Faraday Cups (cooled versions)

High Power: Type DF 020
Ultra-High Power: Type DF 060

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FARADAY CUP (cooled version) Type DF 020

Application:

Measurement of mean beam current of particle accelerator.

Principle:

Accelerated particles (high energy primarily) are stopped in the cup and an electric charge is detected as corresponding electric current. The Faraday Cup may be moved into the beam by means of an air pressure actuated vacuum feedthrough.

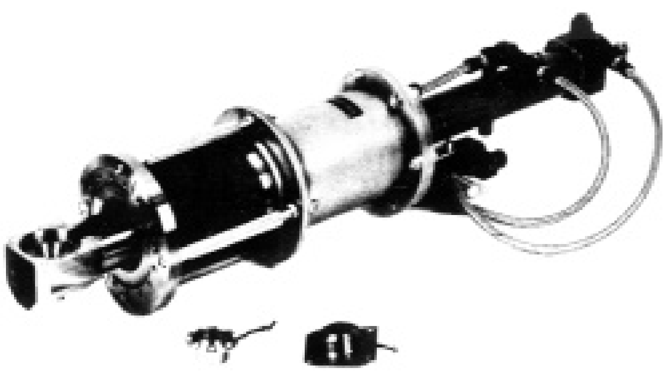

Fig. 1

Faraday cup mounted to a 6” O.D. (CF-100) flange. Also shown: tandem air actuator, membrane bellow conical tantalum body (cup). The left of the photograph shows the removed cylinder which is used for secondary particle suppression; ceramic spheres are used for insulation. Also shown: tantalum aperture which is used to shield the cylinder against direct bombardment from particles.

Technical Specifications:

Housing	:	Stainless steel
Cup	:	Tantalum
Shielding of HV electrode	:	Tantalum
Insulation of cup	:	Ceramic spheres
Cup opening diameter	:	1.2 inches
Stroke: ‘in’ and ‘out’ movement	:	3.54 inches
Accuracy of positioning in reference to beam axis	:	0.010 inches
Drive for ‘in’ and ‘out’ movement	:	Tandem air pressure actuated piston
Pressure	:	60 - 90 psi (4-6 atm)
Sealing	:	Membrane bellow with conflat system
Leak Rate	:	10^{-10} Torrs x liter/second

Technical Specifications: (continued):

Supporting flange (for standard chamber)	:	6" O. D. (CF – 100)
Connector for current.	:	BNC
Suppression of secondary particles	:	Electric field and/or magnetic field.
Connector for high voltage (electric secondary particle suppression)	:	BNC (HV)
Maximum high voltage	:	2500 Volts
Insulation	:	100 Mohms
Strength of magnetic field for secondary particle suppression	:	Dipole field, 500 Gauss on beam axis.
Cooling	:	Ta tubes with ceramic insulation.
Cooling media	:	Deionized water (2.5 – 25) x 10^{-6} mho/inch
Maximum beam power level	:	6 kW
Locking in the event of pressure Failure.	:	Special mechanism holds cup out-side of beam line.
Position indicator	:	Both positions 'in' and 'out' beam are indicated by means of micro-switches.
Damping of 'in' and 'out' movement	:	Variable
Air pressure control	:	Magnetic valves 24 V. d.c.

60 kW FARADAY CUP Type DF 060

Technical Specifications:

Beam particles	:	Deuterons (d+)
Energy	:	400 keV
Current	:	150 milliamperes d.c.
Power	:	60 kW
Intensity distribution	:	Approx. Gaussian (1 cm full width at _ max.)
Peak power density	:	55 kW/cm ^{2} at beam center.
Off-axis distance	:	2 cm max.
Beam pipe diameter	:	3.5 inches (ID)
Maximum weight	:	220lb (approx. 100 kg)
Vacuum	:	10^{-5} to 10^{-7} Torrs
Cup aperture	:	Diameter: 3 inches
Entrance limiter (aperture)	:	Diameter: 7.5 inches
Voltage at entrance of limiter (aperture)	:	± 500 V d.c.
Voltage at Faraday Cup	:	± 1000 V d.c.
Stroke of air actuated feedthrough	:	Approx. 5 inches
Maximum time for Faraday Cup insertion	:	2 seconds
Vacuum chamber maximum diameter	:	15 _ inches

Design:

Because of the low particle penetration into the Faraday Cup, most heat will be generated at or near the Cup's surface, yielding power densities of nearly 800 to 1000 Watts per square millimeter. In light of these power densities, the only useful material which is able to withstand such heat loads must be one that:

(a) has a very high melting point, and

(b) at the same time, provides excellent thermal-conductivity.

Such characters are displayed by a special type of graphite but which, unfortunately, has different expansion coefficients in X and Y directions. Since graphite cannot be cooled directly with water and the proposed special graphite substance is only available in disc form with limited overall dimensions, our design is as follows:

Design (continued):

- The graphite discs are assembled in a sandwich format.
- The beam hits those discs at an angle (reduction of surface heat density).
- The individual discs are mounted in copper bodies under consideration of all thermal expansion coefficients.
- Size of graphite disc will be optimized to assure a maximum temperature of only 800 to 900°C between copper and graphite boundaries.
- At the same time, these copper cooling bodies require a design, in terms of dimensions and arrangement of cooling channels, where surface heat dissipation does not exceed Q/A less than 200 W per square cm. Otherwise, "film boiling" might occur.
- Surface temperature for the faraday cup never exceeds 1500 to 1800°C
- To minimize the expense of the special graphite material, a more cost-efficient graphite will be used for the outer boundaries of the desired Faraday Cup.
- Secondary electron suppression is part of the Cup feature.
- Cup body itself will be 350 to 400 mm long.
- Cooling will be done with deionized water.

Information Regarding Design/Engineering:

Thermal calculations involve finite element programs for numerical application to partial differential equations, all under consideration of the previously mentioned surface heat distribution and non-isotropic Lambda values. In addition, fluid dynamics plus mechanical calculations are necessary. We also provide calculations for:

- neutron production;
- gas load;
- life expectancy (empirical);
- failure modes (empirical).