

MODEL FC-72A FARADAY CUP

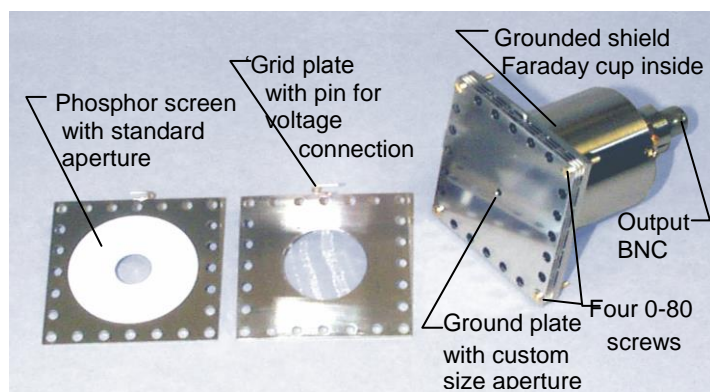


Fig. 1 Faraday Cup FC-72A with optional phosphor screen and grid shown separately

INTRODUCTION

The Kimball Physics model FC-72A 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-72A is UHV compatible and fully bakeable.

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. An outer, grounded cylinder provides shielding. An electrical connection is made to the base of the Faraday cup, terminating in a BNC. The current is then conducted to a vacuum feedthrough and so to an ammeter.

The FC-72A usually has a 11.28 mm diameter aperture (1 cm² area) in a 2 inch square plate. Custom smaller aperture sizes are available.

A 12 inch in-vacuum cable and BNC feedthrough on a 1½ CF flange, or a custom-designed feedthrough, is available from Kimball Physics as a separate option.

For continuous measurement, the power entering the standard FC-72A Faraday cup must not exceed 4 watts. The Faraday cup temperature should not be raised above 350°C due to outgassing.

OPTIONAL PHOSOPOR SCREEN

A phosphor screen made with high luminosity P22 phosphor (ZnS:Ag) is available as an option on the front plate of the FC-72A 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.

SPECIFICATIONS

FC-72A	
Aperture size	11.28 mm dia.=1 cm ² area Custom smaller dia. available
Plate size	5.08 cm square
Length	7.16 cm
Operating temperature	350°C max.
Input power continuous	4 watts max. recommended
Grid voltage	1000 V max on retarding grid (custom available)

OPTIONAL GRIDS

The FC-72A Faraday cup can have 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 Fig. 4 on page 2.

The ground grid is attached to the phosphor screen / initial aperture plate, and both are grounded by being connected to the shield. There is also a final, non-grid plate as part of the grounded shielding cylinder.

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 from zero to a voltage which cuts off the current completely.

This is illustrated in Fig. 2 on page 2, where the technique is used to analyze the energy spread of ions from a typical ion gun. The Faraday cup current at any given retarding grid potential represents the total current due to ions with energy greater than that potential. The data in Fig. 2 can be differentiated to yield an energy profile (Fig. 3) that indicates the ion energies present in the beam. The standard Faraday cup can have up to 1000 V applied to the retarding grid; for higher voltages, optional larger insulators are available.

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, so that current is not lost. The suppression grid also reduces the capacitive coupling between the retarding grid and the Faraday cup.

BIASING THE FARADAY CUP

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

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MODEL FC-72A FARADAY CUP cont.

POWER INPUT CAUTIONS

For continuous measurement, the maximum beam power recommended into the standard FC-72A 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, 1 mA 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 input results in approximately 150°C, and a 4 W input results in 300°C.

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 heat capacity of the cup, a 20 W input for 40 sec into the FC-72A will raise the cup temperature by approximately 150°C. The cup will cool from 200°C to room temperature in about 15 min.

Care must always be exercised with 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 gun 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 sec.

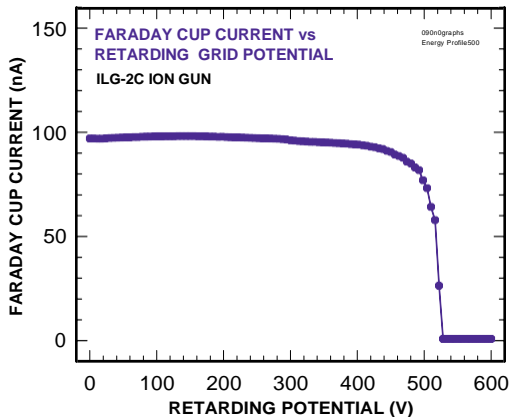


Fig. 2 The use of the Faraday cup as an energy analyzer measuring ion beam current

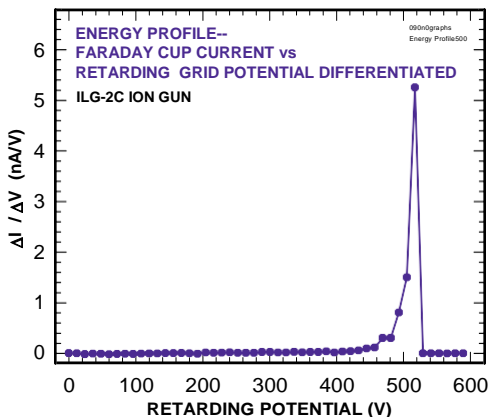


Fig. 3 Calculated energy profile of ions in beam (Graph derived from data in Fig. 2)

INSTALLATION AND OPERATING PROCEDURE

CAUTION

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

1. Position the Faraday cup in the target area inside the vacuum chamber.
2. Connect the output BNC on the back of the Faraday cup to an electrical feedthrough on the vacuum system (an in-vacuum coaxial cable/ CF flange/ BNC assembly is available from Kimball Physics).
3. Connect the feedthrough to a suitable user-supplied ammeter. **NEVER collect beam current in the Faraday cup unless the cup output is connected to an ammeter or grounded.** Without proper termination, the Faraday cup terminal will charge up to full beam energy and electrical discharging will result.
4. **Optional Faraday cup grids:**
 - a. For the retarding grid (R in Fig. 4): Connect a 0 to 1000 V power supply (negative for electrons or negative ions, and positive for positive ions) through a vacuum electrical feedthrough to the pin on the second grid plate using Teflon-coated stainless steel wire with a spring connector end.
 - b. For the suppression grid (S in Fig. 4): Similarly connect a 0 to 50 V power supply to the pin on the third grid plate
5. 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.
6. Measure electron or ion current with the ammeter.

REPLACING OPTIONAL APERTURE PLATES, GRIDS OR PHOSPHOR SCREENS

1. Loosen the four 0-80 gold-plated, socket head screws on the front plate of the Faraday cup, and remove the nuts.
2. Lift off the Faraday cup from the back, keeping the plates and insulators (ceramic spacers) in order on the screws.
3. Replace the desired aperture plate, grid, or phosphor screen, and then reassemble.

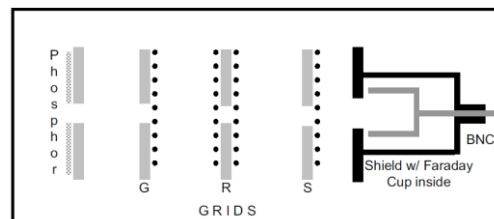


Fig. 4 Diagram of Faraday cup with optional grids and phosphor screen plate.