass, means for connecting said electrodes respectively to suitable sources of electric potential, an annular electrically conducting shield extending across and co-axially with the second face of said insulating plate, and means for connecting said conducting shield to a suitable sourc of electric potential, so that said beam of ions passes through the aperture in said annular conducting shield and is prevented from coming into contact with the surface of the insulating plate.

2. An electrostatic analyser for a mass spectrometer comprising a chamber adapted to form a path for a beam of ions, means for evacuating said chamber, an annular electrically insulating plate extending across said chamber, two electrodes mounted on the first face of said insulating plate and extending along the direction of movement of said ions, longitudinal edges to said electrodes defining a gap through which said ion beam is adapted to pass, means for connecting said electrodes respectively to suitable sources of electric potential, an electrically conducting shield including a cylindrical portion extending within said annular insulating plate and a flat portion extending across the second surface of said insulating plate, and means for connecting said conducting shield to a suitable source of electric potential, so that said beam of ions passes through the aperture in said annular conducting shield and is prevented from coming into contact with the surface of the insulating plate.

3. An electrostatic analyser for a mass spectrometer comprising a chamber adapted to form a path for a beam of ions, means for evacuating said chamber, an annular sheet of optically flat, heat resisting glass forming an insulating plate extending across said chamber, two electrodes mounted on the first face of said insulating plate and extending along the direction of movement of said ions, longitudinal edges to said electrodes defining a gap through which said ion beam is adapted to pass, means for connecting said electrodes respectively to suitable sources of electric potential, an annular electrically conducting shield extending across and co-axially with the second face of said insulating plate, and means for connecting said conducting shield to a suitable source of electric potential, so that said beam of ions passes through the aperture in said annular conducting shield and is prevented from coming into contact with the surface of the insulating plate.

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