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Technique for covering large apertures in ion optics with electroformed metal mesh

Robert J. Noll, Lloyd L. Ochalla, and James C. Weisshaar
Department of Chemistry, University of Wisconsin-Madison, Madison, Wisconsin 53706

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We describe a method for covering large apertures of nearly arbitrary size and shape in ion optics with uniformly taut, flat, electroformed metal mesh. An O-ring trapped between two plates in a specially cut, beveled groove provides uniform radial tensioning of the mesh as the plates are bolted together.

In time-of-flight mass spectrometry (TOF-MS),[1] we often need to create piecewise constant electric fields in large volumes of space through which ions travel. This has required covering apertures of 3–7 cm diam in stainless-steel plates with high transmittance, electroformed metal mesh (usually nickel, 70 lines/in., free plated to 85% transmittance).[2] One application is the measurement of ion-molecule total reaction cross sections[3] by pulsed TOF-MS; another is the measurement of metastable ion fragmentation channels using a "reflectron" electrostatic mirror.[4]

It is sometimes possible to design sets of electrodes with open holes that use symmetry to create approximately constant electric fields near the axis of ion flight. In other cases, we have used a retaining ring to press-fit the nickel mesh into the steel aperture. This procedure involves trial and error to find the retaining ring diameter that holds the mesh taut but does not tear it on installation. Installation requires a deft touch; slightly puckered or strained meshes were common in apertures up to 1 in. diam and unavoidable in those larger than 1 in.

Our new method allows us to cover large openings of nearly arbitrary shape. The resulting wire mesh surfaces appear flat and uniformly taut on visual inspection with a magnifying glass. The new system holds the mesh between two plates, one of which contains a specially modified O-ring groove (Fig. 1). The groove is cut slightly deeper than usual with the inner wall beveled at 30 degrees to the normal as shown. As the "sandwich" of plates, mesh, and O-ring is pressed together, the O-ring gradually and uniformly stretches the mesh as it expands radially outward in the groove's bevel. A pair of guide pins (not shown) aid assembly of the two flanges. Table I compares two examples of successful O-ring groove dimensions with standard groove dimensions.

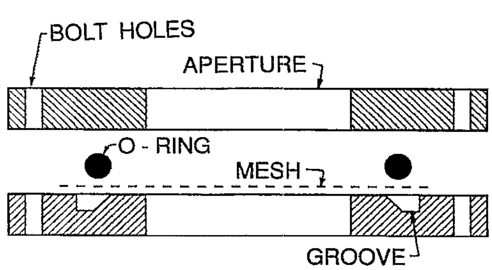

FIG. 1. Schematic of sandwich consisting of two stainless-steel plates, modified O-ring groove, electroformed nickel mesh, and O-ring. Dimensions not to scale.

TABLE I. Comparison of O-ring groove dimensions for normal static seal and for stretching metal mesh.

Nom. O-ring (in.)	Application	Depth (in.)	i.d. (in.)	o.d. (in.)
$3\frac{1}{4}\times\frac{1}{8}$	static seal	0.113	3.255	3.580
	mesh	0.127	3.155	3.500
$3\frac{1}{4}\times\frac{3}{32}$	static seal	0.083	3.255	3.496
	mesh	0.087	3.280	3.526

Assembly is quite easy. We place the mesh over the aperture in the flange with the O-ring groove and lay the O-ring on top of the mesh and groove so that the mesh lies smooth and flat. Then we place the second plate on top of the O-ring and tighten the bolts slowly and uniformly. The tilt angle of the beveled groove wall controls the rate and extent of radial expansion of the O-ring.

We have made three successful prototypes of aluminum: a 2.8 in. × 0.5 in. slot within a nominal $3\frac{1}{4}$ in. × $\frac{1}{8}$ in. O-ring; a 2.8-in.-diam circular aperture within the same O-ring; and a 2.8-in.-diam circular aperture within a $3\frac{1}{4}$ in. × $\frac{3}{32}$ in. O-ring. In all cases we produced very flat meshes on the first trial. The electrical resistance between mesh and plate was less than 0.2 Ω.

In the actual reflectron, each assembly will be 0.69 in. thick. Use of a 1/16-in. O-ring and a smaller bevel angle may permit thicknesses as small as 1/4 in. We see no obvious limitation on the size and shape of apertures that can be covered with flat mesh in this fashion.

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