Faraday Cup FC-73

APPLICATIONS:

- Continuous Collection and Measurement of Charged Particle Current
- Measurement of Emitted Beam from Electron or Ion Gun
- Gun Alignment and Setting Operating Parameters

FEATURES / OPTIONS:

- 5.0 mm Aperture
- Input Power Continuous up to 4 watts.
- Standard with Three Grids to Enable Use as Energy Analyzer
- Optional Phosphor Screen
- 2.75" CF Flange Mounting
- Custom Apertures to 9.5 mm

Faraday Cup FC-73

Introduction

The Kimball Physics model FC-73 Faraday cup, connected to an ammeter, is used to collect and measure charged particle current, such as the beam emitted from an electron or ion gun. The FC-73 is mounted on a 2.75" CF flange for convenient attachment to the vacuum system. The Faraday cup is UHV compatible and fully bakeable to 350°C.

The Faraday cup consists of a hollow stainless steel cylinder closed at the base, with an appropriately sized aperture for collecting the electrons or ions. The FC-73 has a standard aperture diameter of 5.0mm; however, custom aperture sizes are available. A grounded aperture holder provides shielding. The Faraday Cup is electrically connected directly to a BNC which then can be connected to an ammeter.

For continuous measurement, the power entering the standard FC-73 Faraday cup should not exceed 4 watts. The Faraday cup temperature should not be raised above 350°C due to outgassing.

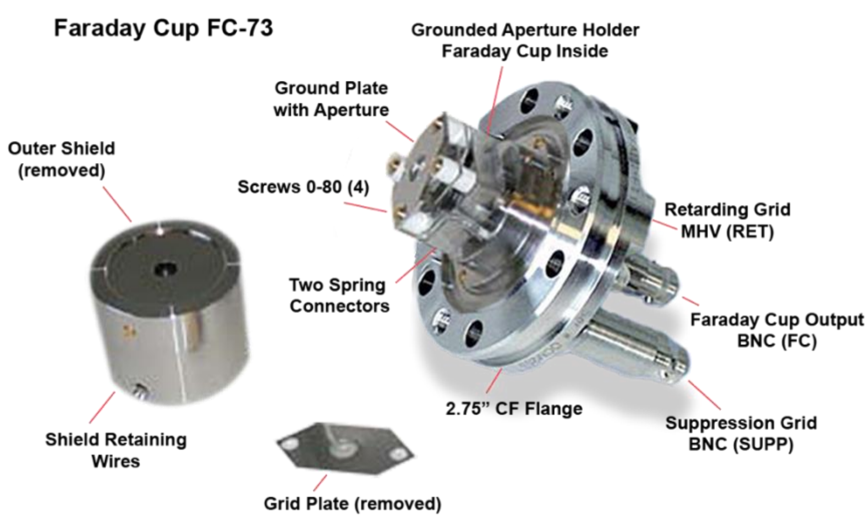

Figure 1. Features of the FC-73 Faraday Cup.

Grids

The FC-73 Faraday cup has a set of three grids so that it can be used as an energy analyzer. These grids are, in the order that the electrons or ions go through them: ground, retarding, and suppression, labeled G, R and S in the diagram with Figure 1.

The ground grid is attached to the aperture plate and is grounded by connection to the shield. A variable potential is applied to the retarding grid to analyze the energies of electrons or ions. The grid voltage is negative for electrons/negative ions, or positive for positive ions. The current into the Faraday cup is measured, while the retarding grid voltage is varied, typically in a range from the accelerating voltage minus 10% to the accelerating voltage plus 10% or any voltage which cuts off the current completely.

This technique, with data illustrated in Figure 3, is used to analyze the energy spread of electrons from an electron gun. The Faraday cup current at any given retarding grid potential represents the total current due to particles with energy greater than that grid potential.

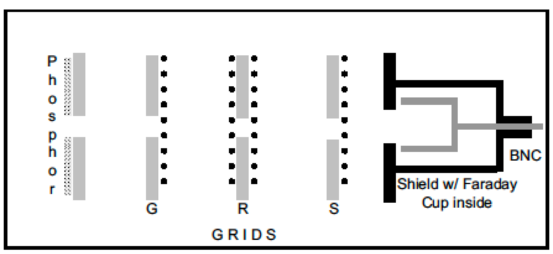

Figure 2. Schematic of Faraday Cup Grids

The data in Figure 3 can be differentiated to yield an energy profile (Figure 4) that indicates the energies present in the beam. The standard FC-73 Faraday cup can have up to 5000V applied to the retarding grid. When a low voltage is applied to the suppression grid, it can be used either to suppress secondary and scattered electrons or to suppress scattered ions from the Faraday cup so that current is not lost. The *suppression grid also reduces the capacitive coupling between the retarding grid and the Faraday cup. At low beam energies, the suppression grid voltage must not be too high, or it can interfere with the beam.*

Optional Phosphor Screen

A phosphor screen made with high luminosity P22 phosphor (ZnS: Ag) is available as an option on the front plate of the FC-73 Faraday cup. The use of a grounded phosphor target screen is helpful as it allows visual, real-time observation of the spot. The phosphor screen emits a pale blue light (photons) when bombarded by high energy particles (threshold value approximately 500 eV for electrons and 1000 eV for ions). The screen can be used for gun alignment and to set the proper operating parameters necessary to obtain maximum beam uniformity or minimum spot size. Note that excessive current or exposure may cause phosphor screen damage.

Biasing the Faraday Cup

If there is no suppression grid, the Faraday cup can be electrically biased to reduce scattering of electrons or ions collected in the

Faraday Cup FC-73	
APERTURE SIZE	5.0 mm diameter
SHIELD SIZE	3.18 cm diameter
INSERTION LENGTH	2.6 cm with shield
OPERATING TEMPERATURE	350ºC Max
INPUT POWER CONTINUOUS	4 Watts maximum recommended
GRID VOLTAGE	5000 V maximum retarding voltage
MOUNTING FLANGE	2.75" CF

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Faraday cup and to reduce secondary electron emission. For electrons or negative ions, +50V is typically adequate, and for positive ions, -50V. This can be accomplished by placing a battery between the vacuum feedthrough and the ammeter.

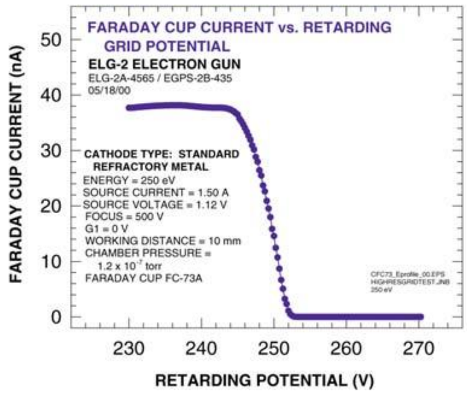

Figure 3. Use of the FC-73 Faraday Cup as an energy analyzer measuring electron beam current.

Power Input Cautions

For continuous measurement, the maximum recommended beam power into the standard FC-73A Faraday cup is 4 watts. The Faraday cup temperature should not be raised above 350°C due to outgassing.

The power input can be calculated by multiplying the beam current times the electron acceleration voltage; for example, 1mA at 20 keV gives 20 W, which is much too high for continuous measurement. The temperature of the Faraday cup increases approximately linearly with the power input. A 2 W continuous input results in approximately 150ºC, and a 4 W input results in 300ºC.

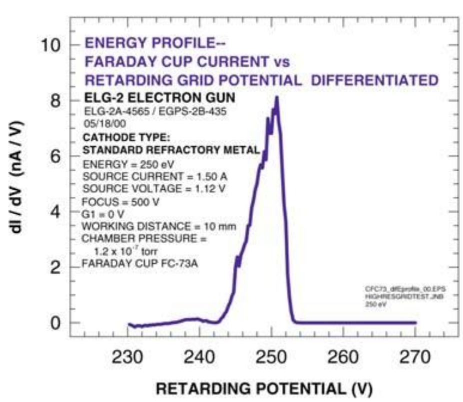

Figure 4. Calculating energy profile of electrons in the beam (Graph derived from data Figure 3).

To use the Faraday cup at high power, measure currents briefly and then let the Faraday cup cool down before repeating the measurement. Due to the heat capacity of the cup, a 20 W continuous input for 40 sec will raise the cup temperature by approximately 150ÅãC. The cup will cool from 200ÅãC to room temperature in about 15 min.

Care must always be exercised when using a highly focused beam, as a high power density can bring the Faraday cup to melting temperature in the impact area of the beam. For example, an electron un with an output of 1 mA at 10 keV focused to a 1 mm spot size has a power density of approximately 13 kW/cm2. Assuming no heat flow, this would bring the Faraday cup stainless steel at the spot to its melting point in only 11 μsec.

CAUTION

High beam power can melt Faraday cup components. Maximum recommended Beam power into the Faraday cup Is 4 W continuous

Installation and Operating Procedure

1. Bolt the 2. CF Faraday cup flange to a port on the vacuum chamber, sealing with a new copper gasket.
2. Connect a suitable user-supplied pico-ammeter to the output BNC on the flange labeled FC. (See Figure 1).
NEVER collect beam current in the Faraday cup unless the output BNC is connected to an ammeter or grounded. Without proper termination of the Faraday cup, the BNC center terminal will charge up to full beam energy and electrical discharging will result.

3. Optional Faraday cup grids:
a. For the retarding grid: Connect a user-supplied power supply that provides voltages approximately 10% higher than beam energy (5000 V max.) to the flange MHV labeled RET. (See Figure 1)
b. For the suppression grid: Connect a 0 to 50 V power supply to the flange BNC labeled SUPP. (Connection types and voltage limits are marked on the connectors).

4. Calculate the expected power input into the Faraday cup and check that it is within the acceptable range. See the discussion of power input cautions.

5. Measure electron or ion current with the user supplied pico-ammeter.

Removing/ Reinstalling the Outer Shield

1. Remove the outer shield by unscrewing the 3 2-56 x 1/8" Philips screws.

2. Replace the shield by putting it over the Faraday cup and replacing the 3 screws. (See Figure 1).

Replacing Aperture Plates, Grids, or Phosphor Screens

1. Remove the outer shield as above

2. Disconnect the two internal spring electrical connections from the plates. (See Figure 1).

3. Remove the four 0-80 socket head screws on the front of the Faraday cup, and lift off the entire aperture holder with the plates.

4. Carefully lift off the plates and insulators (ceramic spacers), noting the original order of the plates.

5. Replace the desired aperture plate, grid, or phosphor screen, and then reassemble.

References

For more information about Kimball Physics Detectors, please visit our website:
Kimball Physics Detectors

Notes:
1. Cautions:
-Silver Plated Bolts or Equivalent Lubrication must be used.
-Please measure the hole depth and other flange / copper ring /part thicknesses
-Choose a correct bolt length such that the bolt doesn't bottom in the tapped hole prior to tightening the structure.
2. Specifications Subject to Change Without Notice.
3. DE Altobelli, DT Taylor 01/17/2023

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