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TRANSPORT IN RECTANGULAR QUADRUPOLE CHANNELS*

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Summary

Multiple electrostatic quadrupole arrays can be produced in many different geometries. However, the fabrication process can be considerably simplified if the poles are rectangular. This is especially true for millimeter sized channels. This paper presents the results of a series of measurements comparing the space charge limits in cylindrical and rectangular quadrupole channels.

Introduction

Electrostatic quadrupoles are ideally suited for small aperture transport systems and especially for multichannel arrays. In a multi-beam system such as a MEQALAC the objective is to pack as many beams as possible into a small area. The packing density goes up dramatically if the pole tips are of rectangular shape as opposed to cylindrical.

Apparatus

The test stand is shown in Fig. 1.

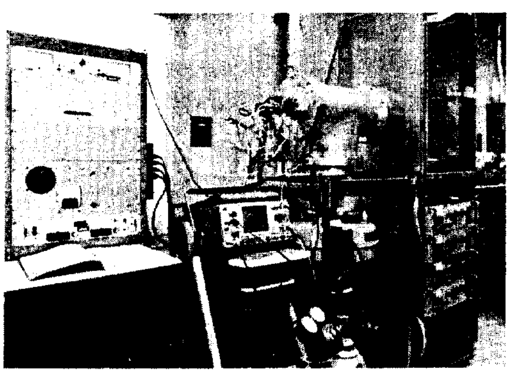

Fig. 1

A plasmatron type source, Fig. 2, mounted at ground potential, for simplicity. Extractor and test apparatus operated at negative voltages.

Both source and extractor have .500" × .100" slits on a .750" radius with a distance of .160" from the extractor to the source. This geometry gave the optimum distance from source to center of first quad .925". See Fig. 3.

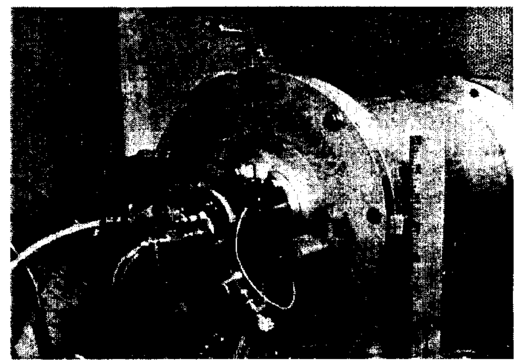

Fig. 2. Ion source

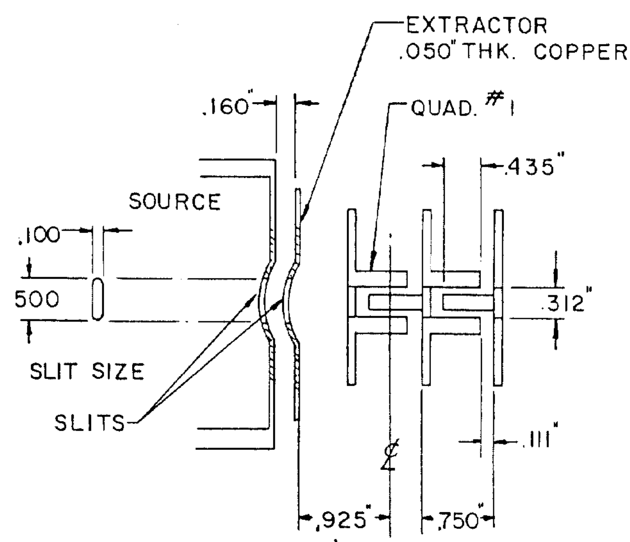

Fig. 3

Two transport channels of .312" bore and 18 cells in length were compared, Fig. 4.

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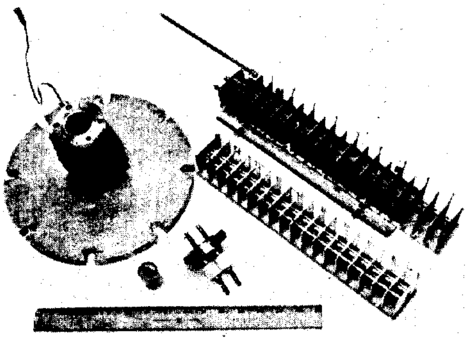

Fig. 4

Figure 5 is a close view of the cylindrical poles and Fig. 6 of the rectangular poles.

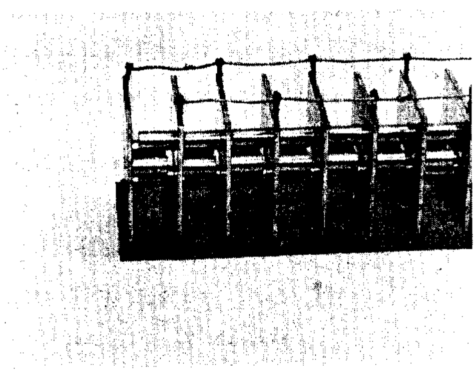

Fig. 5. Cylindrical poles

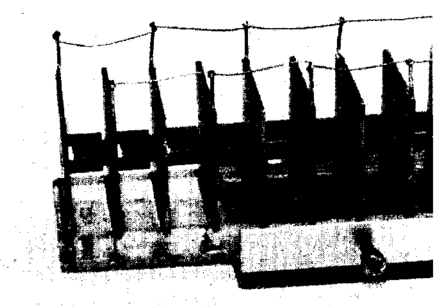

Fig. 6. Rectangular poles

The channels were mounted on a slide rack to allow for extractor to quad adjustment, Fig. 7. Beam alignment was done by adjustment of the source plate for maximum transport. The adjusting screws can be seen in Fig. 2.

Beam current was measured with a biased Faraday cup and transmitted to ground potential via a isolation transformer and a beam current amplifier in Fig. 8.

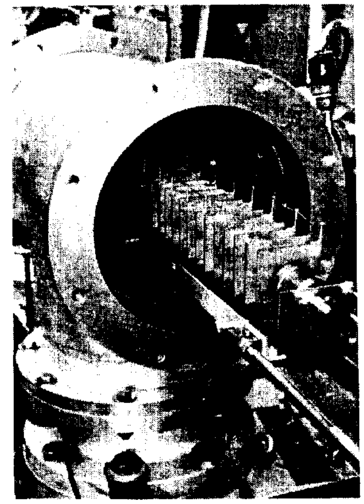

Fig. 7. Quad channel and Faraday cup

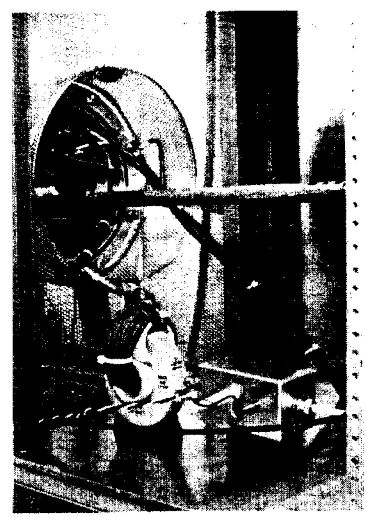

Fig. 8. Beam current transformer

Gas used was argon and the flow rate controlled by a micrometer type hand valve. Flow rate was not measured, but vacuum was on the order of 3×10^{-5}. Four high voltage power supplies mounted in equipment rack (Fig. 1 lower right) supplied extractor quads and bias voltages.

Test Data

Both channels tested are of identical design. The channels as stated are 18 sections long with a .312" aperture. The pole length is .435" with a .315" spacing between quads. (Figure 3) Testing was done at three energies: .5, 1.0, and 2.0 keV.

The cylindrical channel was made of aluminum and the rectangular of stainless steel. Aluminum proved to be a poor choice of material for these low energy beams. A surface charge forms on the poles; this charge is enough to lower transport by as much as 20%.

Sparking of the quads clears the charge for several pulses. Data given for this channel is after clearing charging effect.

Rep rate appears to have another effect on the transport of both channels; this phenomenon is not completely understood at this time. A low rep rate on the order of 1 pulse per 5 seconds as compared to 10 pps produces 5 to 10% more current. All test data for this report was at 10 pps. The graphs in Figs. 9 and 10 give the comparison transport current of the channels.

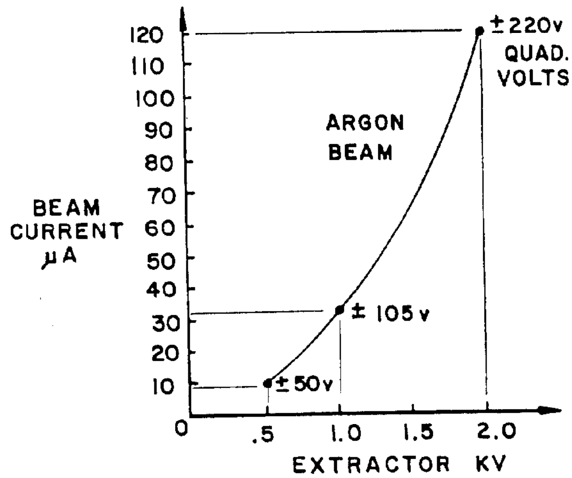

Fig. 9. Cylindrical poles

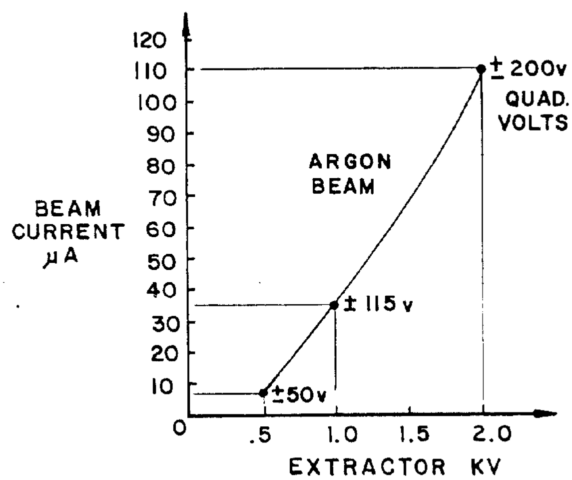

Fig. 10. Rectangular poles

The results indicate a slightly lower current from the rectangular poles. Tests done by A. W. Maschke and reported at this conference, R25, indicate a clearing electrode in front of the channel greatly increases the beam current for either shaped pole.

Witness plates attached to the last quadrupole of each channel in Figs. 11 and 12 indicate the beam size and position.

Fig. 11

Cylindrical channel

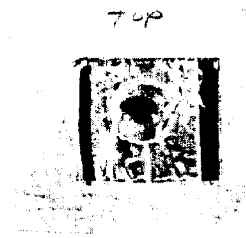

Fig. 12

Rectangular channel

Conclusion

As indicated the rectangular poles did not transport as well as cylindrical poles. The question is then -- Why use them?

Figure 13 shows an end view of a possible four beam array using the aperture size of the single channels tested.

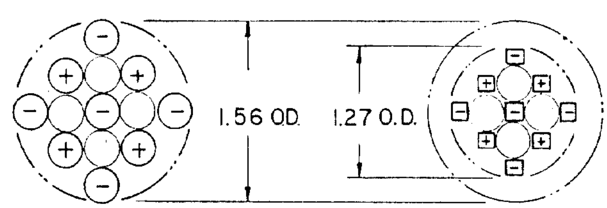

Fig. 13. Both channels 5/16" bore

The diameter of the cylindrical poles is .312" and that of the rectangular, or from the end view square, is .131" × 131". Although less current is transported per channel, it can be seen that the stacking density is greater with the rectangular poles.

Other configurations of rectangular tips could produce even higher densities. One might imagine an ice cube tray design.

It was intended to report on a single aperture 500 radius channel but time did not allow for enough data to be taken. Preliminary testing of the channel indicated it would operate at its space charge limit. The design of this channel appears in J. Brodowski's report on "The Design of a Versatile ESQ Transport System" presented at this conference.

Acknowledgments

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