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MASS SPECTROMETERS

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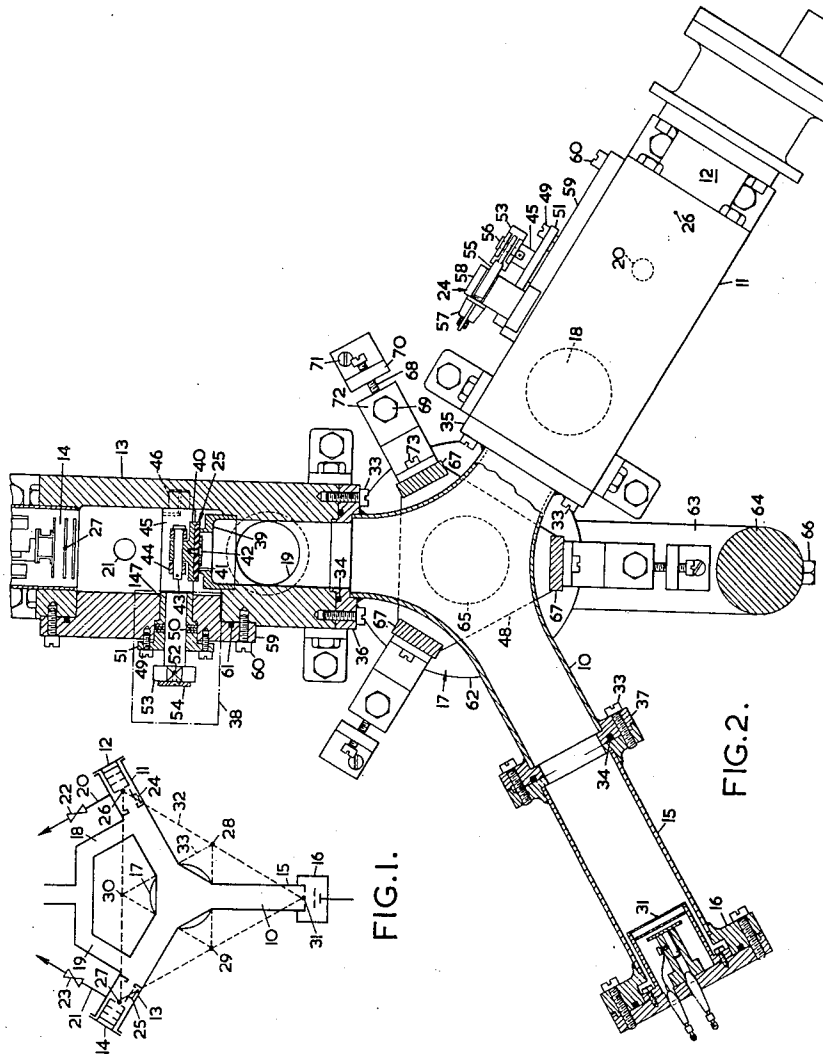


FIG. 1.

FIG. 2.

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MASS SPECTROMETERS

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This invention relates to mass spectrometers and it is concerned principally with mass spectrometers for the analysis of materials in the solid state.

Solid material mass spectrometry gives rise to certain problems not encountered in gaseous analysis. The primary problem is that of treating the solid material so as to produce a steady source of ions without any mass discriminations. Secondary problems arise such as the avoidance of "memory effects" (which are errors due to contamination of the ion chamber by the previous sample) and the method of feeding samples to the ion chamber.

In normal operation, an ion source has to be removed from its associated analysis tube after every sample and thoroughly cleaned to reduce memory effects before any new sample can be loaded. An essential part of the cleaning process is the heating of the ion source in the mass spectrometer until the residual ion beams are too small to interfere with the succeeding sample. The source is then removed, loaded with the sample and reinserted in the instrument. The sampling rate is the total time taken for one complete cycle of operations, much of this time being spent evacuating and admitting air to the spectrometer and obtaining stable ion beams. For a single simple mass spectrometer the minimum time in which this series of operations can be done is 4 hours. A faster rate of sampling requires additional spectrometers.

Schemes have been proposed for feeding samples to the ion chamber so that the vacuum does not have to be destroyed and built up again after each sample. Such known schemes give rise to mechanical complexities and operating difficulties which, in the absence of very skilled operators, prevent any substantial improvement in the sample rate.

The present invention sets forth mass spectrometer apparatus which provides for a more speedy analysis of samples than that possible with conventional apparatus and which is relatively simple to operate.

The mass spectrometer according to the invention comprises pairs of ion sources each associated with a collector system and means for controlling the direction of the analysing magnetic field so that the ion beams from the sources can be individually selected for collection at their associated collector.

In the simplest arrangement the spectrometer anlyser is made in the form of three tubes so as to be Y-shaped. The tubes are spaced from each other by 120° (i.e. beam deflection ange of 60°), one carrying the collector system and the other two each carrying an ion source. The necessary uniform analysing magnetic field is supplied by an electromagnet centred over the confluence of the tubes and means are provided for reversing the field so that ion beams from one or other of the sources are selected for analysis.

A further feature of the invention is the insertion of a simple flap valve in between each of the sources and the main analyser thus permitting easy removal of the ion sources without interfering with the main vacuum system.

The invention will now be further described with reference to the accompanying drawings wherein:

FIG. 1 shows diagrammatically a plan view of a spectrometer embodying the invention.

FIG. 2 shows a part sectional plan view.

Referring to FIG. 1 the analysis chamber comprises a Y-shaped tubular body part **10** having at the end of one leg a valve block **11** to which is attached an ion source **12**; at the end of another leg a valve block **13** to which is attached an ion source **14**; at the end of the third leg **15** an ion collector system **16**. An electromagnet **17** generates a vertical magnetic field, the effective boundary of which is given by the points **28, 29, 30**. Vacuum lines **18, 19** are connected to a high vacuum pump and lines **20, 21** are connected to a rotary pump through valves **22, 23**. Between the ion sources **12, 13** and the analysis chamber **10** there are flap valves **24, 25**.

In this apparatus the usual focussing criterion is achieved when the point source of the ion beam **26**, the apex of the magnetic field **28**, and the collector slit **31** are colinear: similarly for points **27, 29, 31**. Lines joining points **26, 27, 31** are included to emphasize how the instrument is symmetrically disposed.

In the operation of this apparatus ion source **12** carries a sample whilst source **14** is being decontaminated. When the measurement of the sample in source **12** is completed, the magnetic field of electromagnet **17** is reversed and the degree of residual contamination in source **14** is measured. The end of this process is indicated by a small steady beam, and is generally achieved by the time the sample has been measured. Flap valves **24, 25** are closed and sources **12, 14** are withdrawn, source **12** for cleaning and source **14** for loading. Source **14** is replaced and another source fitted for decontamination. Valves **22, 23** are opened to evacuate the valve chambers, the flap valves **24, 25** being subsequently opened for the next cycle of operations. The combination of simultaneous operation of both sources and the use of the flap valve enables one sample per hour to be measured.

Referring now to the more detailed arrangement of FIG. 2 (using identical reference numerals to those used in FIG. 1 where practical for identification purposes). The analysis chamber **10** is shown in section and is provided with flanges **35, 36, 37**. To the flange **35** the valve block **11** and the ion source **12** are connected; similarly to flange **36** the valve block **13** and the ion source **14** are connected. To flange **37** the limb **15** and the collector assembly **16** are connected. The connections are made by bolts **33** and sealing is effected by rings **34**. In the valve body are high vacuum pumping ports **18, 19** immediately behind the valve seat member **39** and flap member **40** and pumping ports **20, 21** in front of the sources **12, 14**. The flap member **40** has a rubber sealing disk **41** which is held in position with screw and washer **42**. The flap member **40** is pivotted on a pin **43** in a forked arm **44**. The arm **44** is carried on a spindle **45** having one bearing **46** in the valve block **13** and the other bearing in a bush **47** located on a flange **59** supported by bolts **60**, and sealed by a ring **61**. (In order to describe the construction of this valve fully, the part enclosed in box **38** is a section at a lower plane than that of the principal section of FIG. 2.) The bush **47** is surmounted by sealing rings **50** and a compression bush **51** which is compressed on to rings **50** by bolts **49**. The spindle **45** has a square head **52** on which is fixed a lever **53** by screw and washer **54**. Now referring to the valve numbered **24**, the lever **53** has a tightening bar **55** held by a pin **56**. The bar **55** passes through a slotted lug **58** and has a wing-nut and washer **57** that can be tightened against the lug so as to close the valve flap **40** tightly on the seat **39**. When open, the flap member **40** is removed completely out of the path of the ion beam from source

14. The ion sources 12, 14, are not shown in great detail as they are of conventional design.

The electromagnet 17 consists of a lower coil 62 and a matching upper coil mounted on a core which is circular in cross section and rectangular in form. The drawing shows the bottom member 63 and the two vertical members 64, 65. The members forming the rectangle are bolted together by bolts 66. The pole pieces, which are not fastened in any way to the core of the electromagnet, are of triangular form 48, with the apexes cut away for convenience of mounting on three supports 67 which are adjustable horizontally by screws 68 and vertically by screws 69. The screws 68 are threaded into brackets 70 held to the frame by screws 71. The ends of the screws 68 press against brackets 72 movable with the screws 69. Screws 73 associate the brackets 72 with supports 67.

The operation of the apparatus of FIG. 2 follows clearly from the description made with reference to FIG. 1.

We claim:

1. A mass spectrometer comprising an evacuable envelope, two ion sources and an associated collector system contained within said envelope, means for setting up an analysing magnetic field across said envelope and means for controlling the direction of the analysing magnetic field so that ion beams produced can be individually selected for collection at the collector system, said envelope being made in the form of three tubes so as to be Y-shaped, the collector system being contained in the foot of the Y and the ion sources being contained one in each arm of the Y.

2. A mass spectrometer according to claim 1 in which a valve is inserted between each of the ion sources and the confluence of the three tubes forming the evacuable envelope.

No references cited.