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Sensitive Fast Response Electron Detector †

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ABSTRACT

A miniature scintillation electron detector was developed for use with a small energy analyzer working in the range of .5 - 1000 eV. The gain was 10^4, and the inherent risetime was ~ 5 nsec, given sufficient input signal. Optical coupling of the signal eliminated ground loops.

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† Supported by the National Aeronautics and Space Administration.

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A small piece of aluminized Nuclear Enterprises 102 plastic scintillator was cemented, using optical epoxy, to one end of a 3.2 mm dia. American Optical Co. type LGM fiber light guide. (Fig. 1) The aluminized layer and the attached electrostatic guard ring were operated at 10-12 kV, the necessary potential for electrons to penetrate the aluminum and the "dead layer" at the surface and create scintillations.[1] The double screening was necessary to prevent low energy electrons in the analyzer chamber from being deflected by stray electric fields and to prevent defocusing of electrons from the scintillator. Kel-F was used for the insulator, and RTV silicone rubber was used to seal the stainless steel collar of the light guide to the Kel-F. A high magnetic permeability material, annealed Hipernik, surrounded the detector. Operation in a magnetic field of at least 100 gauss without impairment of sensitivity was possible.

A 1P-28 photomultiplier was used to detect the scintillator signal. Since the detector was used to examine transient signals, capacitors were used between the last few dynodes. The gain was

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adjusted by varying the potential on dynode six of the nine stage 1P28. In this manner the detector could be used to measure large pulses of incident electrons, without encountering space charge saturation limits on the final dynodes. The current gain of the system was measured by monitoring the current of electrons impinging on the scintillator with a battery operated electrometer and measuring the output current of the photomultiplier. Care was taken to insure that the PM tube was operating in a linear regime. The current gain was $\sim 10^4$ when 10kV was applied to the aluminum layer on the scintillator and the PM tube was operated at 1200 volts. The ultimate risetime of the system was not directly measured, but was estimated to be $\sim$ 5 nsec based on data available for the scintillator plastic and PM tube. The useful input working range of the detector was from $\sim 10^{-4}$ to $\sim 10^{-13}$ amperes. The working risetime was determined by an RC integrator at the output of the PM tube, which satisfied $\tau_1 \ll RC \ll \tau_2$, where τ_1 is the average time between individual pulses from the PM tube, and τ_2 is the time scale of the fastest feature of the input signal. RC = .1 μsec was commonly used in practice.

For incident electrons above a few hundred electron volts, it was necessary to compensate for enhancement of output signal, since more energy was being deposited in the scintillator. A curve of output current as a function of scintillator minus source potential at constant input current was used to obtain the compensation factor. Ambient gas pressure up to 2×10^{-4} Torr was used with no deleterious effect on performance.

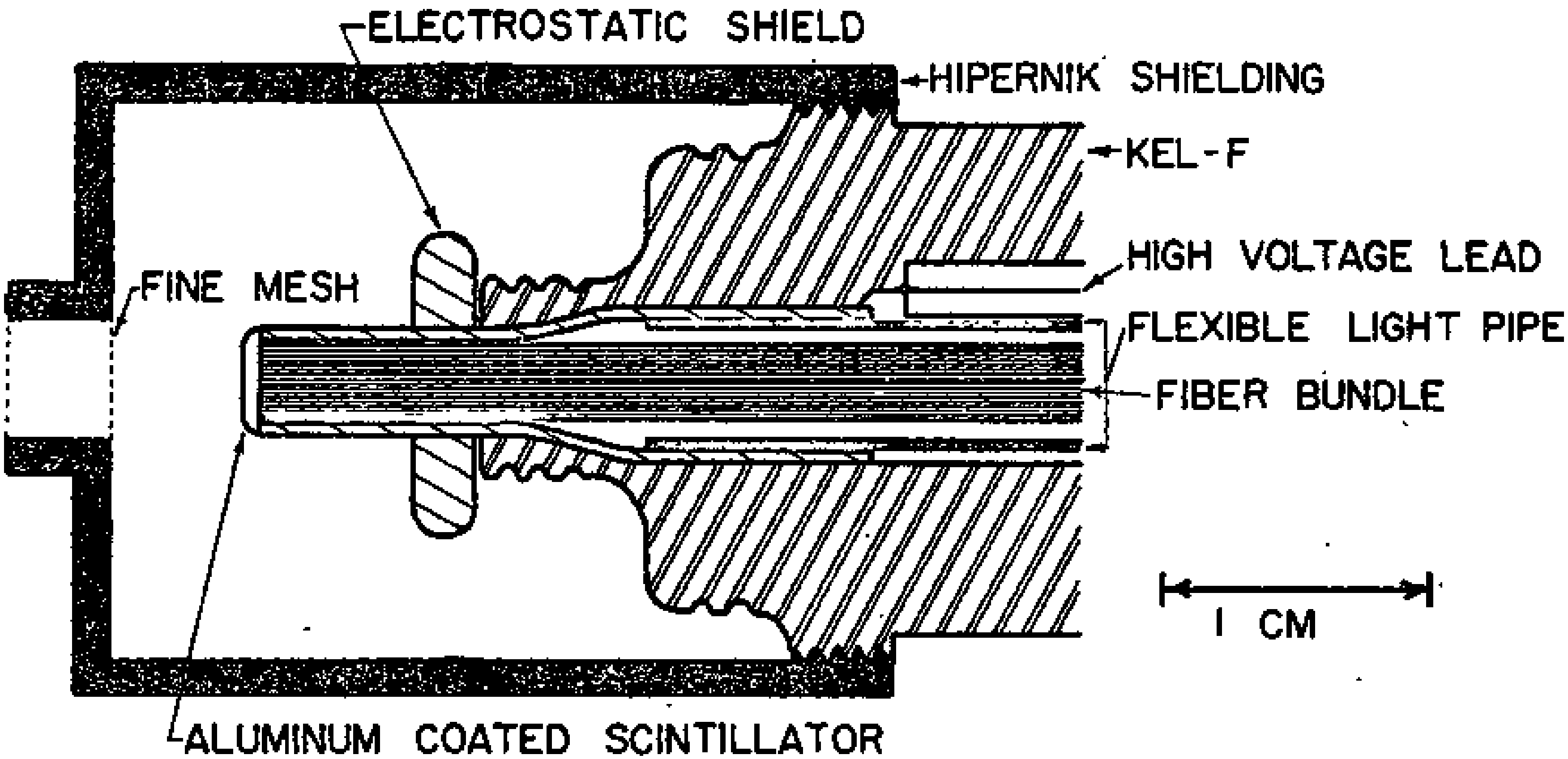
ELECTROSTATIC SHIELD
HIPERNIK SHIELDING
KEL-F
HIGH VOLTAGE LEAD
FINE MESH
FLEXIBLE LIGHT PIPE
FIBER BUNDLE
1 CM
ALUMINUM COATED SCINTILLATOR

FIGURE CAPTION

Figure 1: Cross section of electron detector. Electrons entering through the fine mesh are accelerated to the scintillator held at high potential. A PM tube detects the resulting light signal.

REFERENCES

1. Hans-Henning Kausch-Blecken von Schmelling, Zeit. fur Phys. 160, 520 (1960).