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NASA TECH BRIEF

Monopole Mass Spectrometer with Improved Sensitivity and Reduced Background

A monopole mass spectrometer with improved sensitivity and reduced background has been developed by a NASA contractor. It has been determined that the sensitivity of such a spectrometer can be increased by almost an order of magnitude, when a weak external magnetic field is applied in such a direction that the ion beam is deflected towards the rod. This magnetic field also eliminates the background noise at the low end of the mass scale. In addition, there is the added advantage that the voltage adjustment is less critical for a monopole spectrometer than for a quadrupole one.

In the monopole mass spectrometer a magnetic field configuration is used similar to that of the well-known quadrupole mass spectrometer. In the monopole one, however, the three rods are replaced by the grounded symmetry planes between the rods, the two planes forming the so-called v-electrode that is on ground potential, making it possible for a single rod to produce the characteristic field. The ion orbits in both instruments are identical and are comprised of two independent oscillations in a y-direction from the apex of the v-electrode to the center of the rod, as well as in an orthogonal direction. In the quadrupole design, the ions can oscillate several times about the instrumental axis without being removed unless the amplitude is so large that the ions strike any of the four rods. The ions in the monopole design are also removed if they strike the v-electrode, preventing oscillations about the instrumental axis, since all ions face removal after about a half cycle of oscillation in the y-direction. As a result, the monopole voltage adjustment is substantially less critical than that needed for the quadrupole device, and the voltages required to analyze a specific mass range are reduced significantly. Although this is a definite advantage of the monopole device, only a small number of the incoming ions can be utilized in it. That portion of any slightly diverging incoming beam that is directed to the v-electrode is removed immediately. Also, a fraction of the ions that are originally directed away from the v-electrode, but which enter the field during the time interval when the field is directed toward the v-electrode, are removed by this electrode. Therefore, the transmission coefficient of the monopole filter is significantly less than that for the quadrupole filter.

In the development of the monopole mass spectrometer, it was assumed that its sensitivity could be increased by deflecting the ion beam away from the v-electrode using a weak, external magnetic field normal to the axis of the monopole spectrometer. The direction of this field was such that the beam was deflected both away from the apex of the v-electrode and towards the center of the rod electrode. In an experiment, it was observed that the imposition of such a magnetic field increased the peak heights by a fraction of 5 to 10. This observed effect was attributable primarily to the ion beam deflection where it had to be expected that a deflection towards the v-electrode would reduce the sensitivity. As a matter of fact, a relatively slight beam deflection is sufficient to produce the desired effects.

The imposition of the magnetic deflection field had another beneficial effect. Since voltages on the rod are relatively low in the vicinity of hydrogen 1 and 2, heavier ions are hardly deflected and have a high probability of being transmitted through the monopole filter. This causes an increased background at the low

(continued overleaf)

end of the mass scale, which can be eliminated by the application of the transversal magnetic field.

Notes:

1. This innovation should be of particular interest to research and development agencies of scientific equipment manufacturers, the oil industry, and the steel industry; it should also be useful in geological explorations.
2. The following documentation may be obtained from:

   Clearinghouse for Federal Scientific
   and Technical Information
   Springfield, Virginia 22151
   Single document price $3.00
   (or microfiche $0.65)

Reference: NASA CR-101445 (N69-28972), Mass Spectrometer for D-Region Studies

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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