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Comparative Performance of Double-Focus and Quadrupole Mass Spectrometers

Light-weight flight-type models of double-focus and quadrupole mass spectrometers have been compared with respect to the size, weight, and power required to achieve the same resolution and sensitivity at a given mass number; the comparison was made with the aid of mathematical relationships and the analysis was confined to the conditions of equal ion-source area and sensitivity variations of not more than 40% over the mass range.

For the analysis, a mission was considered which gave the quadrupole instrument a weight-to-power penalty of 226 g/W. To minimize the effective weight, the actual weight was made equal to the weight penalty. For alternative missions, different weight penalty may be required to obtain the minimum effective weight.

The symmetrical double-focus instrument has the least weight and largest ion current; therefore, the derived design is based on symmetrical electric and magnetic sectors, both taken at an angle of 90° since this angle provides the (nearly) shortest ion path length. A weight-to-power penalty was not used for the design since primary emphasis was on the maximum mass number, and maximum power consumption is a function of mass range and not maximum mass number.

When the instruments are used with equivalent ion sources and a voltage spread of 10V, the quadrupole has about twice the weight and maximum power. The sizes of the two types are about the same. The maximum dynamic voltage for the quadrupole is less than the static voltage for the double-focus mass spectrometer. The maximum ion current for the quadrupole is about four times that of the double-focused instrument. (However, the ion source suffers before the ion current limit is reached for either instrument.) The voltage stability and mechanical tolerance are about the same for both instruments. With weight and power as bases of comparison, the double-focus mass spectrometer seems to be the better.

In computed data, the weight of the double-focus instrument is the magnet weight only, while the weight of the quadrupole is the weight of only the four rods. The weight of the vacuum envelope for the double-focus instrument should be considerably less than that of the quadrupole, since it is much smaller; however, the combined weight of the magnet yoke and the vacuum housing may be about equal to the weight of the quadrupole housing.

Suggested techniques for reducing the magnet weight of the double-focus instrument include utilization of z-axis focusing, which would permit a longer object slit. With an object slit four times as long, the weight of the magnet could be reduced by a factor of two; maximum voltage would be reduced by a factor of 4 and power by a factor of 16. A reduction in magnet weight by a factor of 2 might also be achieved by using a smaller angle for the magnetic sector with an increase in the ion path length. Quadrupole weight might be reduced by removal of material from the center of the rods or by using lighter material such as metallized ceramic.

(continued overleaf)

Note:

The following documentation may be obtained from:

National Technical Information Service
Springfield, Virginia 22151
Single document price $6.00
(or microfiche $0.95)
Reference:

JPL Technical Memorandum TM 33-456 (N70-40790), Comparative Performance of Double-Focused and Quadrupole Mass Spectrometers.

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